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Tank 241-SX-104 Leak Assessment Report

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U.S. Department of Energy Contract DE-AC27-99RL14047

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Abstract: Tank 241-SX-104 was declared an "Assumed Leaker" single-shell tank in 1988 based on a six-inch decrease in the interstitial liquid level. The tank was re-investigated in 1998 and determined not be be actively leaking at that time. On May 19, 2008, a new leak assessement was initiated based on an interstitial liquid level decrease that exceeded the decrease criterion. This report provides the leak assessment results. The assessment was conducted by an independent leak assessment panel. The panel concluded that tank 241-SX-104 is not actively leaking, and that the water used to install the liquid observation well in December, 2006 obscured the true interstitial liquid level feature. When the correct feature was identified and tracked, the data show a stable interstitial liquid level and no indication of a new leak.

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Tank 241-SX-104
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EXECUTIVE SUMMARY

Tank 241-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. At that time, the tank was classified as a “Sound” tank.

Between 1985 and 1988 the interstitial liquid level in the tank slowly decreased, exceeding the allowable -0.3 foot (ft) decrease criterion in February, 1988. A leak investigation completed in July, 1988 declared the tank to be an “Assumed Leaker”. Between May and August, 1988, 99,900 gallons (99.9 kgal) of liquid was pumped from the tank.

Between February, 1997 and January, 1998 the rate of decrease in the tank SX-104 interstitial liquid level changed from about -1 inch (in) per year to -6 in per year; and the waste surface response to changes in atmospheric pressure increased from between -0.7 and -3.0 in of level change per in of mercury to almost -6.0 in of level change per in 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 interstitial liquid level baseline was attributed to evaporation due to increased wicking of interstitial liquids 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 investigation recommended that the tank not be declared a re-leaker.

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.

The leak assessment used a panel of experienced CH2M HILL Hanford Group, Inc. engineers and managers to review the tank available in-tank and ex-tank data and the previous leak assessments to determine whether the tank was re-leaking. The panel consisted of: D. J. Washenfelder, (Assessment Coordinator, Technical Integration Program Manager); D. G. Baide, (West Systems Engineering Manger); D. A. Barnes, (Surveillance System Engineer, In-tank and Ex-tank Surveillance); J. W. Ficklin (SX Tank Farm Maintenance and Facility Operations Manager); J. G. Field (Environmental Engineering Manager); and M. A. Fish (SX Tank Farm Single-Shell Waste Tank System Engineer).

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

Leak Hypothesis:

“A leak from tank 241-SX-104 caused the decrease in the interstitial liquid level calculated from neutron monitoring scans in the Riser 7A Liquid Observation Well.”

Non-Leak Hypothesis:

“Water used to install the tank 241-SX-104 Liquid Observation Well created an artificially high liquid level near the Liquid Observation Well and obscured the true interstitial liquid level feature. When the correct feature is monitored the data show a stable liquid level and no indication of a leak.”

The team 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 is that tank SX-104 is not actively leaking; and that the Non-Leaker hypothesis is the most likely explanation for the observed change in the interstitial liquid level.

The recommendation of the assessment team is to leave the tank SX-104 leak integrity status unchanged by the assessment; and to rebaseline the Riser 7A interstitial liquid level to the latent feature believed to represent the true interstitial liquid level.

The results of this assessment were presented to the Executive Safety Review Board on July 31, 2008. The Board accepted the recommendations of the assessment team.

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Abbreviations and Acronyms

A:C	aluminum to caustic ratio
DCRT	double-contained receiver tank
DOE-GJO	U.S. Department of Energy Grand Junction Office
DOE-RL	U.S. Department of Energy Richland Operations Office
GRE	gas release event
ILL	interstitial liquid level
LOW	liquid observation well
PN	partial neutralization
PNNL	Pacific Northwest National Laboratory
RAS	Radionuclide Assessment System
SHMS	standard hydrogen monitoring system
SL	surface level
SpG	specific gravity
SST	single-shell tank
TD	total depth
TOC	total organic carbon
UOR	Unusual Occurrence Report

Units

ft	foot
Gal	gallon
id	inside diameter
in	inch
kgal	kilogallon (1,000 gallons)

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, Rev. A-1, *Tank Leak Assessment Process*. The formal leak assessment was initiated May 19, 2008 following a decrease in the interstitial liquid level (ILL) that exceeded the allowable -1.2 in.

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.

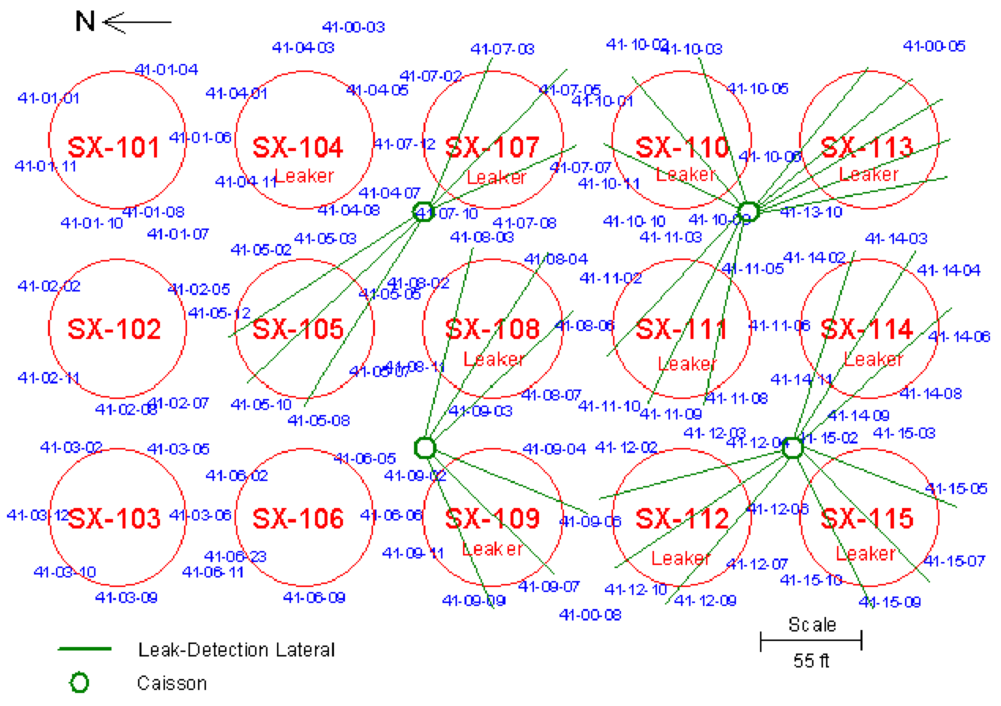
Between 1985 and 1988 the ILL in the tank slowly decreased, exceeding the allowable -0.3 ft. decrease criterion in February, 1988. A leak investigation completed in July, 1988 declared the tank to be an “Assumed Leaker”.

Between February, 1997 and January, 1998 the rate of decrease in the tank SX-104 ILL changed from about -1 in per year to -6 in per year; and the waste surface response to changes in atmospheric pressure increased from between -0.7 and -3.0 in of level change per in of mercury to almost -6.0 in of level change per in 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 liquids 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.

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 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. 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.

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 SX-104, SX-105, SX-106 cascade. Drywells illustrated in the plan are identified by their associated tank number and clock position from North. In addition to the six drywells surrounding tank SX-104, drywells 41-01-06 and 41-07-12 are considered part of the tank's drywell baseline. Tank SX-104 is one of five SX tanks not equipped with laterals extending beneath the base of the tank.



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*. For each step, a description of the process, products, and responsibilities is provided.

The leak assessment used a panel of experienced CH2M HILL Hanford Group, Inc. engineers and managers to review the tank SX-104 available in-tank and ex-tank data, and the previous leak assessments to determine whether the tank was re-leaking. The panel consisted of: D. J. Washenfelder, (Assessment Coordinator, Technical Integration Program Manager); D. G. Baide, (West Systems Engineering Manger); D. A. Barnes, (Surveillance System Engineer, In-tank and Ex-tank Surveillance); J. W. Ficklin (SX Tank Farm Maintenance and Facility Operations Manager); J. G. Field (Environmental Engineering Manager); and M. A. Fish (SX Tank Farm Single-Shell Waste Tank System Engineer).

3.0 TANK HISTORY

The 241-SX Tank Farm is part of the third generation of Hanford tank farms, and was built to contain self-boiling waste from the Reduction Oxidation (REDOX) Plant. The tanks were constructed between 1953 and 1954 and are located in the central part of the 200 West Area. There are 15 single-shell tanks in the 241-SX Farm, each with a 1,000,000 gallon (gal) capacity. They are 75 ft in diameter, approximately 44.5 ft tall with a domed top, and have been covered with about 7 ft of overburden. The base of the original construction excavation and corresponding base of the tanks is about 52 ft in depth. Ten of the 15, including tank SX-104, have been declared “assumed leakers”.

Tank SX-104 is the first tank in a cascade series of three tanks including tank SX-105 and tank SX-106. The tank entered service in the first quarter of 1955. Tank SX-104 received REDOX waste from the first quarter of 1955 until the third quarter of 1971. The tank received REDOX evaporator bottoms from tank SX-105 (received into tank SX-105 in 1967 – 1969) and REDOX ion exchange waste (post-B Plant cesium removal) from tank SX-105 in the third quarter of 1971 until the second quarter of 1975. From the third quarter of 1975 until the second quarter of 1976, the tank received evaporator bottoms and recycle wastes from the 242-S Evaporator-Crystallizer (242-S). The tank received concentrated 242-S feed and residual liquid during the third quarter of 1976 until the third quarter of 1977. During the fourth quarter of 1977, the tank received partial neutralized 242-S slurry product. In the first quarter of 1980, the content of the tank was classified as double-shell slurry feed.

Saltwell pumping 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 (DCRT) became plugged. Pumping was resumed on March 19, 1998, following the installation of a dilution system in the saltwell in order to make it easier to pump the waste to tank 241-SY-102. Pumping was interrupted and resumed on March 23, 1998, and was again interrupted.

Saltwell pumping 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 115,100 gallons (115.1 kgal) of liquid waste was transferred to tank SY-102 before failure occurred. Waste volume calculations show 47.7 kgal of drainable interstitial liquid remaining in the tank, of which approximately 43.6 kgal are estimated to be pumpable. On April 26, 2000, the tank was declared interim stabilized.

Tank SX-104 waste temperature is about 130^{o}F, or 54^{o}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^{o}C, and was complete at 22^{o}C (8C510-PC98-024).

Currently tank SX-104 contains 310 kgal of saltcake and 136 kgal of sludge. The waste estimates are based on Best Basis Inventory waste templates and process knowledge. The tank has not been core sampled. Video observation reveals there is no supernatant liquid.

4.0 TANK LEAK ASSESSMENT HISTORY

Tank SX-104 was declared an "Assumed Leaker" in 1988 following a 6 in decrease in the ILL. In 1998 the tank was again evaluated to determine if it was actively leaking. Figure 4-1 locates these events on the tank SX-104 timeline.

4.1 1988 LEAK ASSESSMENT

Environmental Protection Deviation Report 88-03 was issued February 19, 1988 to document an ILL decrease exceeding the -0.3 ft decrease criterion measured with the gamma probe. The neutron probe was noted to be stable.

Unusual Occurrence Report (UOR) WHC-UO-88-024-TF-03 dated August 30, 1988 indicates that 99,900 gal were pumped from the tank between May18, 1988 and August 16, 1988; and that the tank was declared an "Assumed Leaker" on July 13, 1988 (see 113331-88-416 *Engineering Investigation: Interstitial Liquid Level Decrease in Tank 241-SX-104*, July, 1988 [D193015350]). The report 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 3, 1988 copy 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 September 28, 1988 copy.

Environmental Protection Deviation Report 88-03 indicates that the decrease criterion was confirmed with the gamma probe, and that the neutron probe remained stable. However, the UOR indicates that the ILL decrease was verified with the Gamma, Neutron, and Acoustic probes. It does not say whether or not the neutron and acoustic probes confirmed that the -0.3 ft decrease criterion had been exceeded however.

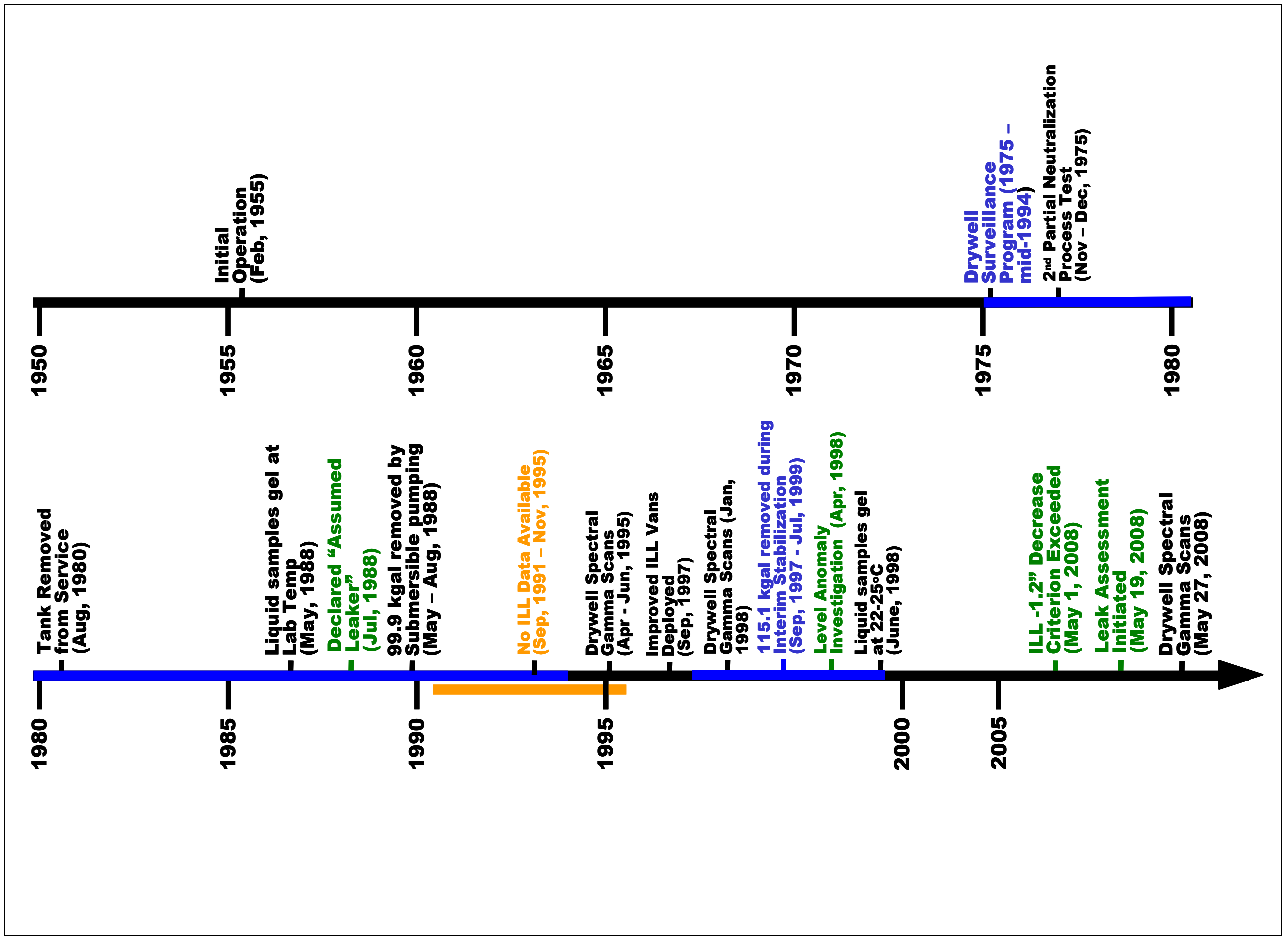
The estimated leak volume represented by the 6 in ILL decrease was 5,300 gal, when corrected for porosity and for thermal contraction of the cooling waste. This was rounded to 6,000 gal for reporting purposes.

4.2 1998 LEAK ASSESSMENT

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 the ILL being affected by changes in barometric pressure combined with a reduction in waste porosity, based on empirical measurements from water additions in February, 1997 and February, 1998, and 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*).

Figure 4-1. Tank SX-104 Event Timeline



5.0 IN-TANK DATA

5.1 SURFACE LEVEL BEHAVIOR

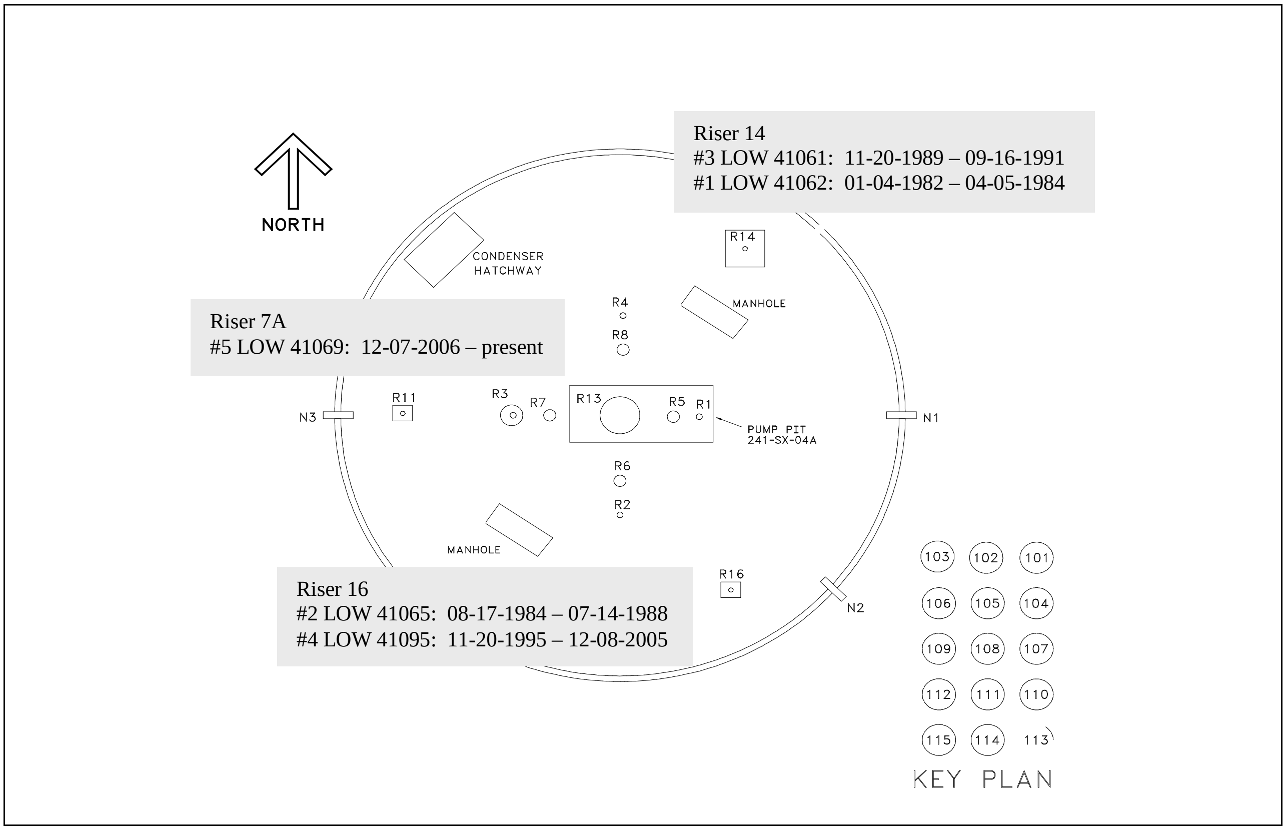
Tank SX-104 is equipped with an ENRAF surface level measurement gauge. The July 7, 2008 in-tank video shows that the ENRAF is suspended over a broad, shallow waste depression, and that the displacement plummet has been contacting a solid waste surface. In this circumstance the ENRAF provides no meaningful leak assessment data.

5.1.1 Interstitial Liquid Level 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.

Figure 5-1. Tank SX LOW Locations 1982 – 2008

Five LOWs have been installed in Tank SX-104; four have failed.
The Riser 7A LOW was installed in December, 2006.



Riser 14
#3 LOW 41061: 11-20-1989 – 09-16-1991
#1 LOW 41062: 01-04-1982 – 04-05-1984

Riser 7A
#5 LOW 41069: 12-07-2006 – present

Riser 16
#2 LOW 41065: 08-17-1984 – 07-14-1988
#4 LOW 41095: 11-20-1995 – 12-08-2005

5.1.2 Interstitial Liquid Level 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.

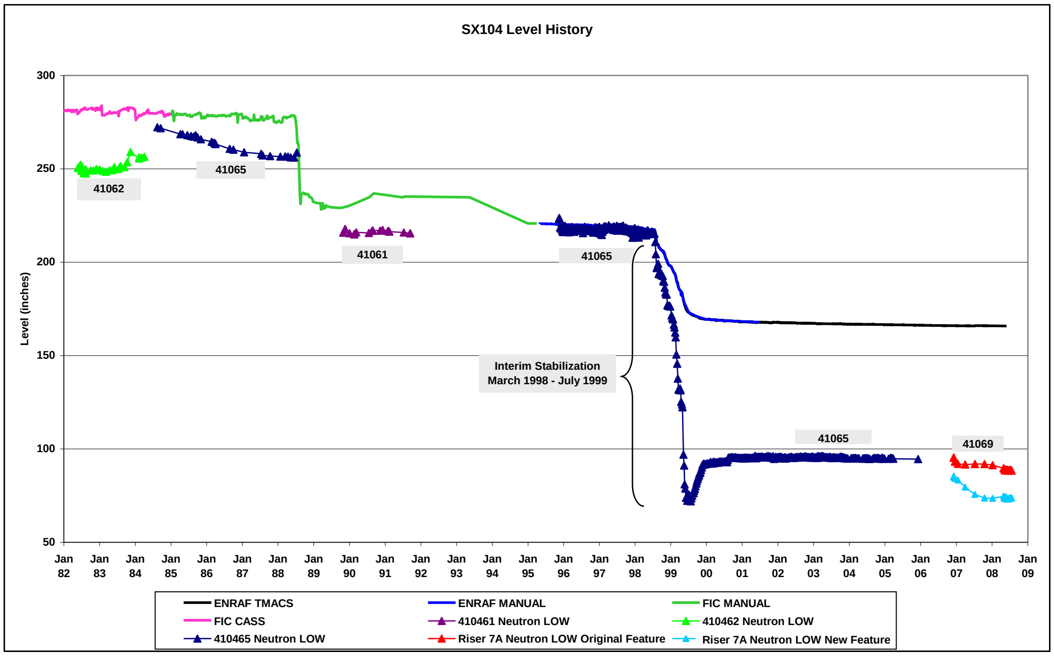
Interstitial liquid level monitoring using the new well immediately after installation on December 7, 2006, showed the predictable increase in ILL from the installation water. Subsequent neutron scans showed the ILL following a natural, predictable decline. The ILL re-stabilized by January, 2008, as 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, γ 72.036 in). No further γ scans were made. Figure 5-2 illustrates the ILL history from 1982 to present.

Figure 5-2. Tank SX-104 Interstitial Liquid Level History December, 1982 – June, 2008

The figure shows the ILL calculated from the original feature for LOWs 41061, 41062, 41065, and for both the "Original" and "New" feature for LOW 41069 installed in December, 2006.



5.1.3 Changes in Interstitial Liquid Level Neutron Scan Shape

Review of the individual ILL neutron scans that were made between December 7, 2006 after the Riser 7A LOW was first installed, and July, 2008, show that a new ILL secondary feature began to form about 15 in below the original ILL as the installation water dissipated through the waste. The original ILL feature became less pronounced.

On June 10, 2008, and June 17, 2008, gamma ray scans were run with the weekly neutron scans to investigate the new feature. The gamma ray scans indicated that the radiation interface was within about 1 to 1-1/2 in of the new ILL feature. The gamma ray scans typically detect the ILL from a stepwise radiation increase due to the soluble Cs-137 radioisotope present in interstitial liquid.

Figure 5-3 illustrates the time-sequenced development of the new ILL secondary feature.

Figure 5-3. Tank SX-104 Liquid Observation Well Neutron Scan Shape Change December, 2006 – June, 2008

The time-sequenced Riser 7A LOW scans indicate the presence of a new ILL forming in the waste. The curves have been smoothed to make the ILL features more apparent.

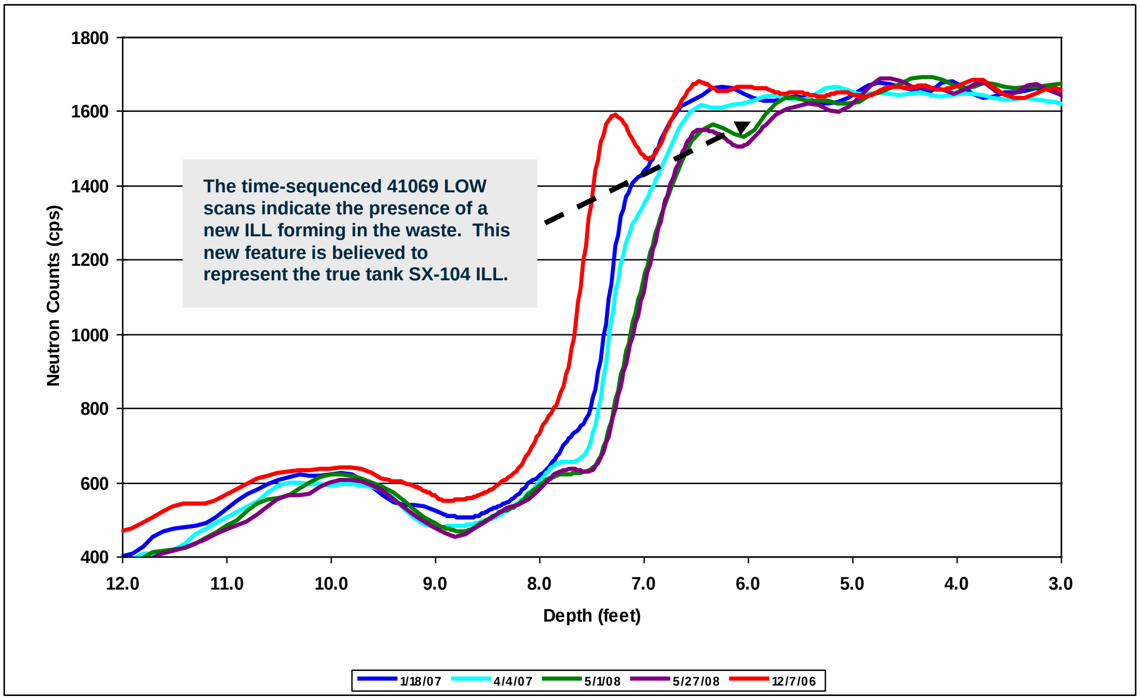


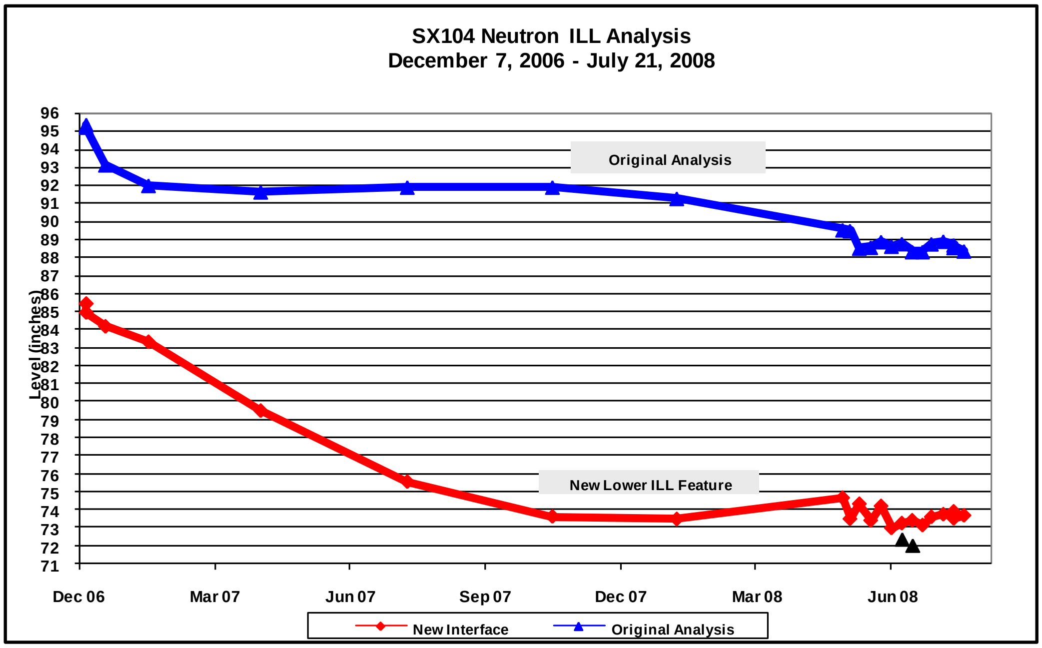
Table 5-1 presents the ILL readings for the original feature and the new secondary feature. Figure 5-4 shows that when the new ILL secondary feature is plotted, the ILL decreases asmytotically over time, consistent with the dissipation of the installation water into the waste and loss of installation water hydraulic head as this occurs.

Table 5-1. Interstitial Liquid Level Original Feature and New Feature December, 2006 – July, 2008

	Original Feature Neutron Scan		**New Feature Neutron Scan**		
Date	**ILL Reading (Inches)**	**ILL Reading Change (Inches)**	**ILL Reading (Inches)**	**ILL Reading Change (Inches)**	**ILL Reading (Inches) Gamma Scan**
12/07/2006	95.364		85.416		
12/07/2006	95.220	-0.144	84.924	-0.492	
12/20/2006	93.132	-2.088	84.156	-0.768	
01/18/2007	91.992	-1.140	83.304	-0.852	
04/04/2007	91.632	-0.360	79.500	-3.804	
07/12/2007	91.896	0.264	75.576	-3.924	
10/18/2007	91.896	0.000	73.656	-1.920	
01/10/2008	91.272	-0.624	73.512	-0.144	
05/01/2008	89.532	-1.740	74.688	1.176	
05/06/2008	89.484	-0.048	73.524	-1.164	
05/12/2006	88.512	-0.972	74.352	0.828	
05/20/2006	88.560	0.048	73.440	-0.912	
05/27/2008	88.872	0.312	74.232	0.792	
06/03/2008	88.620	-0.252	73.020	-1.212	
06/10/2008	88.764	0.144	73.284	0.264	72.384
06/17/2008	88.320	-0.444	73.440	0.156	72.036
06/24/2008	88.320	0.000	73.176	-0.264	
06/30/2008	88.752	0.432	73.632	0.456	
07/08/2008	88.896	0.144	73.776	0.144	
07/15/2008	88.692	-0.204	73.932	0.156	
07/15/2008	88.548	-0.144	73.548	-0.384	

Figure 5-4. Riser 7A Interstitial Liquid Level Original Feature and New Feature December 7, 2006 – July 21, 2008

The figure shows the ILL calculated from both the original feature and from the latent “new” feature believed to represent the true ILL.



5.1.4 Relationship between Surface Level and Interstitial Liquid Level

Table 5-2 illustrates the difference between the waste surface level and the ILL for the three periods covered by leak assessments was reviewed and reconciled: 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.

Table 5-2. Surface Level and Interstitial Liquid Level During Tank SX-104 Leak Assessments

Event	Evaluation Period	Waste Surface Average Level (SL)	Interstitial Average Liquid Level (ILL)	△ Between SL and ILL	Probable Waste Behavior
1988 Leak Investigation	April, 1985 – April, 1988	277.9”	256.176”	-21.7”	Probably a floating crust over the top of a liquid/slurry layer. The interface between the crust and the liquid/slurry would be reported as the ILL even though it does not correspond to the classic ILL concept of liquid within the pores of a mostly solid waste matrix.
May – Aug, 1988 -- 99.9 kgal removed via Submersible Pumping					
1998 Level Anomaly Investigation	February, 1997 – February 1998	219.55” SL △ = ~ 58.3”	214.896” ILL △ = ~ 41.3”	-4.7”	Liquid/slurry layer underlying the floating crust mostly removed from the tank during submersible pumping; ILL △ is equivalent to ~88% porosity for the liquid/slurry layer based on the 99.9 kgal removal.
Sep, 1997 – Jul, 1999 -- 115.1 kgal removed via Jet Pumping					
2008 Leak Assessment	January, 2008 – July, 2008	165.88” SL △ = ~ 53.7”	89.031” ILL △ = ~ 125.9”	-76.8”	The original floating crust probably settled onto underlying solid, mostly compacted, waste as a result of the 1988 submersible pumping. The underlying waste continued to settle as the liquid was withdrawn from the waste pores during interim stabilization. ILL △ is equivalent to ~33% porosity during interim stabilization activity, based on the 115.1 kgal removal. Calculated porosity reported on the SX-104 stabilization form was 34% (HNF-SD-RE-TI-178 p. 254)

5.1.5 Waste Origin

It is believed that the tank SX-104 interstitial liquid is a product of the second Partial Neutralizaton (PN) process test - the "Nitric Acid Partial Neutralization/Acid Injection Process Test" - using a modified acid injector design. The test was run intermittently between November 14, and December 19, 1975 (ARH-CD-597). 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 ([D196226689]). Although the process test proposal called for sampling each of the three phases of the test, the analytical report only has two sample results.

5.1.6 Waste Characteristics – 1988 Samples

The May, 1988 samples gelled at laboratory temperature. The sample results show a [PO_4] of 0.1M ± 20%, and a [P] = 0.15M (12221-PCL88-147). 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.

5.1.7 Waste Characteristics –1998 Samples

The tank was also grab sampled in April 1997, and again in June 1998. Results from the April 1997 sampling event were used to assure 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).

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^oC to 22^oC laboratory temperature. About 10 volume % free liquid remained on top of the gel. The samples remained clear from 60^oC until the temperature reached 25^oC, 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).

The composition of the 1998 samples shows remarkable similarities to the old, burping SY-101 supernatant. Table 5-3 compares tank SX-104 and tank SY-101 "Window E" supernatants. Window E was a turbulent, retained gas-driven, waste rollover event that occurred on December 4, 1991. The event triggered a planned waste sampling activity. A full core sample extending from the surface of the waste to approximately 2 in above the bottom of the tank was taken between December 14, and December 16, 1991 (WHC-SD-WM-DTR-0126).

Table 5-3. Comparison of 1998 Tank SX-104 and 1991 Tank SY-101 "Window E" Supernatant Samples

Analyte	SX-104 1998 Supernatant M	SY-101 Window E Supernatant M
OH^-	2.306	2.44
Al	1.527	1.82
Na	10.13	12.26
NO_2^-	2.93	3.53
NO_3^-	2.84	2.51
Cl^-	0.28	0.27
K^+	0.09	0.15
P	0.026	0.055
SpG	1.46	1.51
% H_20	50	42
A:C Ratio	0.67	0.75

If the tank SX-104 supernatant was concentrated by ~ 10%, the analyte concentrations would almost exactly match the tank SY-101 Window E composition, including % H_20 and specific gravity (SpG).

Evaluation using the AlO_2^- x OH^- phase diagram in Figure 5-5 shows that the 1998 samples and Window E samples reside in the same aluminate region. Aluminate is known to catalyze the thermal decomposition of organic complexants, which results in H_2 gas formation. The high surface area of the aluminate crystals is also known to retain gas. These combined phenomena resulted in the tank SY-101 gas release events (GRE), and are most likely still occurring in tank SX-104. The 1988 sample Total Organic Carbon (TOC) analysis for tank SX-104 was 5 - 13.3 g/l; and for tank SY-101 Envelope E 14.4 g/l. The inverse barometric response correlation to the ILL present during the 1998 re-leak investigation also indicates that retained gas was present in tank SX-104.

Total organic carbon is a common source of gas production in the waste tanks. As noted, the TOC in the 1988 tank SX-104 sample was 5 – 13.3 g/l TOC; in the 1997 sample centrifuged solids 1.8 g/l; and in the 1997 sample sludge interstitial liquid 2.2 g/l. The TOC in tank SY-101 Window E samples prior to remediation was 14.4 g/l. If the gas generation rate was proportional to the TOC, then tank SY-101 had a significantly higher generation rate in 1991 than tank SX-104 had in 1997, based on the 1997 samples. However, based on the similarities of the wastes, it is likely that the gas retention properties of the slurries in tank SX-104 and tank SY-101 were similar. The tank SX-104 TOC decrease between the 1988 and the 1997 samples may be the result of slow decomposition, although such a high decomposition rate seems inconsistent with the reported SHMS and GRE data for the tank.

Figure 5-5. Tank SX-104 and Tank SY-101 Window E Aluminate Comparison

(from ARH-ST-133 *Vapor-Liquid-Solid Phase Equilibria of Radioactive Sodium Wastes at Hanford*)

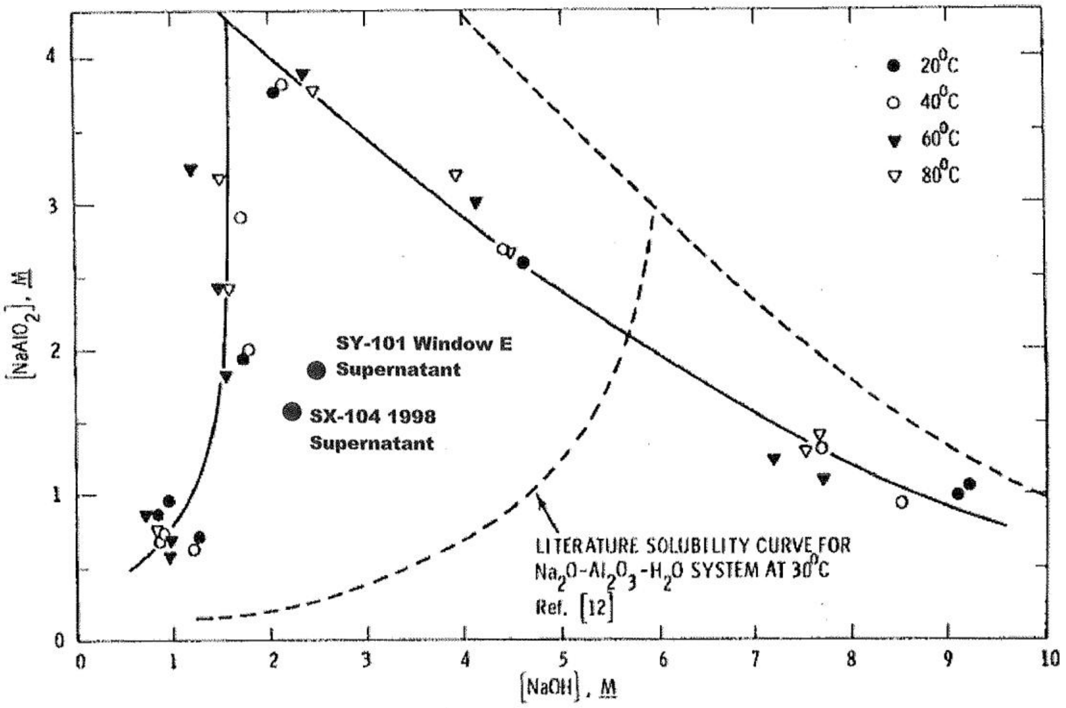


FIGURE 3

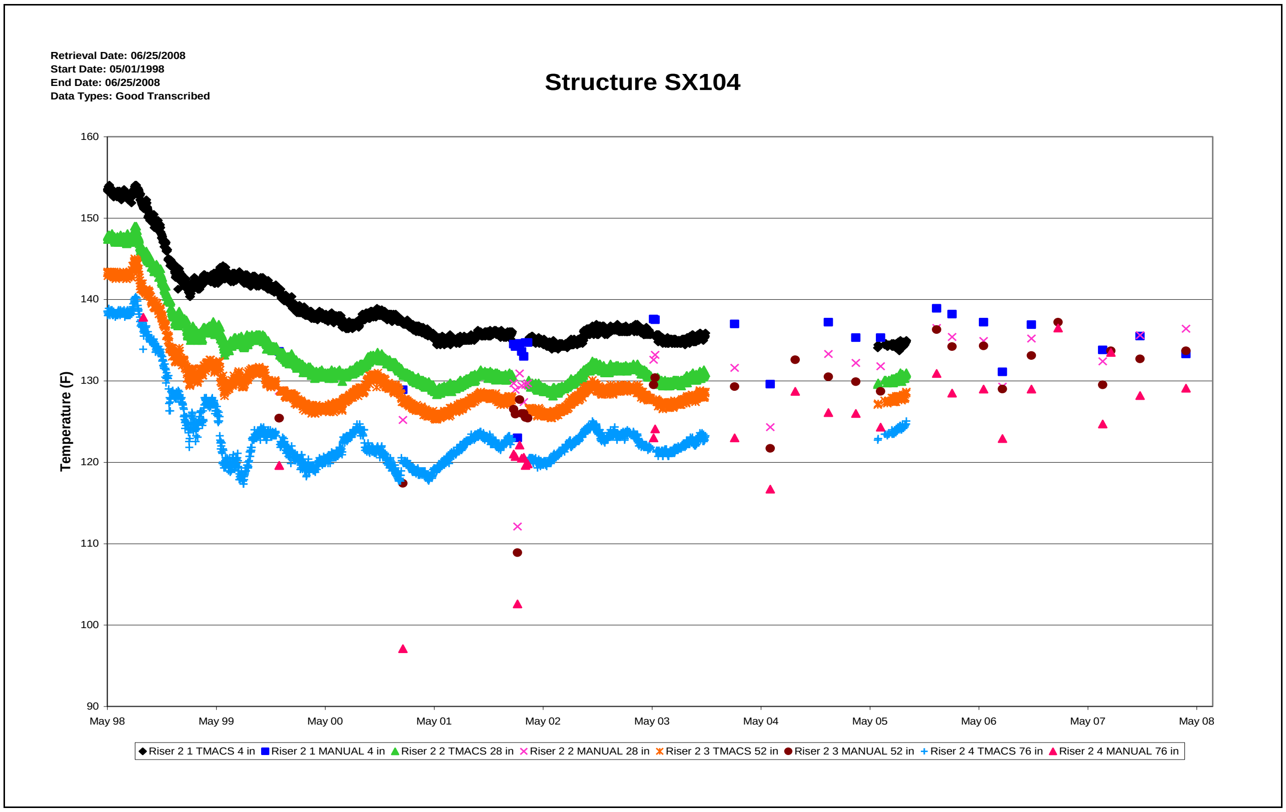
SOLUBILITY OF SODIUM ALUMINATE IN SYNTHETIC WASTE SOLUTIONS
(SATURATED WITH $NaNO_3$, $NaNO_2$, Na_2SO_4, AND Na_2CO_3)

5.1.8 Waste Temperature

The current ~ 88.7 in ILL using the original ILL feature is bracketed by thermocouple #5, about 11 in above the ILL, and thermocouple #4, 13 in below. The last recorded TMACS readings for these thermocouples were 105.3°F (41°C) on April 30, 2002; and 125.1°F (52°C) on September 2, 2005 (Data Date – May 29, 2008) as illustrated in Figure 5-6.

Figure 5-6. Tank SX-104 Waste Temperature May, 1998 – May, 2008

Tank 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).



5.1.9 Retained Gas

The 1998 re-leak assessment noted a high correlation between changes in barometric pressure and changes in the ILL, and accounted for the apparently 1,000 gal waste loss "... by a combination of reduced porosity and increased capillary pressure. There is also some evidence that the ventilation rate may have been increased..." (LMHC-9851233A R3/HNF-2617). The 2008 leak assessment considered the possibility of mini-GRE's contributing to temporary changes in the ILL.

The demonstrated effect of barometric pressure on the ILL height, and the waste characteristics of the 1998 interstitial liquid sample showing close similarities to the unmitigated tank SY-101 waste, indicate that the waste is capable of generating, retaining, and releasing small amounts of gas. Localized gas release in the vicinity of the LOW would be indicated by a decrease in the ILL similar to the drop measured on May 1, 2008.

Pacific Northwest National Laboratory (PNNL) studied the gas retention and release in the SSTs, and concluded the that the only mechanism capable of producing large spontaneous gas releases was buoyant displacement, which occurs in tanks with a deep supernatant layer (PNNL-11391). The report concluded that SSTs were only capable of small releases of a few cubic meters, based on theory and laboratory and field observations; and since gas bubbles can only cling to submerged solids, gas is usually only released when the volume of waste is disturbed. The report also prioritized the SSTs by flammable gas potential based on barometric pressure surface level response (dL/dP); extent of post-transfer surface level rise; and tank headspace gas concentrations. Table A.1 *SST Prioritization Data* estimated the tank SX-104 dL/dP as ~ + 0.0001 in/in Hg. The positive number indicates that there is no waste surface correlation with barometric pressure. Table 3.1 *Void Fraction Estimates* shows that tank SX-104 consistently ranked as one of the least responsive tanks to changes in barometric pressure affecting the surface level. Similar results were obtained when level rise was considered. The relationship between waste surface level and ILL changes was not discussed.

In March, 1995 a Standard Hydrogen Monitoring System (SHMS) consisting of High- and Low-range Whittaker™ cells for H_2, and a grab sample station was installed on tank SX-104. During saltwell pumping, tank SX-104 showed no evidence of spontaneous gas release of significant amounts of flammable gas – one of only four tanks on the SST Flammable Gas Watch List (Public Law 101-510, Section 3137, *Safety Measures for Waste Tanks at Hanford Nuclear Reservation)* to do so. Comparison between tank SX-104 and the other watch list SSTs show that it consistently ranked at or near the bottom for all comparisons of generation or release of gas (RPP-7249). In December, 1999 the contractor recommended that the tank SX-104 SHMS be removed from service since the tank had "... minimal gas release activity, and/or ... active ventilation, ..." (LMHC-9958931).

The gas generation rate, retained gas volume, and spontaneous and induced gas release histories for tank SX-104 are discussed in RPP-7249. The 2001 report notes that, "... all of the spontaneous gas releases observed since monitoring was installed in 1995 have all been less than 3 m^3 (100 scf) of hydrogen and occur over many hours to days..." for the Flammable Gas Watch List SSTs. None of the 19 SSTs on the watch list exhibited significant releases, and the steady-state gas release rate was insignificant. Table 6-2 *Barometric Pressure Effect Gas Volume Estimates in Single-Shell Tanks* notes that there is "No apparent dL/dP correlation" for tank SX-104. Only one other tank in the 19-tank list is similarly labeled. Table 6-3 *Average Gas Fraction and Gas Volume Estimates from Neutron Logs* estimates a 7.9% gas fraction below the ILL, with a best-estimate standard gas volume of 250 ± 125 m^3 for tank SX-104.

In 2004 PNNL provided an estimate of the surface dL/dP (in/in Hg) values for tank SX-104 for a four-month period between January 1, 1997 and January 20, 1999. The estimated dL/dP was -0.056 ± 0.055 in/in Hg, supporting earlier conclusions that there is no, or almost no, correlation between surface level changes and dP change. This is consistent with the PNNL-11391 +0.0001 in/in Hg within the limits of error. Evaluation of tank SX-104 ILL response to barometric pressure is not presented in RPP-15488, *Investigation of Tank Void Fraction using Liquid Level Response to Atmospheric Pressure Change* April 2005 [D4509875].

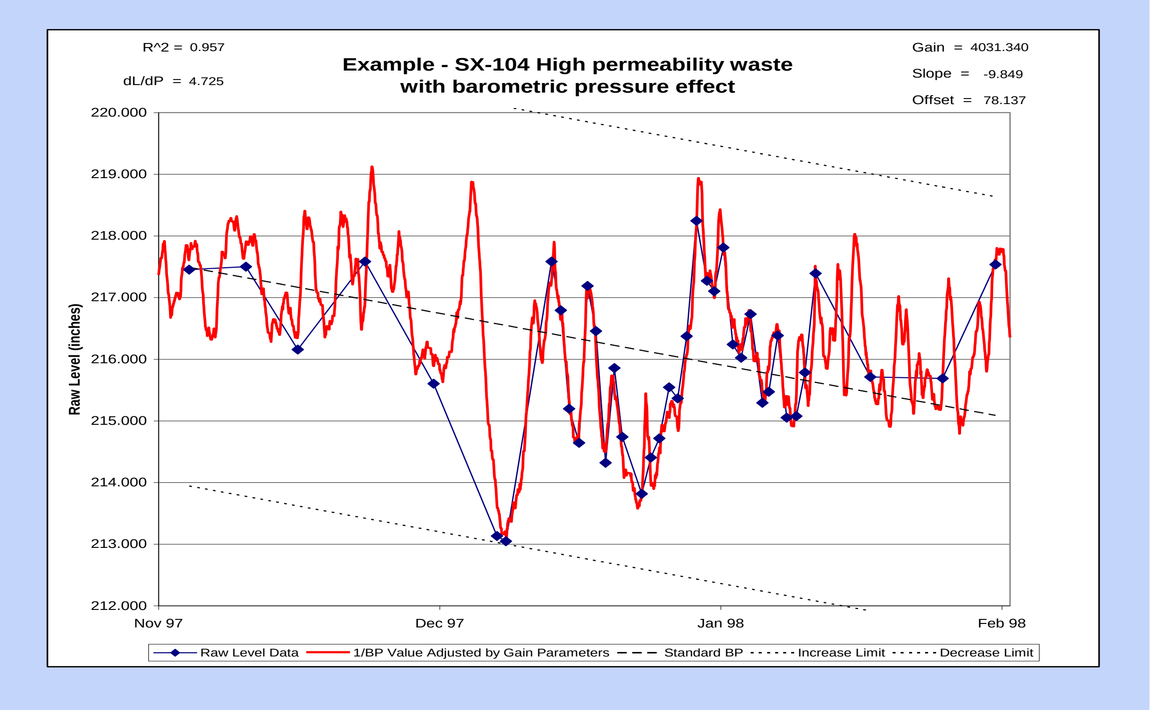
5.1.10 Waste Barometric Pressure Response

In the 1998 leak assessment, the variations in ILL were attributed to in barometric pressure combined with changes in waste porosity based on empirical measurements from water additions in February, 1997 and February, 1998, and increases in capillary strength from the reduced porosity. The leak assessment showed good correlation between the inverse of the barometric pressure (i.e., the “Barometric Pressure Effect” – BPE) and changes in the ILL.

Figure 5-7 is from the 1998 analysis. At the time of the analysis tank SX-104 had not been saltwell pumped. The surface was a floating crust with the ILL less than 5 in below the surface. The porosity of the layer beneath the crust was calculated to be 88%, indicating that it was still mostly liquid slurry.

Figure 5-7. Barometric Pressure Effect on ILL
November, 1997 – February, 1998

During the 1998 leak assessment, tank SX-104 had a ~ 5 in thick floating crust covering liquid slurry. The slurry composition was very similar to tank SY-101 waste known for its gas retention and release behavior. Changes in barometric pressure during this period would have been immediately telegraphed to the slurry; retained gas, and waste porosity and capillary strength would have determined the magnitude of the ILL response.



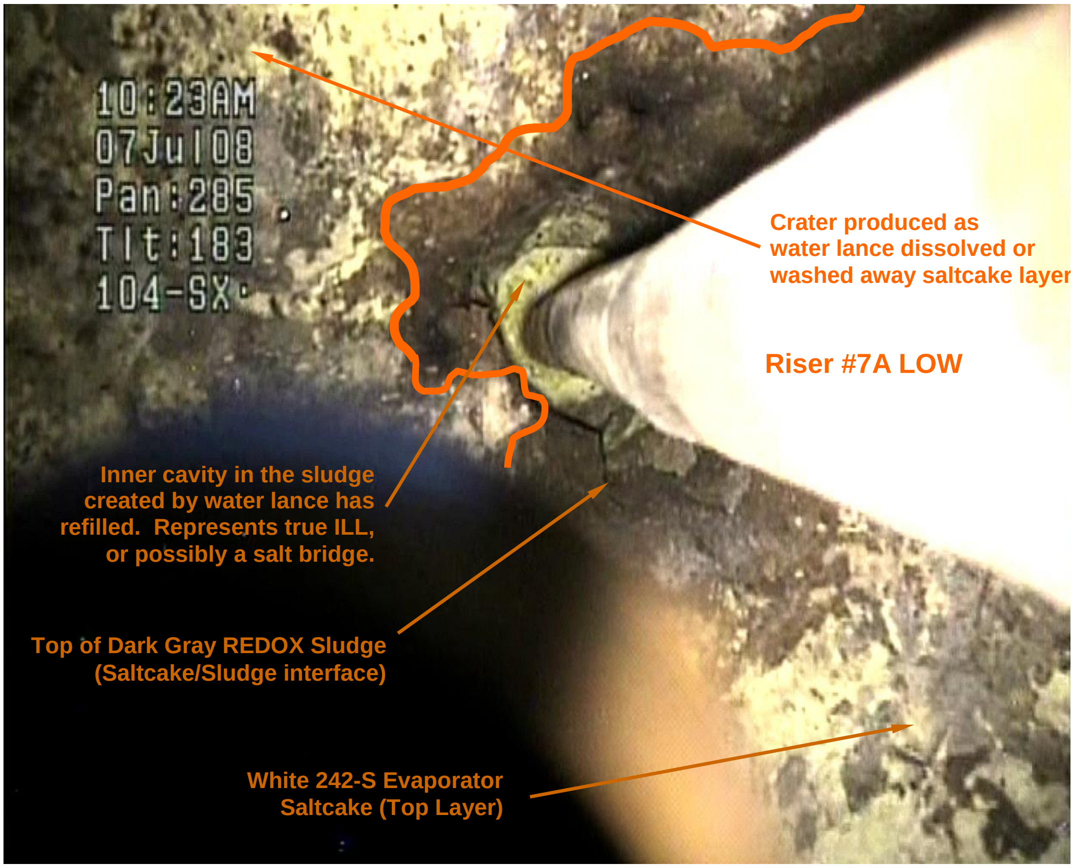
By July, 1999, 115.1 kgal of interstitial liquid had been pumped from the tank. The ILL is now about 77 in below the waste surface. If changes in barometric pressure are still acting on the interstitial liquid, the ILL response is very muted. A recheck of the correlation between the barometric pressure and changes in the ILL conducted during the present leak assessment showed that there is no longer a meaningful correlation.

5.1.11 In-Tank Photographs

The October 21, 1999 post-interim stabilization in-tank video taken from Riser 3 shows a dry, very rough waste surface with deep fissures. Some fissures appear to contain a liquid pool, but confirmation of this is frustrated by the camera viewing angle and lighting. Since the ILL is believed to be about 8 ft below the waste surface it is likely that all or most of the "pools" are optical illusions.

A new in-tank video taken from Riser 3 and Riser 7B was completed on July 7, 2008. The video shows significant shearing and cleavage of the waste surface, with the waste at higher elevation on the tank wall, then fracturing and dropping in the direction of the saltwell screen. The Riser 7A LOW is located inside a small excavated cavity of uncertain depth. The bottom of the cavity appears to have once been liquid that has solidified to a greenish yellow surface.

Figure 5-8. Photo Detail of Riser 7A Installation, July 7, 2008



The dark sludge layer has been exposed around the cavity (outlined in figure). Further away, remnants of greenish yellow saltcake are visible.

Insertion of the LOW into the excavated inner cavity would have caused the installation water to well upward and spread onto the waste surface. Later as the water began to dissipate into the waste, it is likely that the lip of the inner cavity, or a lower inner cavity feature was mistakenly interpreted as the ILL. The 2008 leak assessment identifies this as the “Original Feature ILL”.

The mixture of sludge and saltcake visible in the photograph also indicates that the rate of installation water redistribution through the waste surrounding the LOW would be affected by the permeability of the different materials. Localized sludge regions would impede redistribution relative to saltcake regions.

The “New Feature ILL” believed to be the true ILL is about 15 in below the Original Feature, and about 76 in below the waste surface level as measured by the ENRAF.

The in-tank video shows no evidence of the black asphalt membrane seeping out from behind the liner where it is exposed above the waste surface; nor evidence of dome concrete spalling or recurring surface patterns suggesting concrete or rebar degradation has occurred.

6.0 EX-TANK DATA

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 tank's concrete footing. The metal liner has a 37-ft 6-in radius. The concrete wall around 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

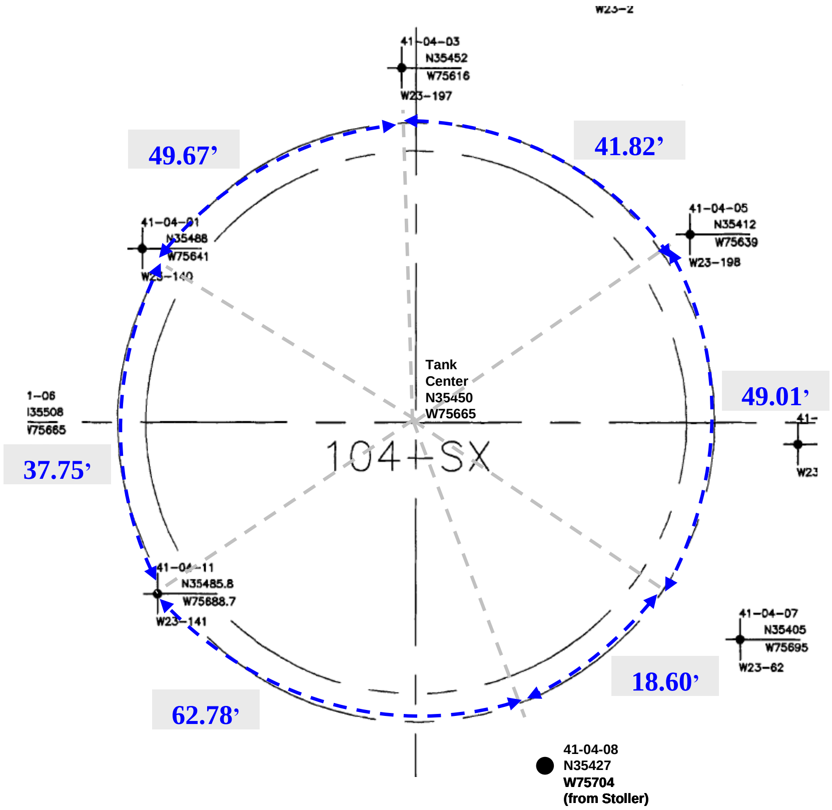
Drywell*	Drywell Distance from Tank Center (ft.)	Drywell Distance from Outside Radius of 2' Concrete Tank Wall (ft.)	Drywell Distance from Outside Radius of 1'-10" Concrete Tank Footing (ft.)	Clockwise Footing Perimeter Distance to Next Adjacent Drywell (ft.)
41-04-01	44.944	5.444	3.569	49.67
41-04-03	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.

The 1988 and 1998 waste samples gelled at laboratory temperature; the waste would be expected to behave similarly at soil temperature (assumed to be 55F, or ~13C). The waste properties might prevent a small leak from migrating far enough to be detected in one of the drywells. Although none of the six drywells shows a change in soil contamination level, it is difficult to draw any integrity conclusion from this information alone.

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 55F, or ~13C). 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 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. 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 Spectral Gamma Logging System has since supplanted the Gross Gamma system. The Gross Gamma scans are reproduced from HNF-3136 in Figure 5-10. Note that, in addition to the six drywells surrounding tank SX-104, three nearby drywells – 41-00-03, 41-01-06, and 41-07-12 – were tracked as part of the tank SX-104 drywell data. These latter drywells can be located from Figure 1-1.

Figure 6-2. Historical Gross Gamma Logs 1974 – 1994

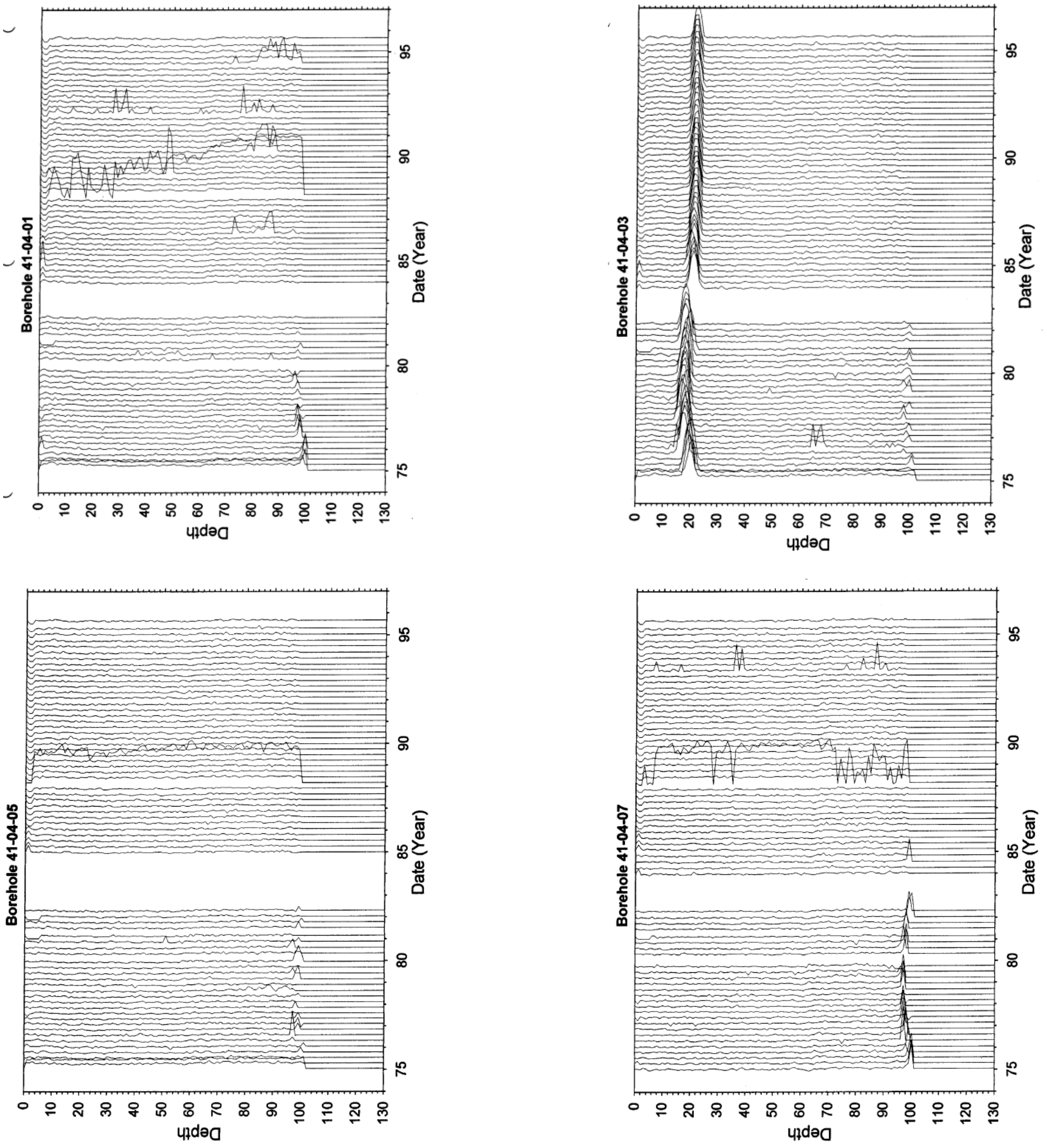


Figure 5-10. Historical Gross Gamma Logs 1974 – 1944 (cont.)

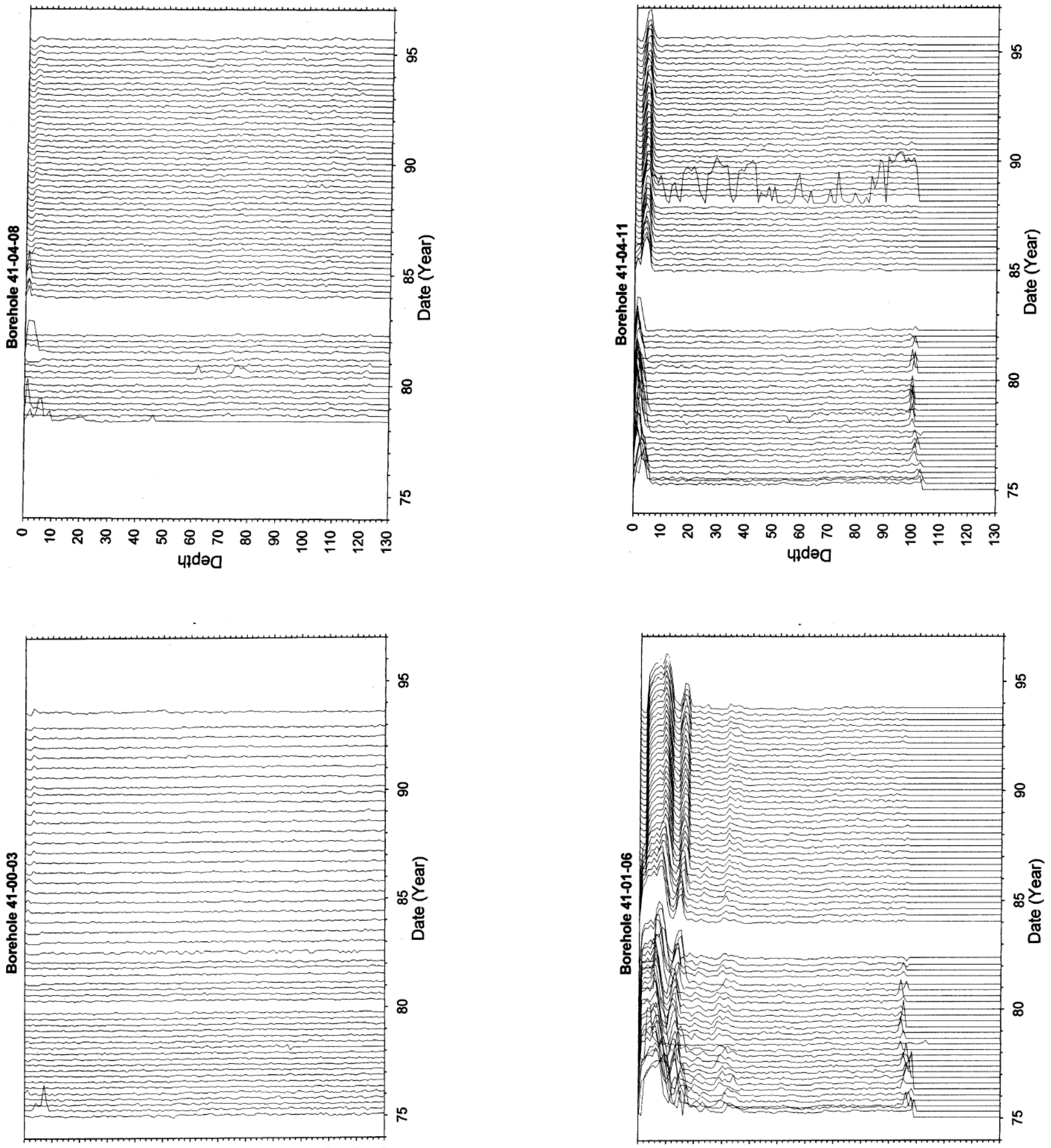
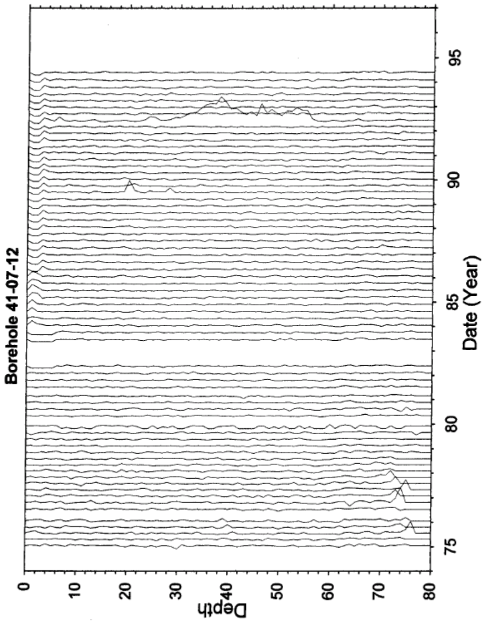


Figure 5-10. Historical Gross Gamma Logs 1974 – 1944 (cont.)



Gross Gamma Log Plots Reference:

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

6.1.3 Drywell Spectral Gamma Logs 1995, 1998

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 strong evidence that the tank had ever leaked; and 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).

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. 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 (GJ-HAN-21).

6.1.4 Drywell Gross Gamma and Spectral Gamma Logs Interpretation

Table 5-5 summarizes the 1975 – mid-1994 Gross Gamma logs and the 1995 Spectral Gamma logs for the SX-104 drywells, and the nearby drywells:

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

Drywell	Drywell Notes	Gross Gamma Logs 1975-1995	Spectral Gamma Logs 1995
41-04-01		No significant levels of gamma-ray contamination is present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 100 ft (2). 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 (1).	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 K-40 plot shows an increase in concentration at 62 ft. This increase corresponds to the lithology change at this depth. There is an increase in the variation of the K-40 concentration from 85 ft to TD. In addition, increased U-238 and Th-232 concentrations were measured below 62 ft. These increases are also clearly the result of a change in the lithology. The combination plot for this borehole shows the radioactivity from Cs-137 dominates the total gamma log from 0 to 20 ft, but the K-40 signal is dominant below 20 ft. The slight increase in Cs-137 concentration at 50 ft is not apparent in the total gamma log (1).

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

Drywell	Drywell Notes	Gross Gamma Logs 1975-1995	Spectral Gamma Logs 1995
41-04-03		Stability of Cs-137 contamination at 21 ft. cannot be determined (2). The gross gamma log for this borehole shows only the 20-ft activity peak (1).	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. The K-40 plot shows an increase in concentration at 56 ft. U-238 decreases in concentration at about 76 ft (1).
41-04-05		No significant levels of gamma-ray contamination is present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 100 ft (2). The Tank Farms gross gamma log shows some poorly defined increased activity peaks in the upper 20 ft of the borehole (1).	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. The K-40 plot shows an increase in concentration at about 58 ft that is due to a change in lithology (1).

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

Drywell	Drywell Notes	Gross Gamma Logs 1975-1995	Spectral Gamma Logs 1995
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 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 (1).	No significant levels of gamma-ray contamination is present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 100 ft (2). The Tank Farms gross gamma log shown in the combination plot and the older gross gamma logs did not show any contamination (1).	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 (1).
41-04-08	Drilled in 1978 in the adjacent clocked position to 41-04-07 (1). Possibly intended as a replacement due to contamination inside the 41-04-07 well casing extending from the surface to TD.	No significant levels of gamma-ray contamination is present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 123 ft (2).	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.

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

Drywell	Drywell Notes	Gross Gamma Logs 1975-1995	Spectral Gamma Logs 1995
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(2). The Tank Farms gross gamma log shows the surface contamination (1).	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 natural gamma logs show lithologic changes at 60 and 66 ft, consistent with the lithology changes of other boreholes surrounding this tank. 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 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 (1).

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

Drywell	Drywell Notes	Gross Gamma Logs 1975-1995	Spectral Gamma Logs 1995
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. Therefore, according to (1), the decision was made to not log this borehole with the SGLS. However, the Log Data Report included in (1) for this drywell indicates that it was logged in three log runs January 21 – 23, 1998.	No significant levels of gamma-ray contamination is present above gross gamma probe surveys' detection threshold between 1975 and 1993 in the vadose zone from 2 to 150 ft (2).	Not logged.
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 (2). The Tank Farms gross gamma log shows the surface contamination and a slight peak at 30 ft (1).	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. The K-40 plot shows an increase in concentration at 65 ft. This increase corresponds to the lithology. The lithology change is indicated by the increase of U-238 and Th-232 concentrations at 65 ft(1).

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

Drywell	Drywell Notes	Gross Gamma Logs 1975-1995	Spectral Gamma Logs 1995
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 (1).	No significant levels of gamma-ray contamination is present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 77 ft (2). 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 (1)	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. The K-40 plot shows an increase in concentration at about 65 ft, which is due to a lithologic change. The U-238 and Th-232 gamma-ray fluxes in this borehole are low due to the attenuation of the two casings. The concentrations of these isotopes are barely above minimum detection (1)

Table References

1. 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)
2. 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
3. SD-WM-TI-356 Rev. 0 *Waste Storage Tank Status and Leak Detection Criteria*, March, 1990 [D197006832, D197006846, D197006861, D197006868]

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 (see Appendix C):

"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."

7.0 HYPOTHESES

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

Leak Hypothesis:

"A leak from tank 241-SX-104 caused the decrease in the interstitial liquid level calculated from neutron monitoring scans in the Riser 7A Liquid Observation Well."

Non-Leak Hypothesis:

"Water used to install the tank 241-SX-104 Liquid Observation Well created an artificially high liquid level near the Liquid Observation Well and obscured the true interstitial liquid level feature. When the correct feature is monitored the data show a stable liquid level and no indication of a leak."

8.0 SUMMARY OF ANALYSTS ASSESSMENT

Expert Opinion: D. G. Baide

Estimated Probability of Observed In-Tank and Ex-Tank Data if Tank is actively leaking = 0.22

Basis for Opinion:

- Considering both the LOW neutron scan data and viewing of the July, 2008 video, picking the true ILL feature can be deceptive. It is very likely that the true ILL feature has been identified as part of the current leak assessment. However, it is difficult to confidently predict the water diffusion behavior due to the highly variable – cracked and sloughed – waste.
- Drywell spacing and detector sensitivity require that the waste migrate from the tank and that drywell intersects the plume. The drywell scans are most meaningful when there is a change in radiation level. This did not happen in the gross gamma scans which is favorable to the NL hypothesis, but is not proof that the tank didn't leak. The data do not bias the probability.

Expert Opinion: D. A. Barnes

Estimated Probability of Observed In-Tank and Ex-Tank Data if Tank is actively leaking = 0.05

Basis for Opinion:

- The major neutron feature near 89 inches that was originally interpreted as the ILL is really a sludge-saltcake interface. The true ILL is about 15 inches lower, near 74 inches. If the lower (and smaller) interface is tracked as the true ILL the trend shows a slow redistribution of installation liquid over about a 6-month period, with the level remaining fairly stable since then. If one considers the deeper feature to be the true ILL the data show no indication of a tank leak.
- The [July 7, 2008] video tends to confirm this analysis. There is a large section of saltcake from the surface down that has been significantly washed out from the installation water. Near the bottom of the visible section in the video the material changes dramatically to a dark brown non-crystalline material that is very near gauge, (i.e., very little washout). This is most likely the top of the sludge layer, and the lack of washout results from the greatly reduced solubility in water. This is most likely the major neutron feature seen on the LOW survey. Approximately 1-2 ft below this dark brown surface the hole is filled with small salt crystals. These crystals have fallen in the hole from an upper level, and may be either floating on the true liquid surface, or may have bridged over. In that case the ILL would be somewhat deeper but not visible from the video. In either case the video confirms the interpretation that the true ILL is deeper than the major feature at the top of the sludge.

Using the lower feature as the ILL leads to the conclusion that the probability of a leak is extremely low.

- Gross gamma showed no activity above background until the scans were discontinued in 1994. (There was some activity near the surface, which is not attributable to tank leakage.) The tank SX-104 supernatant would tend to gel at soil temperatures, so if the tank leaked it could very easily miss being detected in a drywell. The clean history slightly supports a sound tank, but not by much.

Expert Opinion: J. G. Field

Estimated Probability of Observed In-Tank and Ex-Tank Data if Tank had Leaked = 0.15

Basis for Opinion:

- The initial ILL feature was probably reading the interface between the sludge and saltcake; the secondary feature is the true ILL (based on understanding how the neutron probe works, understanding capillary action, the correlation between the neutron probe and gamma probe measurements, and the July 7, 2008 video showing the LOW-waste interface and the clear distinction between the sludge and saltcake).
- There could be a small leak in the tank that the ILL would not detect because of variability in measurement data. Also the liquid properties suggest that a leak could be self-sealing and would not be detected.

Expert Opinion: J. W. Ficklin

Estimated Probability of Observed In-Tank and Ex-Tank Data if Tank had Leaked = 0.002

Basis for Opinion:

- 1998 leak re-evaluation and drywell data support the conclusion that the tank had not previously re-leaked.
- The ILL is stable, especially when using the new ILL feature. The initial decrease has restabilized.
- Review of the [July 7, 2008] video supported the analysis of the LOW scan.
- Drywell scans didn't consistently indicate the presence of a leak, but there is the potential that the leak location could be in an area not being monitored.

Expert Opinion: M. A. Fish

Estimated Probability of Observed In-Tank and Ex-Tank Data if Tank had Leaked = 0.18

Basis for Opinion:

- The ILL pattern indicates the tank is not re-leaking. The lower ILL feature is consistent with the installation water being absorbed into the waste.

- From the July 7, 2008 video, there is a liquid-created surface in the LOW waste cavity from a recent liquid level. The appearance of the surface and its location influences the recommendation that the lower feature is the correct ILL.
- The gross gamma drywell scans show no evidence of a leak. It is possible that a small leak could have occurred but been missed. The waste gels at ground temperature. The spectral gamma scans show no evidence of a leak. The compacted ground at the bottom of the tank level (due to the original construction activities) would encourage horizontal movement of the tank waste towards the dry wells.

Expert Opinion: D. J. Washenfelder

Estimated Probability of Observed In-Tank and Ex-Tank Data if Tank had Leaked = 0.22

Basis for Opinion:

- After initial ILL drops in May, 2008, the ILL has restabilized, both at the “primary feature” and also the latent “new feature”. If the tank was re-leaking, then the ILL should continue to drop. When the “new feature” is tracked, the ILL behavior is consistent with the LOW installation water re-distributing through the waste.
- Waste material is solid at ground temperature, so if it did leak from the tank, it probably would try to self-seal.
- The [July 7, 2008] video shows a large cavity around the Riser 7A LOW, and a noticeable change in material appearance from white and luminescent to dark and dull. There is a significant narrowing of the cavity. If this is sludge material, then the permeability would be low, and not much liquid waste could be moving through it.
- Most of the historical gross gamma peaks 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 tank SX-104. Spectral gammas measured in 1995, 1998, and 2008 showed no changes in baseline, consistent with earlier gross gammas.

Summary:

The consensus of the assessment team is that tank SX-104 is not actively leaking. The most likely explanation for the observed behavior of the ILL is that the water used to install the tank SX-104 Liquid Observation Well created an artificially high liquid level near the Liquid Observation Well and obscured the true interstitial liquid level feature.

When the correct interstitial liquid level feature is monitored the data show a stable liquid level and no indication of a leak.

9.0 CONCLUSIONS

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

There was consensus among the members of the assessment team that the available in-tank and ex-tank data indicated that the no-leak hypothesis was more consistent with the data, and that the tank is not actively leaking at this time. The restabilization of the ILL, the consistency between the behavior of the new feature ILL and expected behavior, and the stable baseline readings in the drywells reduce the estimated active leak probability to about 0.14 (about one chance in seven) that the observed in-tank and ex-tank data would be present if the tank were leaking.

The most likely cause of the ILL decrease was the misidentification of the original ILL tracking feature as the true ILL. The team concluded that tank waste characteristics, including localized regions of impermeability in the sludge-saltcake mixture and the capability of the interstitial liquid to generate and release small amounts of gas, impeded the redistribution of the LOW installation water in the waste, and prevented the true ILL tracking feature from being identified. When the correct, latent, feature was identified and tracked, the data showed a stable ILL and no indication of a new leak.

The recommendation of the assessment team is 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.

The results of this assessment were presented to the Executive Safety Review Board on July 31, 2008. The Board concurred with the recommendations of the assessment team.

10.0 REFERENCES

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APPENDIX A
TANK SX-104 LEAK ASSESSMENT TEAM MEETINGS #1 – #7 MEETING MINUTES

A1 INTRODUCTION

The minutes from the Leak Assessment Team meetings were prepared as a cumulative set of minutes that were incremented each week in order to maintain the records of the most recent and all previous meetings as a single record.

MEETING MINUTES

SUBJECT: 241-SX-104 Leak Assessment Meetings #1 - #7				
TO: Distribution	BUILDING: 2750-E/B-225			
FROM: DJ Washenfelder	CHAIRMAN: Same			
DEPARTMENT-OPERATION-COMPONENT Process Analysis/Technical Integration	AREA 200-E	SHIFT	DATE OF MEETING 05/27/2008 - 07/09/2008	NUMBER ATTENDING

Distribution:
DG Baide*
DA Barnes*
JW Ficklin*
JG Field*
MA Fish*
PC Miller
RN Ni
RG Quirk
WB Scott
RP Tucker

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*Leak Assessment Team Members
Attendees

Discussion from July 9th Meeting

- The July 8th ILL reading showed no change from the previous week's reading for both the original feature used to track the ILL and the new feature. The weekly LOW scans should be continued until the team reviews the outcome of the assessment with the Executive Safety Review Board.
- The review and categorization of the ILL selection method for the 77 SSTs containing an LOW and group into categories based on whether the major interface feature or a secondary feature is being tracked has been drafted; following review by the team it will be published as an RPP document.

- The July 7th in-tank video shows significant subsidence of the waste surface occurred as the tank was interim stabilized, with the waste higher on the tank wall, then fracturing and dropping in the direction of the saltwell screen. The Riser 7A LOW is sitting inside an excavated cavity of uncertain depth. The bottom of the cavity appears to have once been liquid that has solidified to a greenish yellow surface.
- There is no evidence of the black asphalt membrane seeping out from behind the liner where it is exposed above the waste surface; nor evidence of dome concrete spalling or recurring surface patterns suggesting concrete or rebar degradation has occurred.
- The difference between the waste surface level and the ILL for the three periods covered by leak assessments was reviewed and reconciled: 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 – present period currently being reviewed and after an additional 115.1 kgal had been pumped from the tank during interim stabilization.
- 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 was 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. The following table shows the differences.

Event	Evaluation Period	Waste Surface Average Level (SL)	Interstitial Average Liquid Level (ILL)	△ Between SL and ILL	Probable Waste Behavior
1988 Leak Investigation	April, 1985 – April, 1988	277.9”	256.176”	-21.7”	Probably a floating crust over the top of a liquid/slurry layer. The interface between the crust and the liquid/slurry would be reported as the ILL even though it does not correspond to the classic ILL concept of liquid within the pores of a mostly solid waste matrix.
May – Aug, 1988 99.9 kgal removed via Submersible Pumping					
1998 Level Anomaly Investigation	February, 1997 – February 1998	219.55” SL △ = ~ 58.3”	214.896” ILL △ = ~ 41.3”	-4.7”	Liquid/slurry layer underlying the floating crust mostly removed from the tank during submersible pumping; ILL △ is equivalent to ~88% porosity for the liquid/slurry layer based on the 99.9 kgal removal.

Event	Evaluation Period	Waste Surface Average Level (SL)	Interstitial Average Liquid Level (ILL)	△ Between SL and ILL	Probable Waste Behavior
Sep, 1997 – Jul, 1999 115.1 kgal removed via Jet Pumping					
2008 Leak Assessment	January, 2008 – July, 2008	165.88” SL △ = ~ 53.7”	89.031” ILL △ = ~ 125.9”	-76.8”	The original floating crust probably settled onto underlying solid, mostly compacted, waste as a result of the 1988 submersible pumping. The underlying waste continued to settle as the liquid was withdrawn from the waste pores during interim stabilization. ILL △ is equivalent to ~33% porosity during interim stabilization activity, based on the 115.1 kgal removal. Calculated porosity reported on the SX-104 stabilization form was 34% (HNF-SD-RE-TI-178 p. 254)

- Panel Elicitations will begin next week.

Discussion from July 2nd Meeting

- The Monday, June 30th ILL reading showed no change from the previous week’s reading, consistent with the stabilization that has been observed for several weeks. Both the original feature used to track the ILL, and the new feature exhibit similar stabilization patterns that are consistent with each other.
- The recent LOW scans suggest that some there some waste may be refilling the bottom 1 – 2’ of the cavity excavated by the water lance to insert the new LOW in December, 2006.
- The explanatory diagram and linkage to the first LOW scan, December 7, 2006, and the latest LOW scan, June 30, 2008, (June 18th Action 1) was presented. It was speculated that the water lance progress may have been impeded as it passed through the last of the saltcake and tried to enter the sludge layer, possibly creating a cavity that influenced the shape of the two γ scans. An effort will be made to locate and review the work package for any indications that this occurred.
- A suggestion to review the LOW scans in other Assumed Leakers containing similar waste for similar ILL behavior was considered. It is possible that saltwell pumping would also mimic a “leak” for purposes of examining the ILL behavior. This purposeful removal activity, with its known durations and removal volumes, would yield more meaningful results since all of the tank waste inventory was affected by saltwell pumping. Small leaks located distant from the LOW might have almost influence on the ILL behavior. The current 77 tank LOW review to identify other SSTs monitored using a latent secondary feature similar to SX-104 should partially answer.

- The in-tank video preparation is scheduled for July 7th barring unfavorable weather or outside temperatures. This is the last required information for the leak assessment.

Discussion from June 25th Meeting

- The Leaker and Non-Leaker Hypotheses were emailed for review during the week:

Leaker Hypothesis:

"A leak from tank 241-SX-104 caused the decrease in the interstitial liquid level calculated from neutron monitoring scans in the Riser 7A Liquid Observation Well."

Non-Leaker Hypothesis:

"Water used to install the tank 241-SX-104 Liquid Observation Well created an artificially high liquid level near the Liquid Observation Well and obscured the true interstitial liquid level feature. When the correct feature is monitored the data show a stable liquid level and no indication of a leak."

- JA Hedges, Ecology, will be briefed on SX-104 leak investigation status by LJ Cusack on June 25th.
- The June 24th LOW scan shows no decrease in ILL using the original feature, and a - 0.27" decrease using the secondary feature. LOW scans will continue on a weekly frequency until the ESRB meets to review the leak assessment team's SX-104 recommendation.
- RP Tucker will see whether the in-tank video schedule can be brought forward to this week. DA Barnes will be in field for the video. Areas of concentration include the Riser 7A LOW – Waste Surface interface looking for lance water effects; the saltwell screen – Waste Surface interface and the tank waste surface looking for subsidence or feature changes since the 1999 video; the exposed liner and liner – Waste Surface interface appearances for suggestions of corrosion or evidence of asphalt mastic leakage behind the liner; the concrete wall and dome for discoloration, deterioration, or surface patterning suggesting rebar corrosion; and the riser – concrete dome interface for deterioration or concrete spalling. The video will be needed and have to be reviewed before presenting the leak assessment to the ESRB.
- JG Field will locate and provide information on the performance of the drywell soil moisture neutron detectors to confirm their detection radius, believed to be about 16" – 18" in soil. The LOW ILL neutron detector capability is believed to be similar in the tank waste.

Discussion from June 18th Meeting:

The ILL feature used for monitoring of the 77 SSTs with installed LOWs was reviewed to determine whether the major interface feature or a secondary feature is being tracked; how the tracked feature was confirmed to be representative of the ILL, such as by showing movement during stabilization; and whether or not the feature selection should be reviewed based on the SX-104 experience. About a dozen tank ILL's are monitored using a secondary feature similar to that present in SX-104. Four tanks require feature selection review. The evaluation will be documented in an internal memo and entered into IDMS to ensure later retrievability as a reference.

Gamma scans were taken June 10th and 17th. They show an interface very close to the ILL interface calculated from the ILL secondary feature (June 10th ILL 73.284", γ 72.384"; June 17th ILL 73.440", γ 72.036"). No further γ scans are planned unless the ILL begins decreasing again.

Discussion of the non-leak hypothesis has reduced the possible explanations for the ILL decrease to the likelihood that the wrong feature was being monitored after the LOW was installed in Riser 7A. Simplified gas release calculations and additional study of the Riser 7A ILL history show that a second candidate hypothesis – that retained gas in the waste was released allowing the interstitial liquid to flow into the empty interstices – is probably not as viable an explanation for the observed behavior.

Discussion from June 11th Meeting:

The ILL based on the secondary tracking feature in the LOW scan has been showing about a ± 1-inch oscillation between weekly readings that is not present in the ILL based on the major – original – tracking feature. This is believed result from switching the neutron detector electronics to a coarser resolution once the probe has been lowered past the major feature. The interim manual calculation method used for the secondary tracking feature may also be a contribution. The June 10th neutron scan employed the same resolution for both features and the oscillations appear to have stopped or be drastically reduced. The last ILL reading is 88.76" up from the prior week's 88.62" at the original tracking feature.

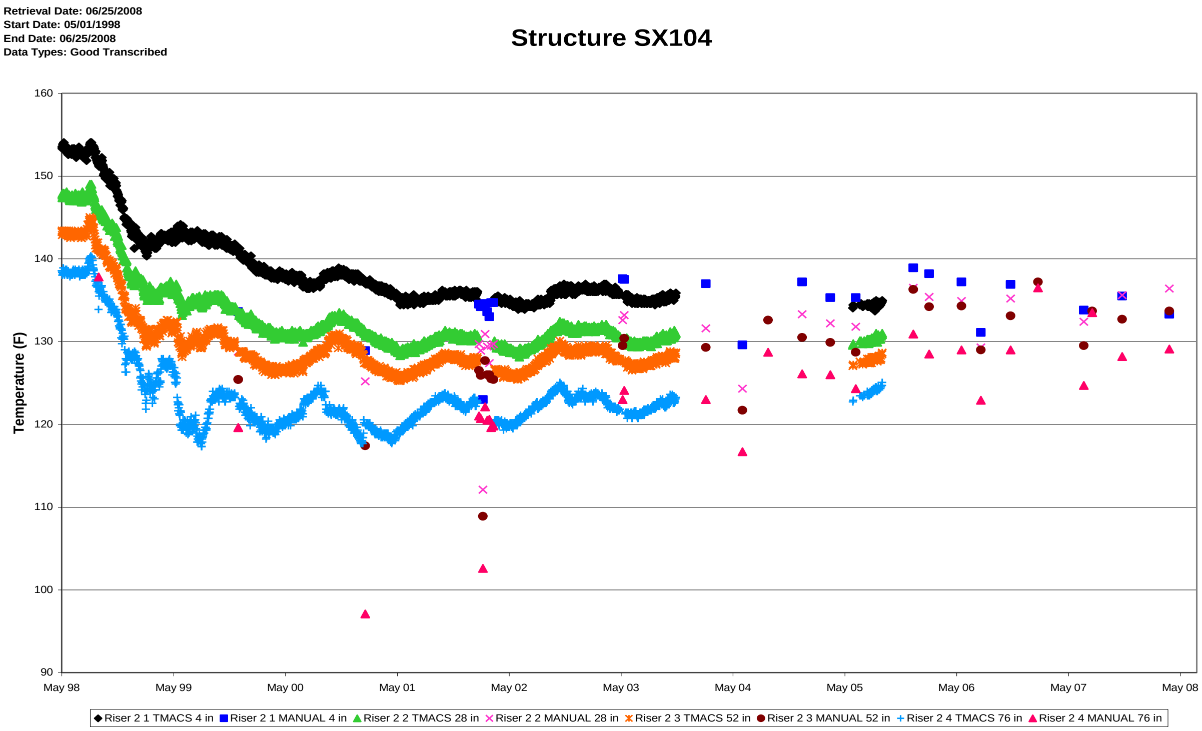
The June 10th LOW scan was completed with both neutron and gamma probes. The gamma probe shows a sharp break about 1" below the ILL calculated from the neutron scan secondary feature, lending credence to the feature's potential use as the new ILL reference tracking feature. Gamma scans will be run with the next two LOW weekly scans.

Tracking the ILL based on both the original feature and the secondary feature will be continued until the results of the re-leak assessment are presented to the ESRB. If ILL tracking is permanently switched to the secondary feature, then a change in the SX-104 interstitial liquid inventory will have to be considered for HNF-EP-0182 *Waste Tank Summary Report for Month Ending ...* and the Best Basis Inventory since both use the reported volume at the time interim stabilization was declared complete.

Considering the possible SX-104 ILL tracking feature change, the ILL tracking feature used for each of the SSTs containing an LOW will be reviewed, and the tanks grouped into categories based on whether the major interface feature or a secondary feature is being tracked; how the tracked feature was confirmed to be representative of the ILL, such as by showing movement during stabilization; and whether or not the feature selection should be further reviewed based on the SX-104 experience.

SX Tank Farm and SX-104 Characteristics and Operating History:

The 241-SX Tank Farm is the third generation of farms at Hanford and was built to contain self-boiling waste from the REDOX facility. The SX tanks were constructed between 1953 and 1954 and are located in the central part of the 200 West Area. There are 15 single-shell tanks in the SX Farm, each with a 1,000,000 gallon (gal) capacity. They are 75 ft in diameter, approximately 44.5 ft tall with a domed top, and have been covered with about 7 ft of overburden. The base of the original construction excavation and corresponding base of the tanks is about 52 ft in depth. Ten of the 15, including SX-104, have been declared “assumed leakers”.



Tank SX-104 is the first tank in a cascade series of three tanks including 241-SX-105 and 241-SX-106. The tank entered service in the first quarter of 1955. Tank 241-SX-104 received Reduction Oxidation (REDOX) waste from the first quarter of 1955 until the third quarter of 1971. The tank received REDOX evaporator bottoms from SX-105 (received into SX-105 in 1967 – 1969) and REDOX ion exchange waste (post-B Plant cesium removal) from SX-105 in the third quarter of 1971 until the second quarter of 1975. From the third quarter of 1975 until the second quarter of 1976, tank 241-SX-104 received evaporator bottoms and recycle wastes from the 242-S Evaporator. The tank received concentrated evaporator feed and residual evaporation liquid during the third quarter of 1976 until the third quarter of 1977. During the fourth quarter of 1977, the tank received partial neutralized feed waste. In the first quarter of 1980, the content of the tank was classified as double-shell slurry feed.

Saltwell pumping began on September 26, 1997; 757 L (200 gal) were pumped in September before the transfer line between 241-SX-104 and 244-S became plugged. Pumping was 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 to 241-SY-102. Pumping was interrupted and resumed on March 23, 1998, and again interrupted.

Saltwell pumping was 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 436 kL (115 kgal) of liquid waste was transferred to 241-SY-102 before failure occurred. Waste volume calculations show 182 kL (48 kgal) of drainable interstitial liquid remaining in the tank, of which approximately 167 kL (44 kgal) is estimated to be pumpable. On April 26, 2000, tank 241-SX-104 was declared interim stabilized (Tank Interpretive Report for SX-104).

Tank waste temperature is about 130^{o}F, or 54^{o}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^{o}C, and was complete at 22^{o}C (8C510-PC98-024).

Additional Information:

1988 Leak Assessment:

Environmental Protection Deviation Report 88-03 issued February 19, 1988 to document the ILL decrease exceeding the -0.3' decrease criterion with the gamma probe. The neutron probe was noted to be stable.

Unusual Occurrence Report WHC-UO-88-024-TF-03 dated August 30, 1988 indicates that 99,900 gallons were pumped from the tank between May18, 1988 and August 16, 1988; and that the tank was declared an "Assumed Leaker" on July 13, 1988 (see 113331-88-416 *Engineering Investigation: Interstitial Liquid Level Decrease in Tank 241-SX-104*, July, 1988 [D193015350]. The report 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 [D193015352].

Environmental Protection Deviation Report 88-03 indicates that the decrease criterion was confirmed with the gamma probe, and that the neutron probe remained stable. However, the UOR indicates that the ILL decrease was verified with the Gamma, Neutron, and Acoustic probes. It does not say whether or not the neutron and acoustic probes confirmed that the -0.3’ decrease criterion had been exceeded however.

In-Tank – 1998 Re-Leak Assessment:

In 1998 the tank was suspected of re-leaking due to observed variations in ILL of up to 6”. 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)

Retained Gas:

The 1998 re-leak assessment noted a high correlation between changes in barometric pressure and changes in the ILL, and accounted for the apparently 1,000 gallon waste loss "... by a combination of reduced porosity and increased capillary pressure. There is also some evidence that the ventilation rate may have been increased..." (LMHC-9851233A R3/HNF-2617). Current leak assessment discussions have considered the possibility of mini-gas release events (GRE's) contributing to temporary changes in the ILL.

PNNL studied the gas retention and release in the SSTs, and concluded the that the only mechanism capable of producing large spontaneous gas releases was buoyant displacement, which occurs in tanks with a deep supernatant layer. The report concluded that SSTs were only capable of small releases of a few cubic meters, based on theory and laboratory and field observations; and since gas bubbles can only cling to submerged solids, gas is usually only released when the volume of waste is disturbed. The report also prioritized the SSTs by flammable gas potential based on dL/dP (cm/kPa) barometric pressure surface level response; extent of post-transfer surface level rise; and tank headspace gas concentrations. Table A.1. *SST Prioritization Data* estimated the SX-104 dL/dP as ~ + 0.0001 in/in Hg. The positive number indicates that there is no waste surface correlation with barometric pressure. Table 3.1 *Void Fraction Estimates* shows that SX-104 consistently ranked as one of the least responsive tanks to changes in barometric pressure affecting the surface level. Similar results were obtained when level rise was considered. The relationship between waste surface level and ILL changes was not discussed (PNNL-11391).

In March, 1995 a Standard Hydrogen Monitoring System consisting of High- and Low-range Whittaker™ cells for H_2, and a grab sample station was installed on SX-104. During saltwell pumping, SX-104 showed no evidence of spontaneous gas release of significant amounts of flammable gas – one of only four SSTs on the watch list to do so. Comparison between SX-104 and the other watch list SSTs show that it consistently ranked at or near the bottom for all comparisons of generation or release of gas (RPP-7249). In December, 1999 the contractor recommended that the SX-104 SHMS be removed from service since the tank had "... minimal gas release activity, and/or ... active ventilation, ..." (LMHC-9958931).

The gas generation rate, retained gas volume, and spontaneous and induced gas release histories for SX-104 are discussed in RPP-7249. The 2001 report notes that, "... all of the spontaneous gas releases observed since monitoring was installed in 1995 have all been less than 3 m^3 (100 scf) of hydrogen and occur over many hours to days..." for the Flammable Gas Watch List SSTs. None of the 19 SSTs on the watch list exhibited significant releases, and the steady-state gas release rate was insignificant (RPP-7249). Table 6-2 *Barometric Pressure Effect Gas Volume Estimates in Single-Shell Tanks* notes that there is "No apparent dL/dP correlation" for SX-104. Only one other tank in the 24-tank list is similarly labeled. Table 6-3 *Average Gas Fraction and*

Gas Volume Estimates from Neutron Logs estimates a 7.9% gas fraction below the ILL, with a best-estimate standard gas volume of 250 ± 125 m^3 for SX-104.

In 2004 PNNL provided an estimate of the surface dL/dP (inch/inch Hg) values for SX-104 for a four-month period between January 1, 1997 and January 20, 1999. The estimated dL/dP was -0.056 ± 0.055 in/in Hg, supporting earlier conclusions that there is no, or almost no, correlation between surface level changes and dP change. This is consistent with the PNNL-11391 +0.0001 in/in Hg within the limits of error. ILL response to barometric pressure is not discussed (RPP-15488).

Maximum Gas Release Equivalent to Observed SX-104 ILL Decrease

The ILL drop from 91.272” to 88.512” between January 10, 2008 and May 12, 2008, the date of the lowest measured ILL, may have resulted from release of retained gas. The volume would have been ~12 m^3 assuming the release involve the entire 2.76” waste layer. It is more likely that only a fraction of the waste layer was involved in the release. This would be consistent with the RPP-7249 observations that the SST observed gas releases were in the range of <3m^3.

The SX-104 assumptions and calculations are presented below:

Surface level on May 31, 2008	165.82”	
ILL on January 10, 2008	91.272”	
ILL on May 12, 2008	88.512”	
Waste Porosity	34%	(HNF-SD-RE-TI-178 Stabilization Evaluation Form)
Waste Bulk Density	1.50	(WMH-9856353 1998 Sample Results)

Equivalent psia of 165.82”overhead waste acting on 91.272” ILL level:

Equivalent psia = [(165.82” – 91.272”)(1.50)]/ (27.679 “ H_2O/psia)
Equivalent psia = 4.04 psia

m3 gas release = [(14.7 psia + 4.04 psia)/14.7 psia][(91.272” – 88.512”)(2750 gal/in)(0.34)/(264.17 gal/m^3)
m3 gas release = ~12 m^3

In-Tank – 1988 and 1997/1998 Sample Comparison:

The May, 1988 samples gelled at laboratory temperature. The sample results show a [PO_4] of 0.1M ± 20%, and a [P] = 0.15M (12221-PCL88-147). The waste would have been at a higher temperature in 1988 due to higher radionuclide thermal decay, which could account for the higher supernatant [P] in the waste in the 1988 samples. As the waste cooled, the saturation boundary shifted, accounting for the lower [P] in the 1998 supernatant, and a higher [P] in the sludge. RPP-23600 indicates that the 1988 supernatant phosphorus concentration should have been soluble at laboratory temperature. Something else must account for the observed gelling.

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. The following table compares the 1988 and 1998 sample [Al], [Na], and [OH^-]:

Sample	**Al M**	**Na M**	**OH M**
1988 Top Water Leach	1.488	14.54	2.1
1988 Bottom Water Leach	1.5094	15.854	2.1111
1998 Supernatant	1.527	10.13	2.306

Evaluation by Dan Herting suggests that the observed solids formation was probably $NaNO_2$ and $NaNO_3$ both crystallizing.

The tank was also grab sampled in April 1997, and again in June 1998. Results from the April 1997 sampling event were used to assure chemical compatibility of the waste with materials that might come in contact with 241-SX-104 liquids pumped during saltwell pumping activities, and to address flammable gas concentrations in the tanks headspace.

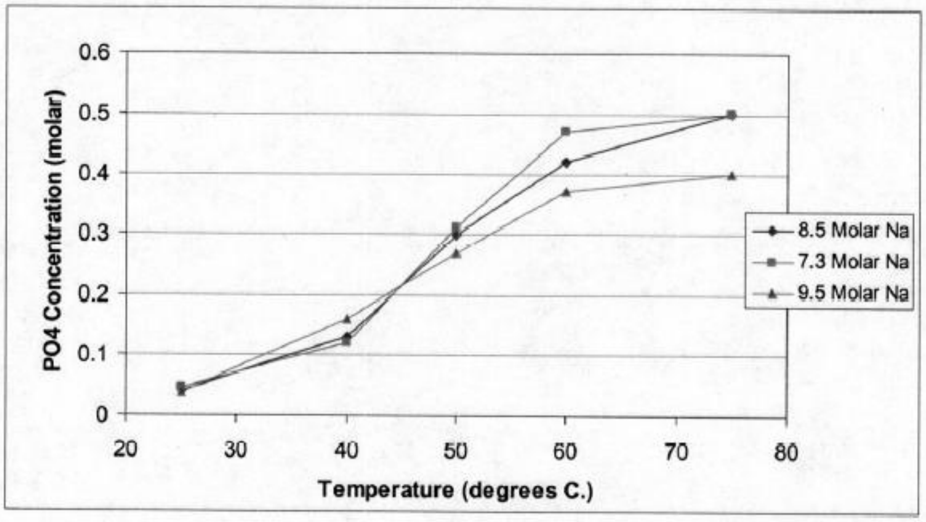
Three grab samples were taken in June, 1998 for dilution studies and inorganic analysis. The purpose of these samples is variously described as either supporting the re-leak assessment, or establishing water dilution requirements for saltwell pumping to reduce the risk of a plugged transfer line. The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

The current 88.7” ILL is bracketed by thermocouple #5, about 11” above the ILL, and thermocouple #4, 13” below. The last recorded TMACS readings for these thermocouples were 105.3°F (41°C) on April 30, 2002; and 125.1°F (52°C) on September 2, 2005 (Data Date – May 29, 2008). There is no evidence that at the 1998 sample Na and P supernatant concentrations and waste temperatures that phosphate gelling would be a problem (see RPP-23600 Figure 13 *Phosphate Solubility as a Function of Temperature for Typical Hanford Site Tank Waste*).

The analytical results for sludge portion of the 1998 sample show that at the measured bulk density of 1.50 g/ml, and phosphorus = 6.75e+03 ug/g, the [P] = ~ 0.32 M. Since the [P] in the supernatant and sludge are in equilibrium, the 0.0255M supernatant concentration probably represents the saturated boundary at the observed waste temperature. There is no mention in the 1998 WMH-9856353 report that gelling was observed in the laboratory.

RPP-23600 Rev. 0

Figure 13. Phosphate Solubility as a Function of Temperature for Typical Hanford Site Tank Waste.[7]



However, dilution and cooling tests were performed on the undiluted supernatant liquid from the 1998 samples. 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).

The supernatant composition of the 1998 sample shows remarkable similarities to the old, burping SY-101 supernatant. The following table compares SX-104 and the SY-101 "Window E" supernatants (WHC-SD-WM-DTR-0126):

Analyte	SX-104 1998 Supernatant M	SY-101 Window E Supernatant M
OH^-	2.306	2.44
Al	1.527	1.82
Na	10.13	12.26
NO_2^-	2.93	3.53
NO_3^-	2.84	2.51
Cl^-	0.28	0.27
K^+	0.09	0.15
P	0.026	0.055
SpG	1.46	1.51
% H_20	50	42
A:C Ratio	0.67	0.75

If the SX-104 supernatant was concentrated by ~ 10%, the analyte concentrations would almost exactly match the SY-101 composition, including % H_20 and SpG.

Total organic carbon is a common source of gas production in the waste tanks. The TOC in the 1988 sample was 5 – 13.3 g/l TOC; in the 1997 sample centrifuged solids 1.8 g/l, and in the 1997 sample sludge interstitial liquid 2.2 g/l. The TOC in SY-101 Window E samples prior to remediation was 14.6 g/l. If the gas generation rate was proportional to the TOC, then SY-101 had a significantly higher generation rate. However, based on the similarities of the wastes, it is likely that the gas retention properties of the slurries in SX-104 and SY-101 were similar.

The only slurry composition record recoverable from IDMS is for the 3rd PN campaign run between July 30, and October 19, 1980 (RH0-CD-1515). The TOC analysis of the slurry was 18.6 g/l (RHO-CD-1515 Table 5. *Product Composition*). Although 104-SX was not a bottoms receiver for the 3rd PN campaign, the TOC was probably typical. The decrease between 1980, the 1988, and the 1997 samples may be the result of slow decomposition, although such a high decomposition rate seems inconsistent with the reported SHMS and GRE data for the tank.

SX-104 – SY-101 Waste Genesis Comparison

The SX-104 saltcake originated from the self-concentration of REDOX waste in the tank, and from 242-S Evaporator Crystallizer operation, including partial neutralization (PN) waste in 1977 according to the Tank Interpretive Report. The source of SX-104 waste is important because SX-104 waste was probably feed for the 1st 242-S Evaporator Crystallizer Double-Shell Slurry (DSS) process test. The DSS was slurried to SY-101 and SY-103. In SY-101 the propensity for the DSS to trap gas caused the waste volume to increase dramatically, eventually requiring the installation of a mixer pump, water dilution, and eventual waste removal to contain the waste within the allowable storage volume. The propensity of the DSS to trap gas may have been a latent characteristic carried over with the PN product that became the DSS campaign feed.

If this is the case, then SX-104 interstitial liquid could be exhibiting similar gas trapping behavior, accounting for some of the ILL behavior characteristics.

The March, 1975 *Nitric Acid Partial Neutralization Process Test* proposal indicates that 630 kgal of terminally-concentrated liquor was available for the test, to be conducted in three stages of progressive concentration. The process test ran for only 17 hours on June 23 and 24, 1975, before being terminated due to unknown concentrations of NO_x in the vessel vent system. The feed was SX-102 and SX-103 material; the PN slurry was sent to SX-105 (ARH-CD-240).

A second process test, the *Nitric Acid Partial Neutralization/Acid Injection Process Test*, using a modified acid injector design was run intermittently between November 14, and December 19, 1975 (ARH-CD-597). 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 SX-104; since no other slurry tanks are mentioned, it is likely the all of the PN/Acid Injection process test product was slurried to SX-104 ([D196226689]). Although the process test proposal called for sampling each of the three phases of the test, the analytical report only has two sample results. The samples are dated November 25, 1975, and December 19, 1975. Average PN supernatant concentrations are listed in the following table. When the average results of the pre-PN and post-PN samples were compared, there was no statistical difference at the 95% CL, with the exception of water content. The solids in the two samples were also analyzed

Analyte	**Average of PN/Acid Injection Process Test 11/25/75 & 12/19/75 Samples M**
$NaAlO_2$	1.77 (A:C = 0.78)
$NaNO_2$	2.72
$NaNO_3$	3.90
NaOH	2.27
Na_2CO_3	0.156
$\%H_2O$	57.1

The PN process test slurry into SX-104 was apparently transferred from the tank before the 2nd PN campaign, because the 60” of SX-104 terminal liquor was designated as feed ([D197248314]).

The TOC analysis of the slurry from the 3rd PN campaign was 18.6 g/l (RHO-CD-1515 Table 5 *Product Composition*). Although 104-SX was not a bottoms receiver for the 3rd PN campaign, the TOC was probably typical. The progressive decrease in the 1980, the 1988, and the 1997 TOC concentrations may be the result of organic decomposition, although such a high rate seems inconsistent with the reported SHMS and GRE data for the tank.

The PN waste for the DSS Process Test must have come from either the PN/Acid Injection process test, or the 1st or 2nd PN campaign since the 3rd PN Campaign between July 30, and

October 19, 1980, occurred about three years later than the Tank Interpretative Report claims waste was being received into SX-104. Also, the 3rd PN campaign report indicates that only tanks S-103, SX-106, and U-107 were slurry receivers, with S-103 being used as the accumulation tank for slurry tank supernatant and condensate returns to the SY-102 feed tank (65260-80-0829 [RHO-CD-1515 Appendix B]).

If the SX-104 material was feedstock for one of the 242-S double-shell slurry (DSS) campaigns, it must have
been used during the that DSS Process Test that occurred April 26 – 28, 1977 (RHO-CD-394). The process test used 365 kgal feed volume and produced 274 kgal of DSS that was slurried to SY-101. From April 29 to October 31, 1977 the slurry level in SY-101 increased 7% indicating retained gas was accumulating. Organic complexants were blamed for the growth and growth of future non-complexed DSS was discounted

The 2nd DSS campaign was not conducted until October 28, - November 8, 1980, well past the time that the PN product had been transferred from SX-104. Letters 65453-80-347 and 65260-80-1344 in the appendices of RHO-CD-1268 *Double-Shell Slurry Campaign*, indicates that the 3rd PN product was the feedstock for the 2nd DSS campaign.

The following table expands the previous table to include PN/Acid Injection Process Test product, the gas-producing SY-101 heel before the 2nd DSS campaign (RHO-CD-1268) and the SY-101 Window E Supernatant:

Analyte	**SX-104 1998 Interstitial Supernatant M**	**Average of PN/Acid Injection Process Test 11/25/75 & 12/19/75 Samples M**	**SY-101 Heel pre-2nd DSS Campaign M**	**SY-101 Window E Supernatant M**
OH^-	2.306	2.27	0.435	2.44
Al	1.527 (A:C = 0.66)	1.77 (A:C = 0.78)	0.174 (A:C = 0.40)	1.82 (A:C = 0.75)
Na	10.13			12.26
NO_2^-	2.93	2.72	0.659	3.53
NO_3^-	2.84	3.90	3.53	2.51
Cl^-	0.28			0.27
K^+	0.09			0.15
P	0.026		0.194	0.055
TOC g/l			6.48	14.6
SpG	1.46			1.50
% H_20	50	57.1	88.25	42

The SX-104 aluminum to caustic ratio (A:C) most closely resembles the SY-101 Window E supernatant. Plotting the OH^- and Al concentrations on the “Barney Diagram” shows that the SX-104 1998 Interstitial Supernatant and the SY-101 Window E Supernatant reside in the same sodium aluminate region, but not much else.

However, it is know that aluminate ion, created during the PN campaigns, catalyzes the thermal decomposition of organic complexants, which results in H_2 gas formation. The weight of the waste above the ILL – about 77 inches deep – may be squeezing the gas bubbles into the interstitial pockets normally occupied by liquid. Percolation to the surface can occur but the gas release is limited to small quantities (CNWRA 97-008 Sections 2.6.2 and 3.6). This behavior would be consistent with the PNNL observations on SX-104 retained gas – i.e., no dL/dP; and the SHMS data indicating little flammable gas was present in the headspace. Possibly the installation of the LOW creates an avenue for these entrapped bubbles to reach the surface, and the displaced interstitial liquid returns to the empty pores.

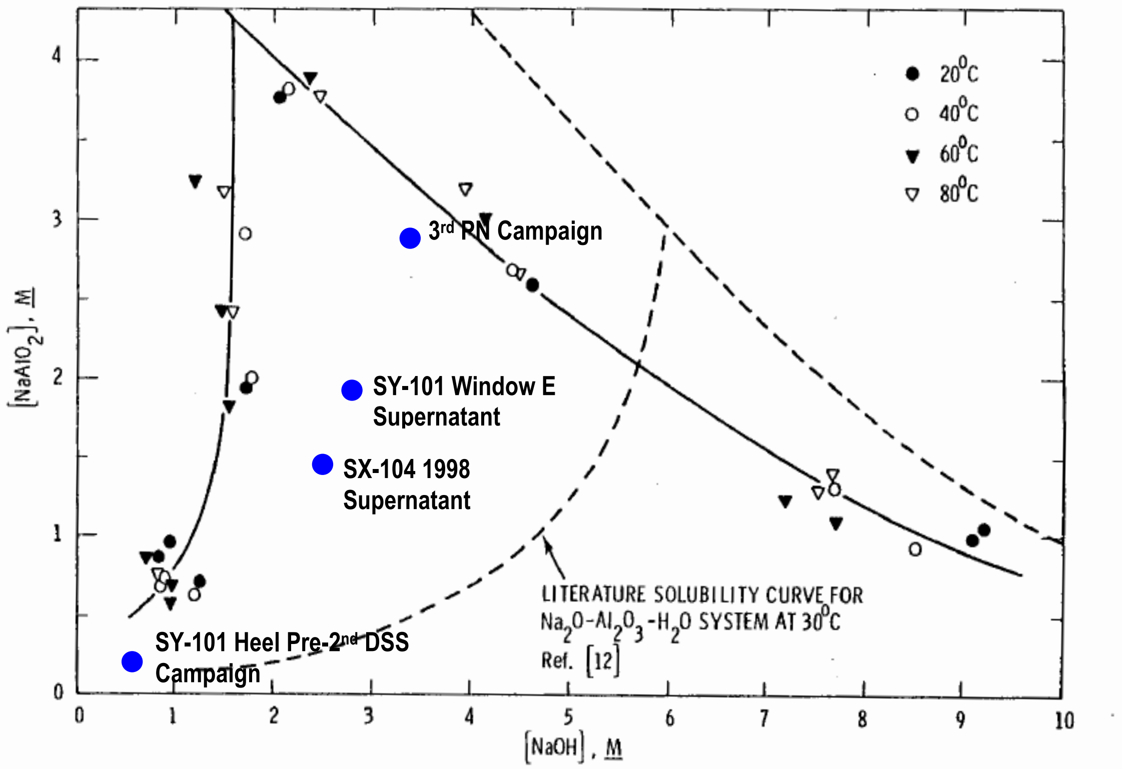


FIGURE 3

SOLUBILITY OF SODIUM ALUMINATE IN SYNTHETIC WASTE SOLUTIONS
(SATURATED WITH $NaNO_3$, $NaNO_2$, Na_2SO_4, AND Na_2CO_3)

from ARH-ST-133 Vapor-Liquid-Solid Phase Equilibria of Radioactive Sodium Wastes at Hanford

Ex-Tank:

Historical Gross Gamma Logs:

Historical gross gamma logs for the period 1975 – mid-1994 are compiled in 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. 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 Spectral Gamma Logging System has since supplanted the Gross Gamma system.

1995 and 1998 Spectral Gamma Scans:

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 strong evidence that the tank had ever leaked; and 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).

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. 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 (GJ-HAN-21).

The following table summarizes the 1975 – mid-1994 Gross Gamma logs and the 1995 Spectral Gamma logs for the SX-104 drywells, and the nearby drywells:

Drywell	Drywell Notes	Gross Gamma Logs 1975-1995	Spectral Gamma Logs 1995
41-04-01		No significant levels of gamma-ray contamination is present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 100 ft (2). 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 (1).	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 TD at concentrations above MDA but less than 1 pCi/g. A small zone of Cs-137 activity at 50 ft corresponds with the bottom of the tank. The K-40 plot shows an increase in concentration at 62 ft. This increase corresponds to the lithology change at this depth. There is an increase in the variation of the K-40 concentration from 85 ft to TD. In addition, increased U-238 and Th-232 concentrations were measured below 62 ft. These increases are also clearly the result of a change in the lithology. The combination plot for this borehole shows the radioactivity from Cs-137 dominates the total gamma log from 0 to 20 ft, but the K-40 signal is dominant below 20 ft. The slight increase in Cs-137 concentration at 50 ft is not apparent in the total gamma log (1).

Drywell	Drywell Notes	Gross Gamma Logs 1975-1995	Spectral Gamma Logs 1995
41-04-03		Stability of Cs-137 contamination at 21 ft. cannot be determined (2). The gross gamma log for this borehole shows only the 20-ft activity peak (1).	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. The K-40 plot shows an increase in concentration at 56 ft. U-238 decreases in concentration at about 76 ft (1).
41-04-05		No significant levels of gamma-ray contamination is present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 100 ft (2). The Tank Farms gross gamma log shows some poorly defined increased activity peaks in the upper 20 ft of the borehole (1).	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. The K-40 plot shows an increase in concentration at about 58 ft that is due to a change in lithology (1).

Drywell	Drywell Notes	Gross Gamma Logs 1975-1995	Spectral Gamma Logs 1995
41-04-07	The drilling records for this borehole indicate that the casing was perforated with a casing knifing tool from the surface to total depth (TD) with four cuts per inch 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 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 (1).	No significant levels of gamma-ray contamination is present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 100 ft (2). The Tank Farms gross gamma log shown in the combination plot and the older gross gamma logs did not show any contamination (1).	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 (1).
41-04-08	Drilled in 1978 in the adjacent clocked position to 41-04-07 (1). Possibly intended as a replacement due to contamination inside the 41-04-07 well casing extending from the surface to TD.	No significant levels of gamma-ray contamination is present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 123 ft (2).	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.

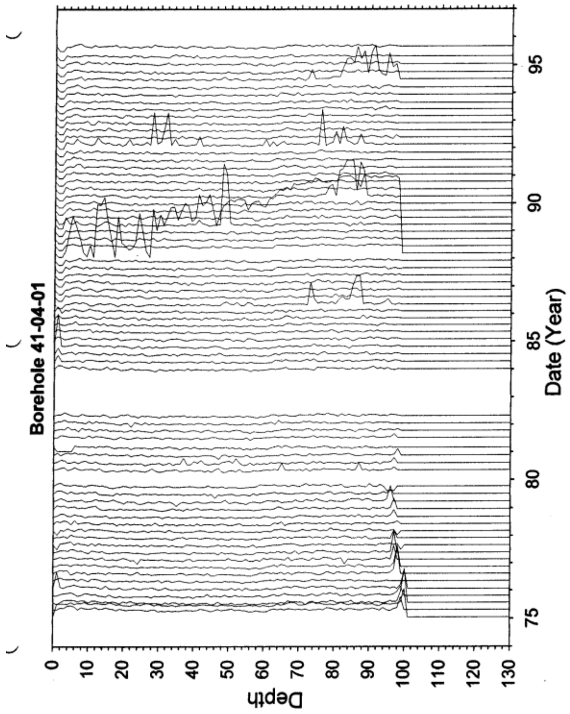
Drywell	Drywell Notes	Gross Gamma Logs 1975-1995	Spectral Gamma Logs 1995
41-04-11		Cs-137 and Eu-154 contamination from 2 – 10 ft. is stable over limited time scale Time decay of peaks is consistent with the isotopes' half-lives(2). The Tank Farms gross gamma log shows the surface contamination (1).	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 natural gamma logs show lithologic changes at 60 and 66 ft, consistent with the lithology changes of other boreholes surrounding this tank. 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 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 (1).

Drywell	Drywell Notes	Gross Gamma Logs 1975-1995	Spectral Gamma Logs 1995
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. Therefore, according to (1), the decision was made to not log this borehole with the SGLS. However, the Log Data Report included in (1) for this drywell indicates that it was logged in three log runs January 21 – 23, 1998.	No significant levels of gamma-ray contamination is present above gross gamma probe surveys' detection threshold between 1975 and 1993 in the vadose zone from 2 to 150 ft (2).	Not logged.
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 (2). The Tank Farms gross gamma log shows the surface contamination and a slight peak at 30 ft (1).	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. The K-40 plot shows an increase in concentration at 65 ft. This increase corresponds to the lithology. The lithology change is indicated by the increase of U-238 and Th-232 concentrations at 65 ft(1).

Drywell	Drywell Notes	Gross Gamma Logs 1975-1995	Spectral Gamma Logs 1995
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 (1).	No significant levels of gamma-ray contamination is present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 77 ft (2). 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 (1)	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. The K-40 plot shows an increase in concentration at about 65 ft, which is due to a lithologic change. The U-238 and Th-232 gamma-ray fluxes in this borehole are low due to the attenuation of the two casings. The concentrations of these isotopes are barely above minimum detection (1)

Table References

1. 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)
2. 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
3. SD-WM-TI-356 Rev. 0 *Waste Storage Tank Status and Leak Detection Criteria*, March, 1990 [D197006832, D197006846, D197006861, D197006868]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Date (Year)
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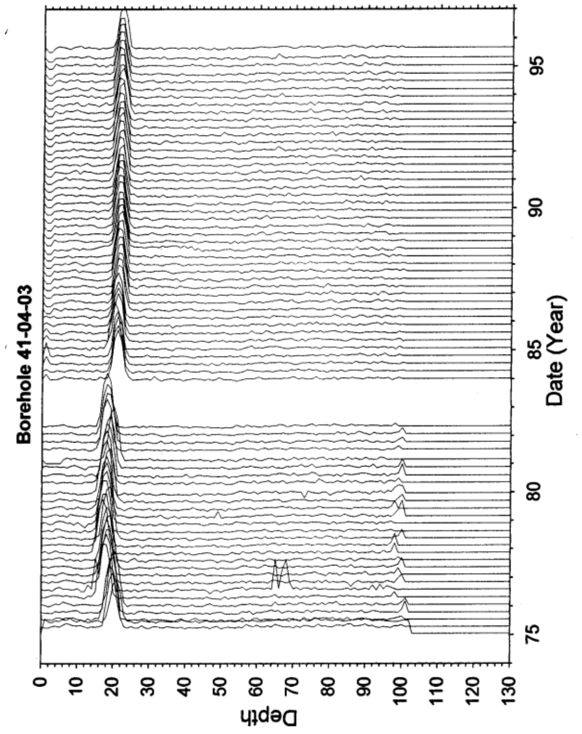
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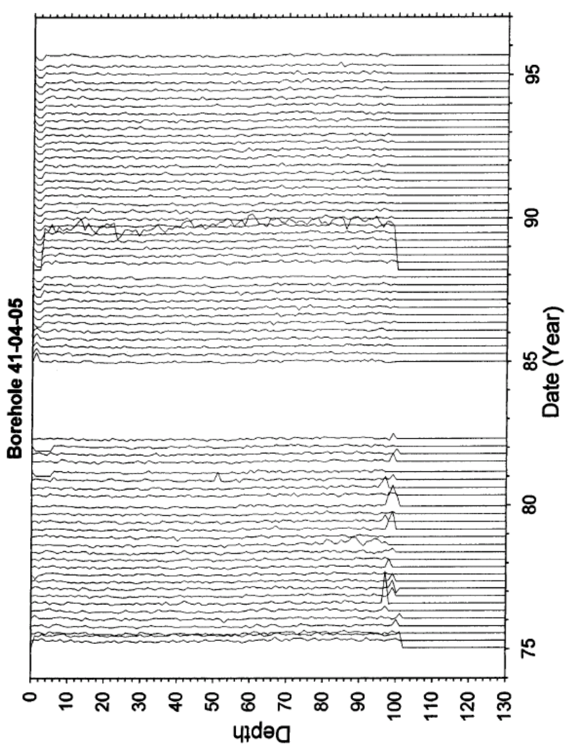
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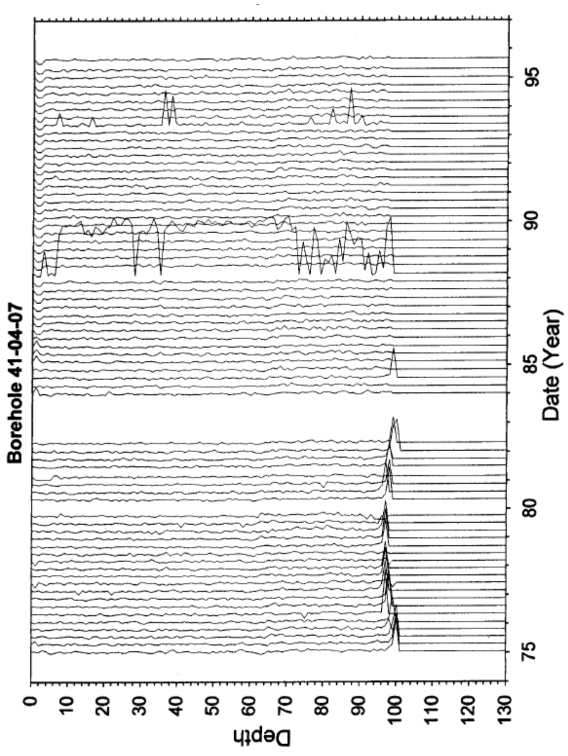
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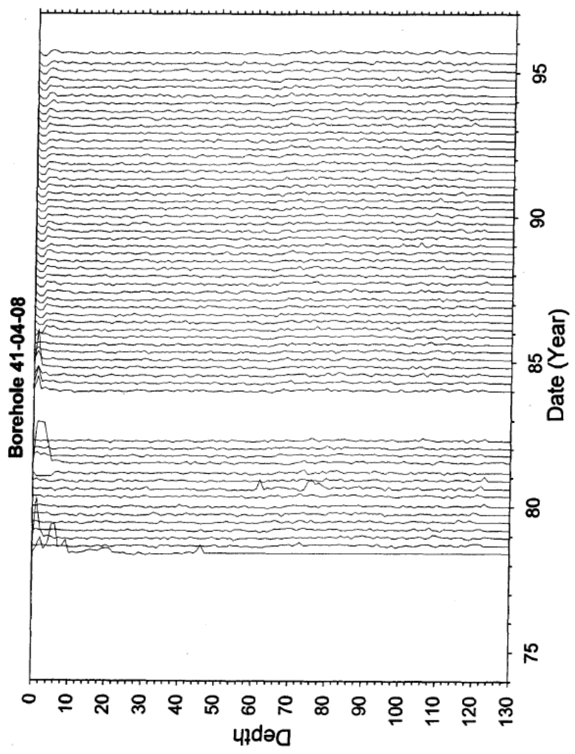
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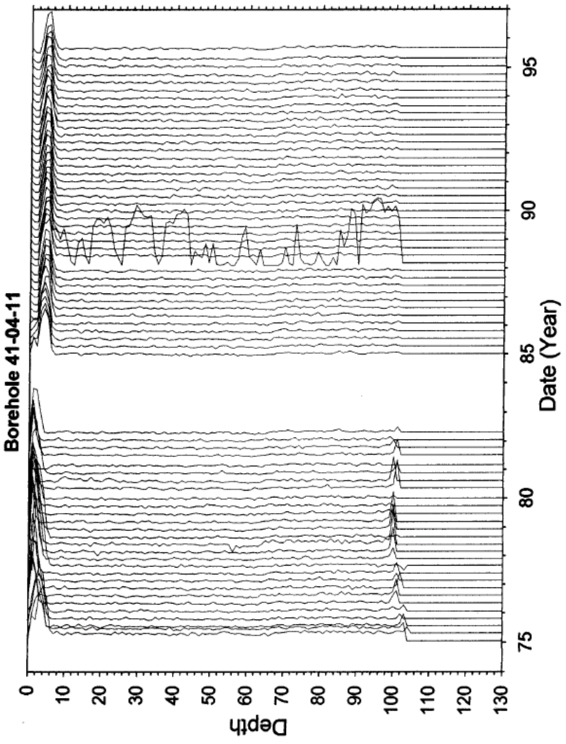
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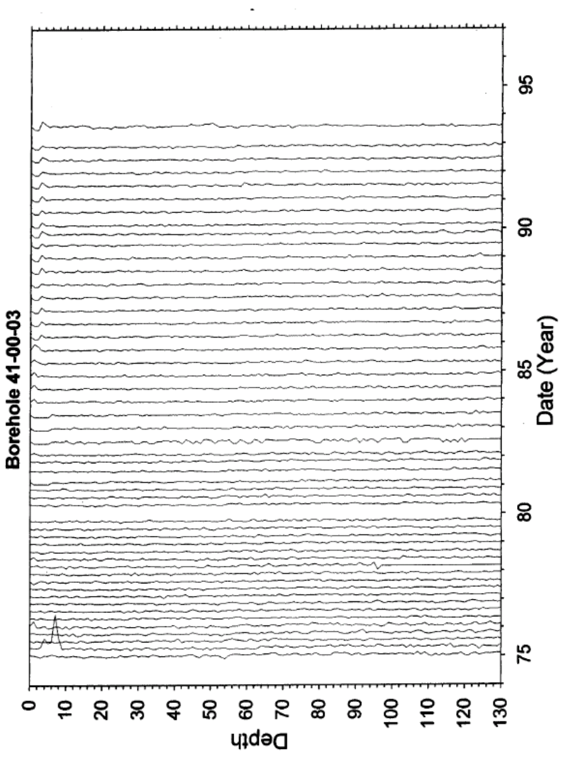
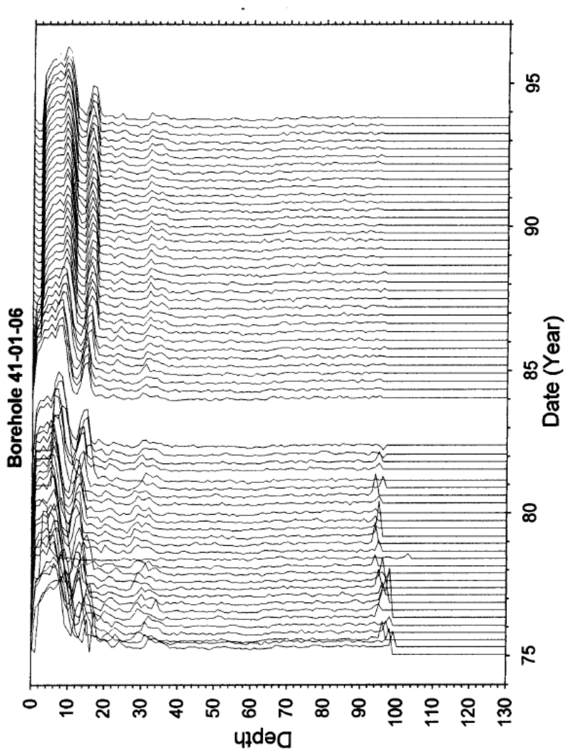
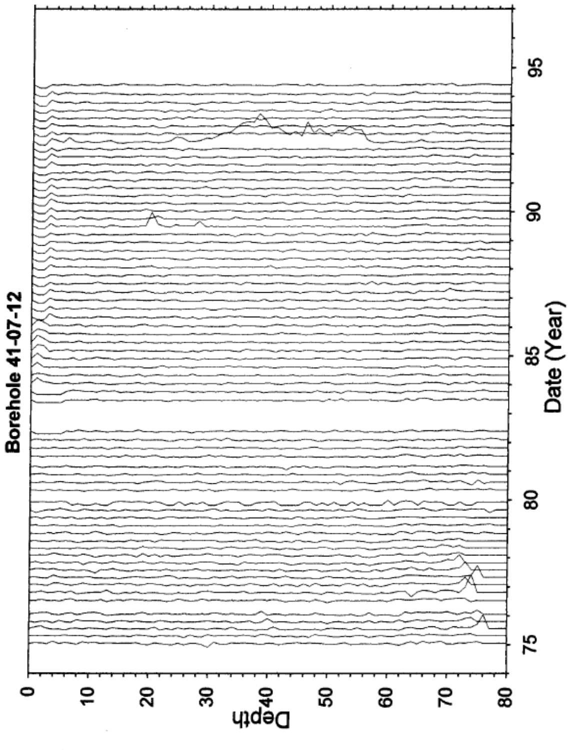
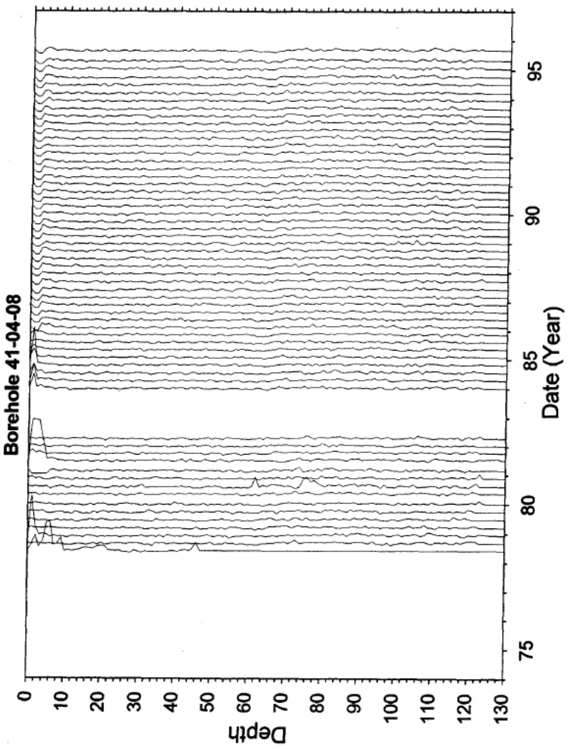






Gross Gamma Log Plots Reference

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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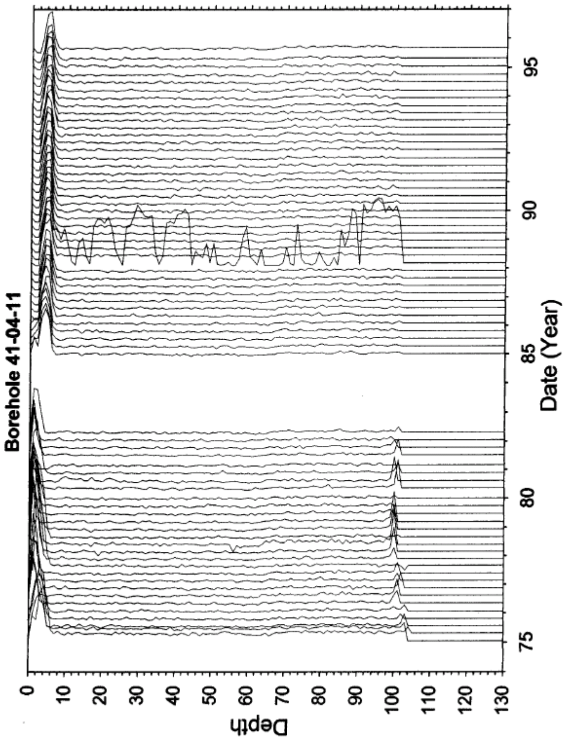
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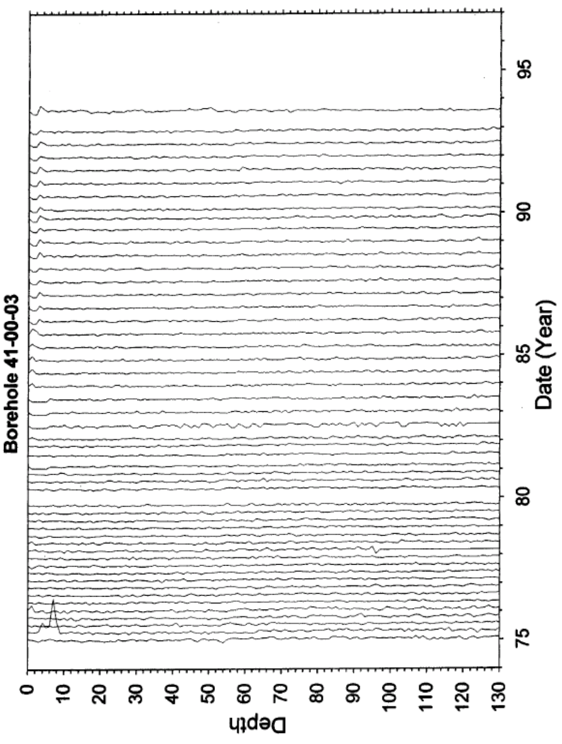
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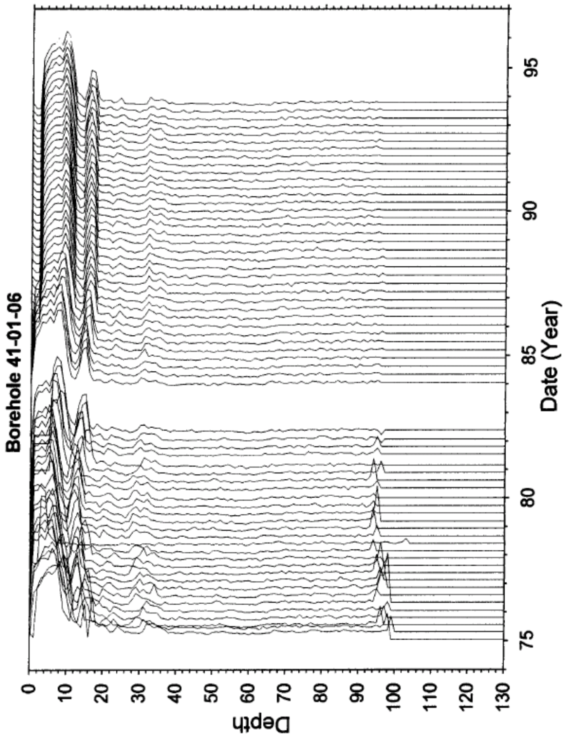
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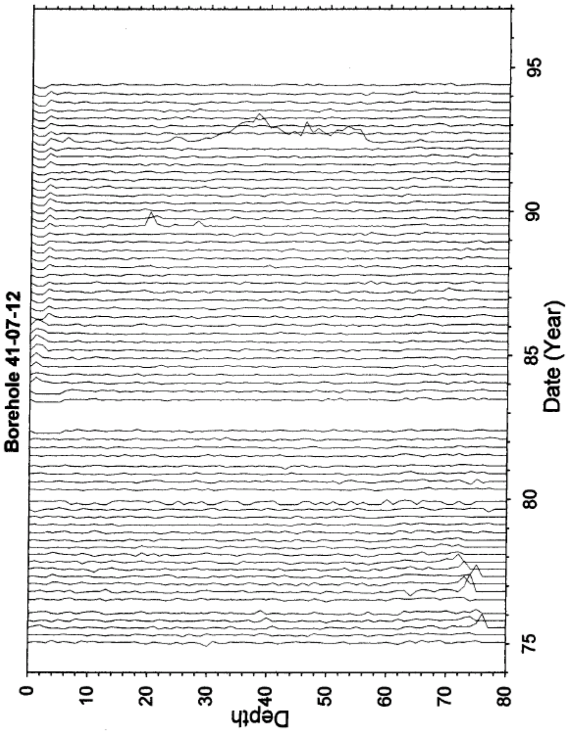


Gross Gamma Log Plots Reference

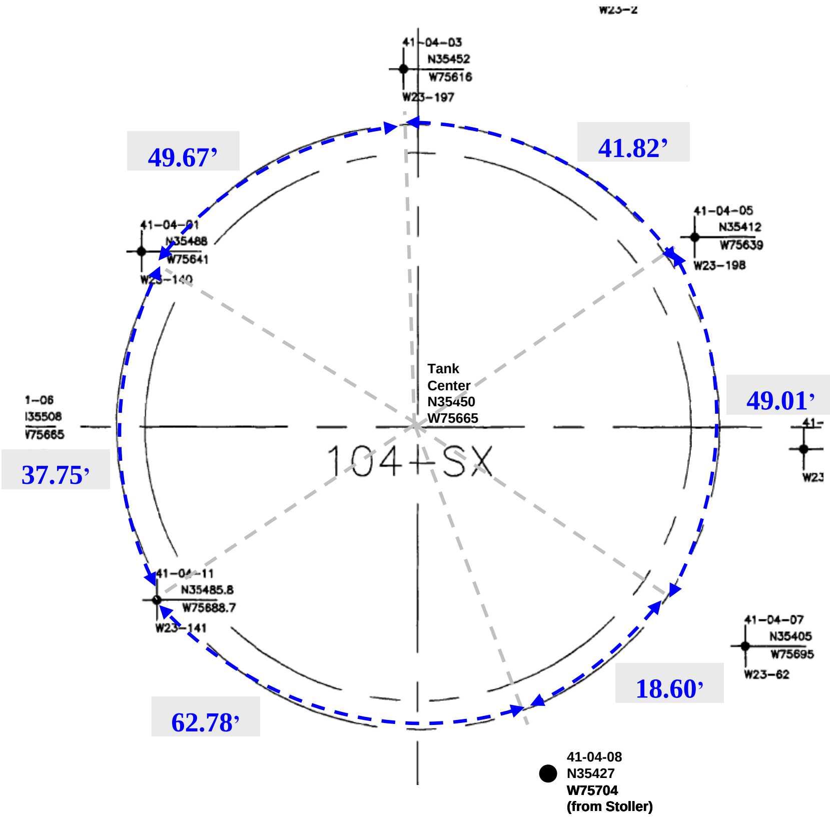
HNF-3136 Rev. 0 Analysis Techniques and Monitoring Results, 241-SX Drywell Surveillance Logs, October, 1999 [D8109566]/WMNW/TRS-ES-VSMA-001, Analysis Techniques Applied to The Dry Well [sic] Surveillance Gross Gamma Ray Data at the SX Tank Farm, February 1998

SX-104 Drywell Locations and Distances from Tank Structure:

The metal liner has a 37-ft 6-inch radius. The concrete wall around the metal liner is 2-ft thick. The concrete footing extends 1-ft 10-inches beyond the outer surface of the concrete wall.

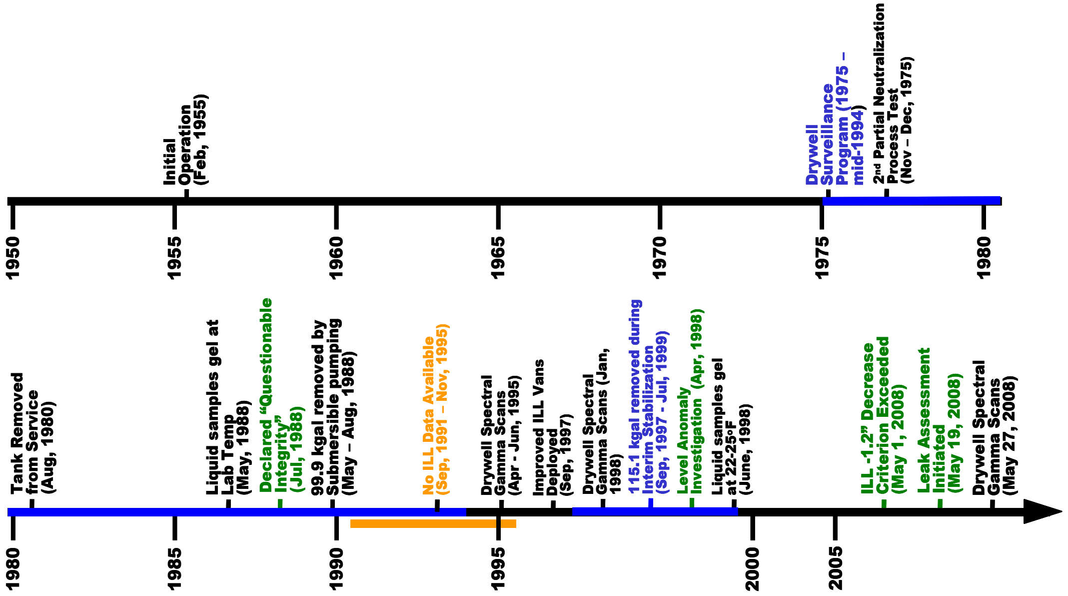
Drywell*	Drywell Distance from Tank Center (ft.)	Drywell Distance from Outside Radius of 2' Concrete Tank Wall (ft.)	Drywell Distance from Outside Radius of 1'-10" Concrete Tank Footing (ft.)	Clockwise Footing Perimeter Distance to Next Adjacent Drywell (ft.)
41-04-01	44.944	5.444	3.569	49.67
41-04-03	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

* Hanford coordinates used for all calculations. Tank center coordinates from H-2-72201. Drywell coordinates from H-2-36944 except 41-04-08 (Stoller Corporation)



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. The 1988 and 1998 waste samples gelled at laboratory temperature; the waste would be expected to behave similarly at soil temperature (assumed to be 55F, or ~13C). The waste properties might prevent a small leak from migrating far enough to be detected in one of the drywells. Although none of the 6 drywells shows a change in soil contamination level, it is difficult to draw any integrity conclusion from this information alone.

Tank SX-104 History Timeline



Team Member Actions Status:

Leak assessment actions from the July 2, 2008 meeting are listed below:

	Member	Action
1.	JM Ficklin/DA Barnes	Locate the December, 2006 Riser 7A LOW insertion work package, and review to determine if there is evidence that the water lance created a cavity at the saltcake-sludge waste interface. *Package # 2W-89-00109 was not electronically archived; and was sent to the Renton, WA Federal document repository*. Status: Complete

Leak assessment actions from the June 18, 2008 meeting are listed below:

	Member	Action
1.	DA Barnes	Prepare simple sketches showing the stages of Riser 7A LOW ILL maturity beginning with initial installation; slow distribution of the lance water into the waste and the waste refilling the lance water-created void around the LOW; and formation of the secondary feature. Maple Lee can convert to professional graphics. *Content of the sketches showing the lance water dynamics has been decided; sketches have to be developed and turned over to graphics for completion. Draft sketches were reviewed at the July 2nd meeting.* Status: On-going. Explanation caption is needed to allow sketch to standalone; color coding of the features representing the December, 2006 and the June 2008 LOW scan features will be used for visual discrimination.
2.	DA Barnes	Prepare simple non-leak hypothesis for the belief that a metastable ILL was being monitored instead of the true ILL. Status: Complete

Leak assessment actions from the June 11, 2008 meeting are listed below:

	Member	Action
1.	DA Barnes	Review ILL selection method for SSTs containing an LOW and group into categories based on whether the major interface feature or a secondary feature is being tracked; how the tracked feature was confirmed to be representative of the ILL, such as by showing movement during stabilization; and whether or not the feature selection should be reviewed based on the SX-104 experience. *About a dozen tank ILL's are monitored using a secondary feature similar to that present in SX-104. Four tanks require feature selection review. The evaluation will be documented in an internal memo and entered into IDMS to ensure later retrievability as a reference. Results to be published as an RPP document.* Status: On-going.
2.	DA Barnes	Email JW Ficklin request to perform gamma LOW scans when neutron scans are done for the next two weeks. *Gamma scans were taken June 10th and 17th. They show an interface very close to the ILL interface calculated from the ILL secondary feature (June 10th ILL 73.284",γ 72.384"; June 17th ILL 73.440", γ 72.036"). No further γ scans are planned unless the ILL begins decreasing again*. Status: Complete

Leak assessment actions from the June 4, 2008 meeting are listed below:

	Member	**Action**
1.	DA Baide	Investigate circumstances and use of the "SX-104 Crust Breaker" identified on H-14-010634 Sheet 2 as installed in Riser 6; and shown on H-2-39594. *Although the crust breaker was to be installed in SX-101 during initial construction, it was installed in SX-104. About 50' long, it consists of a 20' drive shaft and a 30' auger. The lower end of the crust breaker is centered in a cup guide that is welded to the tank floor. The drawing features suggest that it would have been operated manually, although no references to operation were located. The device could not be identified during a review of the 1999 in-tank video.* Status: Complete
2.	DA Barnes	Initiate real-time correlation between the ILL measurements and barometric pressure at the time the measurements are taken. There are no other tanks with weekly frequency LOW scans that could be used for a simultaneous barometric pressure correlation. *Evaluation of the inverse barometric pressure effects on the May, 2008 ILL data indicates that barometric pressure is no longer affecting the ILL. This is different from the close correlation noted during 1998 – 1999, when the ILL was 10 – 11' higher in the waste. It is likely the liquid interface now resides in material that is much more sludge-like than the higher layer. In high capillary force material the liquid level does not respond to barometric pressure*. Status: Complete
3.	DA Barnes	Prepare both "midpoint" (the ILL interpretation calculation using the original feature) and the "shoulder" variations of the ILL analysis looking for waste change contributions to the ILL behavior. *Using the new ILL feature for the ILL interpretation, the ILL appears to have asmytotically stabilized by the January 10, 2008 reading, and then risen slightly by the May 1st reading. Subsequent readings have oscillated over a range of about 1" without an obvious trend.* Status: Complete

4.	DA Barnes	DA Barnes Evaluate the ILL behavior at the earlier LOW riser locations for changes in the shape of the ILL interface scan similar to what is being encountered in Riser 7. *An informal analysis of ILL behavior following the placement of the five SX-104 LOWs shows that three of the five exhibit the presence of the latent shoulder (i.e., the "new" feature). The operating status of the tank (e.g., interim stabilization activity) has not been factored into the analysis at this time.* Status: Complete
5.	DJ Washenfelder	Recover any available data on retained gas inventory for SX-104 waste (RPP-10006 or TWINS). *SHMS flammable gas dome space measurements and PNNL dL/dP barometric surface level response estimates concluded that there was little or no retained gas in SX-104. SX-104 consistently ranked at or near the bottom of all comparisons. However, it is possible that the interstitial liquid is trapping, but not releasing gas. This conclusion is based on the 1998 – 1999 ILL response to barometric pressure. The ILL is currently about 77" below the waste surface. The depth of waste and/or the presence of low porosity waste above the ILL could be damping the barometric effects.* *Incomplete operating history suggests that the SX-104 interstitial liquid may be similar to the SY-101 double-shell slurry that experienced a dramatic volume increase from gas entrapment. This is being investigated.* Status: Complete

Leak assessment actions from the May 27, 2008 meeting are listed below:

	Member	Action
1.	Assessment Team	Review the "midpoint" and "shoulder" ILL tracking features after the June 10th ILL reading is plotted, and select which method should be used to continue ILL analysis of the weekly LOW scans. *Review has been completed. Both tracking features will continue to be used; if the tracking feature is changed to the secondary feature, tank waste inventory changes may be needed. A recommendation will be made to the ESRB as part of the Re-Leak Assessment.* Status: On-going. Tracking recommendation will be considered when ESRB reviews the leak assessment team's integrity recommendation.
2.	DA Barnes	SX-102 with waste similar to SX-104 had a new LOW installed recently. Review SX-102 ILL behavior for similarities to SX-104. *A similar shoulder feature is present in SX-102. Two of the four earlier SX-104 LOW installations have shown shoulders.* Status: Complete
3.	DJ Washenfelder	Finish developing SX-104 PN link to the SY-101 DSS gas retention properties. *The 1975 242-S Partial Neutralization Process Test is the last recorded slurry into SX-104; reliable SX-104 transfer records after the PN process test cannot recovered. However, the PN slurry must have been transferred out of SX-104, and the tank refilled with other material, because 60"of SX-104 terminal liquor was designated as feed for the February – November, 1979 2nd PN campaign ([D197248314] and RHO-CD-1026). The PN slurry from the PN Process Test would not have been feed for the 2nd PN campaign.* *The SX-104 PN Process Test slurry probably did not become feed for the Double-Shell Slurry process test campaign that slurried to SY-101, because the SY-101 samples taken before the 2nd DSS campaign show aluminum:caustic ratios that are very different from the PN Process Test and the present ILL aluminum to caustic ratios. Documentation from the 2nd DSS campaign shows that SX-104 was not feed to that campaign (RHO-CD-1286).* Status: Complete

4.	DA Barnes	Complete comparison of the ILL behavior at the earlier LOW riser locations and changes in the shape of the ILL Riser 7nterface scans. Factor in how the differences in tank operating status might affect the shape of the ILL curves. *Two of the four earlier SX-104 LOW installation shave shown shoulders.* Status: Complete

References:

Briefings:

Date	Title
May 29, 2008	Tank SX-104 Integrity History (DRAFT), DJ Washenfelder

Correspondence - Emails:

Date	Title
2008-05-20	241-SX Leak Assessment Team Members

Correspondence - Letters:

Number	Title
	Analysis of 242-S Slurry Receiving Tank 104-SX During Partial Neutralization Process Test, February 1976 [D196226689]
	242-S Second Partial Neutralization Production Run, February, 1978 [D197248314]
12221-PCL88-147	*Analysis of Tank 241-SX-104 Samples*, August, 1988
8C510-PC98-024	*Tank 241-SX-104 Dilution Testing, Interim Report*, August, 1998
113331-88-416	*Engineering Investigation: Interstitial Liquid Level Decrease in Tank 241-SX-104*, July, 1988 [D193015350]
13240-88-32	*Data Review, Tank 241-SX-140*, April, 1988 [D194028487]
113311-88-0498	*Evaluation of Integrity of 241-SX-104*, July, 1988 [D193015335]
8854920	*Initial/Final Unusual Occurrence Report, WHC-UOR-88-024-TF-03*, August, 1988 [292-001167]
8855768	*Revision of Unusual Occurrence Report for Tank 241-SX-104 Number WHC-UO-028-TF-03*, September, 1988 [D193015352]
LMHC-9851223A R3	*Subcontract Number 80232764-9-K001; Tank 241-SX-104 Level Anomalies*/HNF-2617 Rev. 0 *241-SX-104 Level Anomaly Assessment*, April, 1998 [D198084997]
LMHC-9958931	*Contract Number DE-AC06-99RL14047; Implementation of Field Optimizations – Performance Incentive ORP3.2.3*, December 1999
WMH-9856353	*Analyses Results for the Final Report for Tank 241-SX-104*, July, 1998

Documents:

Number	Title
88-03	*Environmental Protection Deviation Report 88-0, "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,"* February, 1988 [D197202901]
ARH-CD-240	*Nitric Acid Partial Neutralization Process Test*, March 1975
ARH-CD-597	*Nitric Acid Partial Neutralization/Acid Injection Process Test Evaluation*, April, 1976
ARH-ST-133	*Vapor-Liquid-Solid Phase Equilibria of Radioactive Sodium Wastes at Hanford*
CNWRA 97-008	*Hanford Tank Waste Remediation System High-Level Waste Chemistry Manual*
HNF-3136	*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
HNF-EP-0182 Rev. N/A	*Waste Tank Summary Report for Month Ending ...*
HNF-SD-RE-TI-178 Rev. 9	*Single-Shell Tank Interim Stabilization Recor*d, June 2005 [NA03965353]
GJ-HAN-3	*Vadose Zone Characterization Project at the Hanford Tank Farms: Tank Summary Data Report for Tank SX-104*, September, 1995 [D197215018] (\\hanford\data\Sitedata\HLANPlan\Geophysical_Logs\index.html)
GJPO-HAN-4/ DOE/ID/12584-268	*Vadose Zone Characterization Project at the Hanford Tank Farms: SX Tank Farm Report, September, 1996*
GJ-HAN-21	*Hanford Tank Farms Vadose Zone: Reassessment of the Vadose Zone Contamination at Tank SX-104 and a Comparison to the 1995 Baseline*, April 1998 [D8410006]
OSD-T-151-00031 Rev. G-2	*Operating Specifications for Tank Farm Leak Detection and Single-Shell Tank Intrusion Detection*, June, 2006
PNNL-11391	*Gas Retention and Release Behavior in Hanford Single-Shell Tanks*, December 1996
RHO-CD-394	*Double Shell Slurry Process Test Evaluation*
RHO-CD-1268	*Double-Shell Slurry Campaign*
RHO-CD-1515	*242-S Evaporator Crystallizer Third Partial Neutralization Campaign*, March 1982
RPP-7249	*Data and Observations of Single-Shell Flammable Gas Watch List Tank Behavior*, January 2001
RPP-15488	*Investigation of Tank Void Fraction using Liquid Level Response to Atmospheric Pressure Change* April 2005 [D4509875]
RPP-23600	*Phosphate Solubility Technical Basis*, December, 2004
SD-WM-TI-356	*Waste Storage Tank Status and Leak Detection Criteria*, March, 1990 [D197006832, D197006846, D197006861, D197006868]
	Tank Interpretive Report for SX-104 at http://twins.pnl.gov/reports/assembleReport.asp (Data Date = 2008-06-03)

TFC-ENG-CHEM-D-42	*Tank Leak Assessment Process*
WHC-SD-WM-DTR-026	*Laboratory Characterization of Samples Taken in December 1991 (Window E) from Hanford Waste Tank 241-SY-101*

Drawings:

Number	Title
H-2-39594 Rev. 2	*Crust-Breaker Assembly*
H-14-010634 Sheet 2 Rev. 2	*Waste Storage Tank (WST) Riser Data*

APPENDIX B
TANK SX-104 LEAK ASSESSMENT TEAM EXPERT ELICITATION FORMS

B1. TABLE 2 IN TANK DATA

Tank 241-SX-104 Leak Assessment In-Tank Data Form 2008-07-03
(from HNF-3747, Rev. 0)

SURFACE LEVEL MEASUREMENTS (SLM)	**Observation**

ENRAF

Unexplained, repeatable drop>tolerance SX-104 has a solid waste surface. ENRAF is not used for monitoring.	Yes	No	NA
Significant drop	Yes	No	NA
Significant trend change	Yes	No	NA

FIC

Unexplained, repeatable drop>tolerance No installed FIC.	Yes	No	NA
Significant drop	Yes	No	NA
Significant trend change	Yes	No	NA

MANUAL GAUGE

Unexplained, repeatable drop>tolerance No installed MT.	Yes	No	NA
Significant drop	Yes	No	NA
Significant trend change	Yes	No	NA

LIQUID OBSERVATION WELL (LOW) MEASUREMENTS	**Observation**

Unexplained, repeatable drop>tolerance Tank SX-104 is equipped with a liquid observation well (LOW) located in Riser 7A near the central pit, installed in December, 2006. This is the 5th LOW that has been installed in the tank. About 200 gallons of water were used to help lance the LOW into position. Earlier LOWS were located around the tank's periphery in Risers 14 and 16; these all eventually failed and were replaced. The SX-104 ILL is monitored quarterly in accordance with the Leak and Intrusion Detection operating specification (OSD-T-151-00031). ILL measurements taken between December 7, 2006 after the LOW was installed, and January 10, 2008 show an initial ILL decrease as the installation water around the LOW began to distribute through the waste, followed by a period of relatively stable level. On May 1, 2008 when the ILL was next measured, the level had decreased by ~-1.7 inches from the January 10, 2008 reading. The scan frequency was increased from quarterly to weekly, in accordance with the leak assessment procedure (TFC-ENG-CHEM-D-42). Measurements on May 6th and May 12th showed further decreases of ~ -0.05 inch and -1 inch. A measurement on May 20th showed no further decrease in the ILL. The ILL measurements through June 30, 2008 have remained relatively stable.	Yes	No	NA
Significant drop On May 1, 2008 when the ILL was next measured, the level had decreased by ~-1.7 inches from the January 10, 2008 reading. The scan frequency was increased from quarterly to weekly, in accordance with the leak assessment procedure (TFC-ENG-CHEM-D-42).	Yes	No	NA
Significant trend change ILL measurements taken between December 7, 2006 after the LOW was installed, and January 10, 2008 show an initial ILL decrease as the installation water around the LOW began to distribute through the waste, followed by a period of relatively stable level. On May 1, 2008 when the ILL was next measured, the level had decreased by ~-1.7 inches from the January 10, 2008 reading. Measurements on May 6th and May 12th showed further decreases of ~ -0.05 inch and -1 inch. A measurement on May 20th showed no further decrease in the ILL. The ILL measurements through June 30, 2008 have remained relatively stable.	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 In March, 1995 a Standard Hydrogen Monitoring System consisting of High- and Low-range Whittaker cells for H_2, and a grab sample station was installed on SX-104. During saltwell pumping, SX-104 showed no evidence of spontaneous gas release of significant amounts of flammable gas – one of only four SSTs on the watch list to do so. Comparison between SX-104 and the other watch list SSTs show that it consistently ranked at or near the bottom for all comparisons of generation or release of gas (RPP-7249). In December, 1999 the contractor recommended that the SX-104 SHMS be removed from service since the tank had "... minimal gas release activity, and/or ... active ventilation, ..." (LMHC-9958931).	Leak	Alt. Hypoth.	NA
Photos/Videos A 1999 in-tank inspection video shows the dry, very rough waste surface with deep fissures. Some fissures appear to contain a liquid pool, but confirmation of this is frustrated by the camera viewing angle and lighting. Since the ILL is believed to be about 8' below the waste surface it is likely that all or most of the "pools" are optical illusions. A followup July, 2008 video will concentrate on areas around the Riser 7A LOW – Waste Surface interface looking for lance water effects; the saltwell screen – Waste Surface interface and the tank waste surface looking for subsidence or feature changes since the 1999 video; the exposed liner and liner – Waste Surface interface appearance for suggestions of corrosion or evidence of asphalt mastic leakage behind the liner; the concrete wall and dome for discoloration, deterioration, or surface patterning suggesting rebar corrosion; and the riser – concrete dome interface for deterioration or concrete spalling. The video will be needed and have to be reviewed before presenting the leak assessment to the ESRB. The in-tank video was completed on July 7,2008. The waste surface is dry, massively fissured and sheared and appears to drop from the tank wall to the tank center location of the saltwell pump installation. There is a cavity in the saltcake surrounding the Riser 7A LOW that was probably dissolved away by the LOW installation water. Within the cavity, a few feet below the surface of the waste, the waste appearance changes from white and dark gray of the walls, believed to possibly be intermixed saltcake and sludge, to pale yellows and greens on the "pool" surface . This waste surface seems to be flat, suggesting that the installation water eventually became salt-saturated, and the salt recrystallized. Leak Assessment team estimates of the cavity depth to the smooth surface range from about 2 feet to about 8 feet. The ENRAF plummet is suspended over a dry, broad, relatively flat depression. It appears to be free of the waste, with clean surfaces. There are no tar streak indications on the tank wall that would be indicative of stored high heat waste causing the mastic lining between the liner and the concret to liquify, vaporize, and squeeze out from behind the liner. There are no obvious concrete dome surface patterns or concrete spalling that would be indicative of potential structural degration. One area of the dome seems to have striations; another has white surface streaks indicative of either an ancient intrusion or reflux and evaporation in the tank dome. The October 21, 1999 video taken in Riser 3 (adjacent to Riser 7)about 3 months after cessation of interim stabilization pumping, is much better quality tape, making accurate comparisons between the two videos difficult. The overall impression is that the waste fissures and shears seem more localized in the earlier video; and the slope of the waste surface from the walls to tank center not so apparent. One of the decapitated drywells is photographed.	Leak	Alt. Hypoth.	NA
Weather conditions Comparison	Leak	Alt. Hypoth.	NA
Barometric pressure In 1998 the tank was suspected of re-leaking due to observed variations in ILL of up to 6". 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)	Leak	Alt. Hypoth.	NA
Precipitation	Leak	Alt. Hypoth.	NA
Temperature	Leak	Alt. Hypoth.	NA

Total waste depth is ~162.2”. Interstitial liquid level is ~ 88.7” based on the original ILL feature. Highest elevation thermocouple in the waste is TC #5, 100” above the tank bottom, ~ 11” above the ILL, and 62.2” below the waste surface. The last waste temperature recorded from TC #5 was ~ 105.3°F or 41°C on April 30, 2002. The last waste temperature recorded from Riser 24 (TC #4) located 76” above the tank bottom, ~ 13” below the ILL was ~ 125.1°F or 52°C on September 2, 2005 (Data Date = 2008-05-29). These tank temperatures are hot enough to maintain the intersititial liquid in the liquid form based on the 1998 laboratory dilution studies. Dilution and cooling tests were performed on the undiluted supernatant liquid from the 1998 samples. The undiluted samples formed gels composed of interlocked sodium phosphate dodecahydrate (Na3PO4□12H2O) needle crystals and NaNO3 rhombohedra when cooled from 60oC to 22oC laboratory 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).			
Surface flooding	Leak	Alt. Hypoth.	NA
Process history The 241-SX Tank Farm is the third generation of farms at Hanford and was built to contain self-boiling waste from the REDOX facility. The SX tanks were constructed between 1953 and 1954 and are located in the central part of the 200 West Area. There are 15 single-shell tanks in the SX Farm, each with a 1,000,000 gallon (gal) capacity. They are 75 ft in diameter, approximately 44.5 ft tall with a domed top, and have been covered with about 7 ft of overburden. The base of the original construction excavation and corresponding base of the tanks is about 52 ft in depth. Ten of the 15, including SX-104, have been declared “assumed leakers”. It is believed that the SX-104 interstitial liquid is a product of the second Partial Neutralizaton process test - the "Nitric Acid Partial Neutralization/Acid Injection Process Test" - using a modified acid injector design. The test was run intermittently between November 14, and December 19, 1975 (ARH-CD-597). 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 SX-104; since no other slurry tanks are mentioned, it is likely the all of the PN/Acid Injection process test product was slurried to SX-104 ([D196226689]). Although the process test proposal called for sampling each of the three phases of the test, the analytical report only has two sample results. Comparison of the PN/Acid Injection test samples, the 1998 intersitital liquid level samples, and the SY-101 Window E core samples taken following the December 4, 1991 GRE indicate similar chemistries, particularly between the 1998 interstitial liquid and Window E samples. (If the 1998 samples were concentrated ~ 10% the results would almost overlay the Window E results.) Evaluation using the AlO_2^- x OH^- phase diagram shows that the 1998 and Window samples reside in the same aluminate region. Aluminate is known to catalyze the thermal decomposition of organic complexants, which results in H_2 gas formation. The high surface area of the aluminate crystals is also known to retain gas. These combined phenomena resulted in the SY-101 GREs, and are most likely still occuring in SX-104. The 1988 sample TOC for SC-104 was 5 - 13.3 g/l; and for SY-101 Envelope E 14.4 g/l. The inverse barometric response correlation to the ILL present during the 1998 re-leak investigation indicated that retained gas was present in the tank Retained gas is likely to still be present, and could be displacing interstitial liquid from some of the waste pores. If the gas is released from the pores, interstitial liquid could fill the empty spaces (about 34 vol% based on saltwell pumping). This is one possible explanation for the change in ILL noted between January 10, and May 1, 2008.	Leak	Alt. Hypoth.	NA
Occurrence reports	Leak	Alt. Hypoth.	NA

c	**1988 Leak Assessment:** Environmental Protection Deviation Report 88-03 issued February 19, 1988 to document the ILL decrease exceeding the -0.3' decrease criterion with the gamma probe. The neutron probe was noted to be stable. Unusual Occurrence Report WHC-UO-88-024-TF-03 dated August 30, 1988 indicates that 99,900 gallons were pumped from the tank between May18, 1988 and August 16, 1988; and that the tank was declared an "Assumed Leaker" on July 13, 1988 (see 113331-88-416 Engineering Investigation: Interstitial Liquid Level Decrease in Tank 241-SX-104, July, 1988 [D193015350]. The report 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 [D193015352]. Environmental Protection Deviation Report 88-03 indicates that the decrease criterion was confirmed with the gamma probe, and that the neutron probe remained stable. However, the UOR indicates that the ILL decrease was verified with the Gamma, Neutron, and Acoustic probes. It does not say whether or not the neutron and acoustic probes confirmed that the -0.3' decrease criterion had been exceeded however. **In-Tank – 1998 Re-Leak Assessment:** In 1998 the tank was suspected of re-leaking due to observed variations in ILL of up to 6". 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 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).			
	Construction history	Leak	Alt. Hypoth.	NA
	Gas Release Events In PNNL-11391 PNNL studied the gas retention and release in the SSTs, and concluded the that the only mechanism capable of producing large spontaneous gas releases was buoyant displacement, which occurs in tanks with a deep supernatant layer. The report concluded that SSTs were only capable of small releases of a few cubic meters, based on theory and laboratory and field observations; and since gas bubbles can only cling to submerged solids, gas is usually only released when the volume of waste is disturbed. The report also prioritized the SSTs by flammable gas potential based on dL/dP (cm/kPa) barometric pressure surface level response; extent of post-transfer surface level rise; and tank headspace gas concentrations. Table A.1. *SST Prioritization Data* estimated the SX-104 dL/dP as ~ + 0.0001 in/in Hg. The positive number indicates that there is no waste surface correlation with barometric pressure. Table 3.1 *Void Fraction Estimates* shows that SX-104 consistently ranked as one of the least responsive tanks to changes in barometric pressure affecting the surface level. Similar results were obtained when level rise was considered. The relationship between waste surface level and ILL changes was not discussed. The gas generation rate, retained gas volume, and spontaneous and induced gas release histories for SX-104 are discussed in RPP-7249. The 2001 report notes that, "... all of the spontaneous gas releases observed since monitoring was installed in 1995 have all been less than 3 m^3 (100 scf) of hydrogen and occur over many hours to days..." for the Flammable Gas Watch List SSTs. None of the 19 SSTs on the watch list exhibited significant releases, and the steady-state gas release rate was insignificant . Table 6-2 *Barometric Pressure Effect Gas Volume Estimates in Single-Shell Tanks* notes that there is "No apparent dL/dP correlation" for SX-104. Only one other tank in the 24-tank list is similarly labeled. Table 6-3 A*verage Gas Fraction and Gas Volume Estimates from Neutron Logs* estimates a 7.9% gas fraction below the ILL, with a best-estimate standard gas volume of 250 ± 125 m^3 for SX-104. In 2004 PNNL provided an estimate of the surface dL/dP (inch/inch Hg) values for SX-104 for a four-month period between January 1, 1997 and January 20, 1999. The estimated dL/dP was -0.056 +/- 0.055 in/in Hg, supporting earlier conclusions that there is no, or almost no, correlation between surface level changes and dP change. This is consistent with the PNNL-11391 +0.0001 in/in Hg within the limits of error. ILL response to barometric pressure is not discussed (RPP-15488).	Leak	Alt. Hypoth.	NA
	Equipment maintenance calibration	Leak	Alt. Hypoth.	NA

Waste characteristics Three grab samples were taken in June, 1998 for dilution studies and inorganic analysis to support the re-leak assessment. The supernatant analytical results show [Na] = 10.13M, and [P] = 0.0255M (WMH-9856353). The current ~ 88.7" ILL using the original ILL feature is bracketed by thermocouple #5, about 11" above the ILL, and thermocouple #4, 13" below. The last recorded TMACS readings for these thermocouples were 105.3^{o}F (41^{o}C) on April 30, 2002; and 125.1^{o}F (52^{o}C) on September 2, 2005 (Data Date – May 29, 2008). There is no evidence that at these Na and P supernatant concentrations and waste temperatures that phosphate gelling would be a problem (see RPP-23600 Figure 13 Phosphate Solubility as a Function of Temperature for Typical Hanford Site Tank Waste). The analytical results for sludge portion of the 1998 sample show that at the measured bulk density of 1.50 g/ml, and phosphorus = 6.75e+03 ug/g, the [P] = ~ 0.32 M. Since the [P] in the supernatant and sludge are in equilibrium, the 0.0255M supernatant concentration probably represents the saturated boundary at the observed waste temperature. There is no mention in the 1998 report that gelling was observed in the laboratory. However, dilution and cooling tests were performed on the undiluted supernatant liquid from the 1998 samples. 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^{o}C to 22^{o}C laboratory temperature. About 10 volume % free liquid remained on top of the gel. The samples remained clear from 60oC until the temperature reached 25^{o}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). The May, 1988 samples gelled at laboratory temperature. The sample results show a [PO4] of 0.1M + 20%, and a [P] = 0.15M (12221-PCL88-147). The waste would have been at a higher temperature in 1988 due to higher radionuclide thermal decay, which could account for the higher supernatant [P] in the waste in the 1988 samples. As the waste cooled, the saturation boundary shifted, accounting for the lower [P] in the 1998 supernatant, and a higher [P] in the sludge. RPP-23600 indicates that the 1988 supernatant phosphorus concentration should have been soluble at laboratory temperature. Something else must account for the observed gelling. 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. Evaluation by Dan Herting suggests that the observed solids formation was probably NaNO2 and NaNO3 both crystallizing (personal communication). The supernatant composition of the 1998 sample shows remarkable similarities to the old, burping SY-101 supernatant. If the SX-104 supernatant was concentrated by ~ 10%, the analyte concentrations would almost exactly overlay the SY-101 composition, including % H20 and SpG. The 1988 SX-104 report indicates that the TOC numbers are lower in SX-104, so the gas generation would be slower; however the gas retention properties of the slurries would probably be very similar.	Leak	Alt. Hypoth.	NA
In-tank operations The tank was interim stabilized by jet pumping between March, 1988 and July, 1999. The line plugged after two days' pumping due to the waste properties. In July, 1999 the rear seal on the jet pump failed. At that time there was an estimated 47,700 gallons of drainable interstitial liquid remaining in the tank, with about 43,600 gallons pumpable. An economic benefits analysis was completed using interim stabilization experience from SX-106 and SX-109 with similar waste properties. In these two tanks, the hydraulic properties of the waste resulted in about 29,000 gallons of pumpable remaining behind at the end of interim stabilization pumping. The SX-104 economic analysis used the SX-106 and SX-109 behavior to correct the remaining estimated pumpable volume to 43,600 - 29,000 gallons = 14,600 gallons. The amount of flush water needed to remove the 14,600 gallons and the radiation exposure needed to enter the pit and replace the pump were major factors in the decision to interim stabilize the tank 'as-is'. The interim stabilization paperwork was completed in April, 2000 [HNF-SD-RE-TI-178].	Leak	Alt. Hypoth.	NA
Other (specify) - 1988 Leak Assessment	Leak	Alt. Hypoth.	NA

Tank SX-104 was classified as an "assumed leaker" by a 3 to 2 committee vote in 1988 following a -6" decrease in the interstitial liquid level (ILL) over the previous three year period that exceeded the -0.3' decrease criterion in effect at the time (13331-88-416; 13311-88-0498). There was no supernatant surface level measurement available to corroborate the ILL measurement; none of the drywells surrounding the tank showed any gross gamma peaks. Neutron scans of the drywells showed increased and broadened moisture peaks in the drywells, other drywells in the tank farm that were subsequently checked, and in drywells outside of the SX tank farm. The moisture changes were speculated to be coming from an external source, but no further evaluative work has been found in the records. Evaporation was discounted as a possible cause of the ILL drop because other tanks on the same ventilation system were not showing similar ILL decrease. The total estimated loss was 5,300 gallons based on the -6" decrease, corrected for reduced thermal expansion of the waste as it continued cooling, and a 35% porosity factor. The volume has been rounded up to 6,000 gallons in the Waste Tank Status Summary Reports (HNF-EP-0182)			
Other (specify) - 1998 Re-Leak Assessment In April, 1998 an evaluation of SX-104 ILL decreases that occurred during 1997 was made. The evaluation concluded that the observed ILL changes (up to 6 inches) were the result of changes in the waste porosity and changes in atmospheric pressure. Drywells ringing the tank were rescanned; no changes were detected. The evaluation showed that evaporation was contributing to a slowly decreasing ILL level (LMHC-9851223A). For clarification, SX-104 was not exhausted directly by the SX Sludge Cooler HVAC system; it was exhausted via an underground duct connected to SX-109; SX-109 was connected to the Sludge Cooler HVAC system.	Leak	Alt. Hypoth.	NA
Other (specify) - Gas Retention and GRE See Gas Release Events section above.	Leak	Alt. Hypoth.	NA

B2 TABLE 3 EX-TANK DATA

SPECTRAL GAMMA LOGS (SGL)	Observation

Radionuclides

Man-made? 41-04-01: Cs-137 primarily from the surface to about 20 ft and then at discontinuous locations to TD at concentrations above MDA but less than 1 pCi/g. A small zone of Cs-137 activity at 50 ft corresponds with the bottom of the tank. 41-04-03: Cs-137 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. 41-04-05: 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: 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 (1). 41-04-08: 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: 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. 41-01-06: Cs-137 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: Cs-137 from the surface to about 20 ft; 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.	Yes	No	NA
Multiple?	Yes	No	NA

41-04-03: Cs-137 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. 41-04-11: 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.			

Distribution

Peak at bottom of tank? See Man-made? and Multiple? Sections above	actual data		No or NA
Peak near surface? See Man-made? and Multiple? Sections above	actual data		No or NA
Increased activity in between? See Man-made? and Multiple? Sections above	actual data		No or NA
Increased activity below tank? See Man-made? and Multiple? Sections above	actual data		No or NA

Activity across boreholes

Multiple boreholes? See Man-made? and Multiple? Sections above	Yes	No	NA

Activity over time

Increased activity?	Yes	No	NA
In 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 strong evidence that the tank had ever leaked; and 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). 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. 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 (GJ-HAN-21).			

HISTORICAL GROSS GAMMA LOGS (GGL)	**Observations**

Distribution

Sign. peak at bottom of tank?	actual data		No or NA

HNF-3136 Rev. 0 Analysis Techniques and Monitoring Results, 241-SX Drywell Surveillance Logs, October, 1999 [D8109566] provides the following GGL descriptions based on scans during the period between 1975 and 1995: 41-04-01: No significant levels of gamma-ray contamination is present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 100 feet (2). 41-04-03: Stability of Cs-137 contamination at 21 ft. cannot be determined (2). 41-04-05: No significant levels of gamma-ray contamination is present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 100 feet (2). 41-04-07: No significant levels of gamma-ray contamination is present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 100 feet (2). 41-04-08: No significant levels of gamma-ray contamination is present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 123 feet (2). 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(2). 41-00-03: No significant levels of gamma-ray contamination is present above gross gamma probe surveys' detection threshold between 1975 and 1993 in the vadose zone from 2 to 150 feet (2). 41-01-06: Stability of Cs-137 contamination at 100 ft. cannot be established. Cs-137 contamination at 8, 16, 25, and 34 ft. is stable (2). 41-07-12: No significant levels of gamma-ray contamination is present above gross gamma probe surveys' detection threshold in the vadose zone from 2 to 77 feet (2).		
Sign. peak near surface? See Sign. peak at bottom of tank? Section above.	actual data	No or NA
Sign. increased activity in between? See Sign. peak at bottom of tank? Section above.	actual data	No or NA
Sign. increased activity below tank? See Sign. peak at bottom of tank? Section above.	actual data	No or NA

Activity across boreholes

Multiple boreholes? See Sign. peak at bottom of tank? Section above.	Yes	No	NA
Consistent across boreholes? See Sign. peak at bottom of tank? Section above.	Yes	No	NA

Activity over time

Abrupt increase (bottom)? See Sign. peak at bottom of tank? Section above.	Yes	No	NA
Abrupt increase (elsewhere)? See Sign. peak at bottom of tank? Section above.	Yes	No	NA
Gradual increase (bottom)? See Sign. peak at bottom of tank? Section above.	Yes	No	NA
Gradual increase (elsewhere)? See Sign. peak at bottom of tank? Section above.	Yes	No	NA

CORROBORATING EVIDENCE	Corroborates SGL or GGL Data Given		
Moisture Probe Tank SX-104 was classified as an "assumed leaker" by a 3 to 2 committee vote in 1988 following a -6" decrease in the interstitial liquid level (ILL) over the previous three year period that exceeded the -0.3' decrease criterion in effect at the time (13331-88-416; 13311-88-0498). Neutron scans of the drywells showed increased and broadened moisture peaks in the drywells, other drywells in the tank farm that were subsequently checked, and in drywells outside of the SX tank farm. The moisture changes were speculated to be coming from an external source, but no further evaluative work has been found in the records.	Leak	Alt. Hypoth.	NA
Psychrometrics Tank SX-104 was classified as an "assumed leaker" by a 3 to 2 committee vote in 1988 following a -6" decrease in the interstitial liquid level (ILL) over the previous three year period that exceeded the -0.3' decrease criterion in effect at the time (13331-88-416; 13311-88-0498). Evaporation was discounted as a possible cause of the ILL drop because other tanks on the same ventilation system were not showing similar ILL decrease. In April, 1998 an evaluation of SX-104 ILL decreases that occurred during 1997 was made. The evaluation showed that evaporation was contributing to a slowly decreasing ILL level (LMHC-9851223A). For clarification, SX-104 was not exhausted directly by the SX Sludge Cooler HVAC system; it was exhausted via an underground duct connected to SX-109; SX-109 was connected to the Sludge Cooler HVAC system.	Leak	Alt. Hypoth.	NA
Bore hole core sample	Leak	Alt. Hypoth.	NA
Laterals SX-104 is not equipped with laterals.	Leak	Alt. Hypoth.	NA
Weather conditions			
Barometric pressure In 1998 the tank was suspected of re-leaking due to observed variations in ILL of up to 6". 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)	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 Tank 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 22oC (8C510-PC98-024). The distances between drywells around the tank range from 18.60 feet between drywells 7 and 8 to 62.78 feet between drywells 8 and 11. The 1988 and 1998 waste samples gelled at laboratory temperature; the waste would be expected to behave similarly at soil temperature (assumed to be 55F, or ~13C). The waste properties might prevent a small leak from migrating far enough to be detected in one of the drywells. Although none of the 6 drywells shows a change in soil contamination level, it is difficult to draw any integrity conclusion from this information alone.	Leak	Alt. Hypoth.	NA
In-tank operations	Leak	Alt. Hypoth.	NA
Other (specify)	Leak	Alt. Hypoth.	NA
Other (specify)	Leak	Alt. Hypoth.	NA

B3. TABLE 6 ELICITATION FORMS

Expert Opinion: D. G. Baide

Tank SX-104 Leak Assessment Expert Elicitation Form 2008-06-10-17
(From HNF-3747, Rev. 0)

Elicitation Date: 7/22/2008

Elicitation from: DG Baide

Eliciation by: DA Barnes/DJWashenfelder

Hypotheses:

Leaker: “A leak from tank 241-SX-104 caused the decrease in the interstitial liquid level calculated from neutron monitoring scans in the Riser 7A Liquid Observation Well.”

Non-Leaker: “Water used to install the tank 241-SX-104 Liquid Observation Well created an artificially high liquid level near the Liquid Observation Well and obscured the true interstitial liquid level feature. When the correct feature is monitored the data show a stable liquid level and no indication of a leak.”

Prior Probability - Part 1

True State		**Liklihood Ratio**
L	**NL**	**L:NL**
p(L)	p(NL)	Ω_0
0.40	0.60	0.67

Considering the 1988 (Dunford) evaluation, and the 1998 Leak Re-assessment (Barnes/Kirch), and past difficulties with LOW failures, data are biased toward nl-leaking probability.

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

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

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

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

Surface Level Measurement	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)
	NA	NA	1.00

No surface level measurement.

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

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

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

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

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

In-Tank Data Liquid Observation Well - Part 3

Liquid Observation Well	p(LOW|L) (if no LOW, enter NA here and in Parts 4 and 5)	p(LOW|NL)	L(LOW)
	0.30	0.70	0.43

Considering both the LOW neutron scan data and viewing of the July, 2008 video, picking the true ILL feature can be deceptive. It is very likely that the true ILL feature has been identified as part of the current leak assessment. However it is difficult to confidently predict the water diffusion behavior due to the highly variable - cracked and sloughed - 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

Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

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

Considering that in-tank data sources may be interdependent:

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

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

L(SLM|LOW) = p(SLM|LOW,L)/p(SLM|LOW,NL) . If either surface level measurement data or LOW 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.

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

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

Considering that in-tank data sources may be interdependent:

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

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

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

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

Gross Gamma Drywell Logs	p(GGL|L) (if no GGL, enter NA here and in Parts 8 and 9)	p(GGL|NL)	L(GGL)
	0.50	0.50	1.00

Drywell spacing and detector sensitivity require that the waste migrate from the tank, and that drywell intersects the plume. The drywell scans are most meaningful when there is a change in radiation level. This did not happen in the gross gamma scans, which is favorable to the NL hypothesis, but is not proof that the tank didn't leak. The data do not bias the probability.

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

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

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

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

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

Spectral Gamma Drywell Logs	p(SGL|L) (if no SGL, enter NA here and in Parts 8 and 9)	p(SGL|NL)	L(SGL)
	0.50	0.50	1.00

SGL scans in 1995 and 1997, and the 2008 RAS scans show no changes in the drywell backgrounds that would indicate a leak. However, as with the gross gamma scans, a tank could be leaking, and if the drywell did not intercept the plume, there would be no leak indication. The data do not bias the probability.

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.

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

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

SGL scans are more sensitive than the GGL scans.

Considering that ex-tank data sources may be interdependent:

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

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

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

Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

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

Considering that ex-tank data sources may be interdependent:

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

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

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

Combined Liklihood Ratios

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

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

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

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

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

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

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

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

Ex-Tank Liklihood Ratio	L(SGL,GGL)
	1.00

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

Combined Likelihood Ratio for Leak Hypothesis	L(in,ex)
	0.43

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
0.22	0.78	0.29

Ω_1 = posterior (post-leak assessment) odds in favor of leak hypothesis. Ω_1= L(in,ex) x Ω_O
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)

Expert Opinion: D. A. Barnes

Tank SX-104 Leak Assessment Expert Elicitation Form 2008-06-10-17
From HNF-3747, Rev. 0)

Elicitation Date: 7/15/2008

Elicitation from: DA Barnes

Eliciation by: DJ Washenfelder

Hypotheses:

Leaker: "A leak from tank 241-SX-104 caused the decrease in the interstitial liquid level calculated from neutron monitoring scans in the Riser 7A Liquid Observation Well."

Non-Leaker: "Water used to install the tank 241-SX-104 Liquid Observation Well created an artificially high liquid level near the Liquid Observation Well and obscured the true interstitial liquid level feature. When the correct feature is monitored the data show a stable liquid level and no indication of a leak."

Prior Probability - Part 1

True State		**Liklihood Ratio**
L	**NL**	**L:NL**
p(L)	p(NL)	Ω_0
0.40	0.60	0.67

Set prior probability slightly below neutral because current liquid interface is in a sludge, which has very poor drainage characteristics and the supernatant tends to gel when cooled. Both of these characteristics tend to reduce the probability of a leak.

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

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

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

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

Surface Level Measurement	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)
	NA	NA	1.00

Enraf is sitting on top of hard, crystaline saltcake which would not respond to a liquid loss. Enraf data cannot be used as a valid leak indicator.

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

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

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

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

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

In-Tank Data Liquid Observation Well - Part 3

<table>
<tr><td>Liquid Observation Well</td><td>p(LOW|L)
(if no LOW, enter NA here and in Parts 4 and 5)</td><td>p(LOW|NL)</td><td>L(LOW)</td></tr>
<tr><td></td><td>0.10</td><td>0.90</td><td>0.11</td></tr>
</table>

I now believe that the major neutron feature near 89 inches that was originally interpreted as the ILL is really a sludge-slatcake interface. The true ILL is about 15 inches lower, near 74 inches. If the lower (and smaller) interface is tracked as the true ILL the trend shows a slow redistribution of installation liquid over about a 6-month period, with the level remaining fairly stable since then. If one considers the deeper feature to be the true ILL the data show no indication of a tank leak.

Also, the video tends to confirm this analysis. There is a large section of saltcake from the surface down that has been significantly washed out from the installation water. Near the bottom of the visible section in the video the material changes dramatically to a dark brown non-crystalline material that is very near gauge, (i.e., very little washout). This is most likely the top of the sludge layer, and the lack of washout results from the greatly reduced solubility in water. This is most likely the major neutron feature seen on the LOW survey. Approximately 1-2 feet below this dark brown surface the hole is filled with small salt crystals. These crystals have fallen in the hole from an upper level, and may be either floating on the true liquid surface, or may have bridged over. In that case the ILL would be somewhat deeper but not visible from the video. In either case the video confirms the interpretation that the true ILL is deeper than the major feature at the top of the sludge. Using the lower feature as the ILL leads to the conclusion that the probability of a leak is extremely low.

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

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></tr>
<tr><td></td><td>NA</td><td>NA</td><td>1.00</td></tr>
</table>

Enraf data is not relevent, therefore there are also no inderdependencies.

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.

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></tr>
<tr><td></td><td>NA</td><td>NA</td><td>1.00</td></tr>
</table>

Enraf data is not relevent, therefore there are also no inderdependencies.

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.

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

Gross Gamma Drywell Logs	p(GGL|L) (if no GGL, enter NA here and in Parts 8 and 9)	p(GGL|NL)	L(GGL)
	0.45	0.55	0.82

Gross gamma showed no activity above background until the scans were discontinued in 1994. (There was some activity near the surface, which is not attributable to tank leakage.) The SX104 supernatant would tend to gel at soil temperatures, so if the tank leaked it could very easily miss being detected in a drywell. The clean history slightly supports a sound tank, but not by much.

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

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

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

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

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

Spectral Gamma Drywell Logs	p(SGL|L) (if no SGL, enter NA here and in Parts 8 and 9)	p(SGL|NL)	L(SGL)
	0.45	0.55	0.82

As with the gross gamma data, the only isotopes identified were near the surface. Clean surveys near the tank bottom tend to support a sound tank, but the gelling nature of the waste means that drywell data may not be a very reliable indicator. Thus a value slightly below neutral was chosen.

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.

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

Gross Gamma Log - Spectral Gamma Log Interdependence	p(GGL|SGL,L)	p(GGL|SGL,NL)	L(GGL|SGL)
	0.45	0.55	0.82

Neither the gross gamma nor the spectral data is a good leak indicator because of the gelling properties of the waste. Since both were clean at tank depth a value slightly below neutral was chosen.

Considering that ex-tank data sources may be interdependent:

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

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

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

Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

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

NA

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)
0.82	**0.82**	**0.82**	**1.00**

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

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

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

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

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

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

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)
		0.07

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
0.05	0.95	0.05

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

Expert Opinion: J. W. Ficklin

Tank SX-104 Leak Assessment Expert Elicitation Form 2008-06-10-17
From HNF-3747, Rev. 0)

Elicitation Date: 7/16/2008

Elicitation from: JW Ficklin

Eliciation by: DA Barnes/DJ Washenfelder

Hypotheses:

Leaker: “A leak from tank 241-SX-104 caused the decrease in the interstitial liquid level calculated from neutron monitoring scans in the Riser 7A Liquid Observation Well.”

Non-Leaker: “Water used to install the tank 241-SX-104 Liquid Observation Well created an artificially high liquid level near the Liquid Observation Well and obscured the true interstitial liquid level feature. When the correct feature is monitored the data show a stable liquid level and no indication of a leak.”

Prior Probability - Part 1

True State		**Liklihood Ratio**	
L	**NL**	**L:NL**	
p(L)	p(NL)	Ω_0	1998 leak re-evaluation and drywell data support conclusion that the tank had not previously re-leaked.
0.25	0.75	0.33	

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

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

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

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

Surface Level Measurement	$p(SLM \mid L)$ (If no SLM, enter NA here and in Parts 4 and 5)	$p(SLM \mid NL)$	L(SLM)	Surface level data not used for the re-leak assessment; ENRAF is contacting solid surface.
	NA	NA	1.00	

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

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

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

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

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

In-Tank Data Liquid Observation Well - Part 3

Liquid Observation Well	$p(LOW \mid L)$ (if no LOW, enter NA here and in Parts 4 and 5)	$p(LOW \mid NL)$	L(LOW)	The ILL is stable, expecially when using the new ILL feature. The initial decrease has restabilized. Review of the video supported the analysis of the LOW scan.
	0.05	0.95	0.05	

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

Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

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

Considering that in-tank data sources may be interdependent:

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

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

L(SLM|LOW) = p(SLM|LOW,L)/p(SLM|LOW,NL) . If either surface level measurement data or LOW 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.

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

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

Considering that in-tank data sources may be interdependent:

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

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

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

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

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

Drywell scans didn't consistently indicate the presence of a leak, but there is the potential that the leak location could be in an area not being monitored.

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

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

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

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

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

Spectral Gamma Drywell Logs	p(SGL|L) (if no SGL, enter NA here and in Parts 8 and 9)	p(SGL|NL)	L(SGL)
	0.25	0.75	0.33

Spectral gamma scans are consistent with the gross gamma scans.

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.

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

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

Considering that ex-tank data sources may be interdependent:

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

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

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

Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

Spectral Gamma Log - Gross Gamma Log Interdependence	p(SGL|GGL,L)	p(SGL|GGL,NL)	L(SGL|GGL)
	0.25	0.75	0.33

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	0.05	1.00	1.00

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

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

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

In-Tank Liklihood Ratio		L(SLM,LOW)
		0.05

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)
		0.11

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)
		0.01

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
0.0019	0.9981	0.0019

Tank is probably not re-leaking based on review of current and historical data.

Ω_1 = posterior (post-leak assessment) odds in favor of leak hypothesis. Ω_1= L(in,ex) x Ω_O
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)

Expert Opinion: J. G. Field

Tank SX-104 Leak Assessment Expert Elicitation Form 2008-06-10-17
From HNF-3747, Rev. 0)

Elicitation Date: 7/16/2008

Elicitation from: JG Field

Eliciation by: DA Barnes/DJ Washenfelder

Hypotheses:

Leaker: “A leak from tank 241-SX-104 caused the decrease in the interstitial liquid level calculated from neutron monitoring scans in the Riser 7A Liquid Observation Well.”

Non-Leaker: “Water used to install the tank 241-SX-104 Liquid Observation Well created an artificially high liquid level near the Liquid Observation Well and obscured the true interstitial liquid level feature. When the correct feature is monitored the data show a stable liquid level and no indication of a leak.”

Prior Probability - Part 1

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

This is a re-leak assessment. The tank is already classified as an "Assumed Leaker". Prior probability of 0.5 indicates no bias toward "re-leaking" or "not re-leaking" conclusion.

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

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

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

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

Surface Level Measurement	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)
	NA	NA	1.00

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

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

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

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

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

In-Tank Data Liquid Observation Well - Part 3

Liquid Observation Well	p(LOW|L) (if no LOW, enter NA here and in Parts 4 and 5)	p(LOW|NL)	L(LOW)
	0.15	0.85	0.18

The initial ILL feature was probably reading the interface between the sludge and saltcake; the secondary feature is the true ILL (based on understanding how the neutron probe works, understanding capillary action; the correlation between the neutron probe and gamma probe measurements; and the July 7, 2008 video showing the LOW-waste interface and the clear distinction between the sludge and saltcake).

There could be a small leak in the tank that the ILL would not detect because of variability in measurement data. Also the liquid properties suggest that a leak could be self-sealing and would not be detected.

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

Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

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

Considering that in-tank data sources may be interdependent:

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

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

L(SLM|LOW) = p(SLM|LOW,L)/p(SLM|LOW,NL) . If either surface level measurement data or LOW 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.

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

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

Considering that in-tank data sources may be interdependent.

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

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

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

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

Gross Gamma Drywell Logs	p(GGL|L) (if no GGL, enter NA here and in Parts 8 and 9)	p(GGL|NL)	L(GGL)
	0.50	0.50	1.00

Ex-tank drywell data have no bearing on the decision, because they showed no changes. If there had been an increase in the drywells, the probability of a leak would be greater.

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

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

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

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

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

Spectral Gamma Drywell Logs	p(SGL|L) (if no SGL, enter NA here and in Parts 8 and 9)	p(SGL|NL)	L(SGL)
	0.50	0.50	1.00

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.

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

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

Considering that ex-tank data sources may be interdependent:

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

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

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

Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

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

Considering that ex-tank data sources may be interdependent:

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

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

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

Combined Liklihood Ratios

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

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

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

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

In-Tank Liklihood Ratio		**L(SLM,LOW)**
		0.18

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

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

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

Ex-Tank Liklihood Ratio		**L(SGL,GGL)**
		1.00

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

Combined Likelihood Ratio for Leak Hypothesis		**L(in,ex)**
		0.18

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**
0.15	0.85	0.18

Ω_1 = posterior (post-leak assessment) odds in favor of leak hypothesis. Ω_1= L(in,ex) x Ω_O
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)

Expert Opinion: M. A. Fish

Tank SX-104 Leak Assessment Expert Elicitation Form 2008-06-10-17
From HNF-3747, Rev. 0)

Elicitation Date: 7/16/2008

Elicitation from: MA Fish

Eliciation by: DA Barnes/DJWashenfelder

Hypotheses:

Leaker: "A leak from tank 241-SX-104 caused the decrease in the interstitial liquid level calculated from neutron monitoring scans in the Riser 7A Liquid Observation Well."

Non-Leaker: "Water used to install the tank 241-SX-104 Liquid Observation Well created an artificially high liquid level near the Liquid Observation Well and obscured the true interstitial liquid level feature. When the correct feature is monitored the data show a stable liquid level and no indication of a leak."

Prior Probability - Part 1

True State		Liklihood Ratio
L	**NL**	**L:NL**
p(L)	p(NL)	Ω_0
0.60	0.40	1.50

Tank is an "assumed leaker" and probably leaked. Declaration was made after the ILL dropped by 6".

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

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

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

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

Surface Level Measurement	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)
	NA	NA	1.00

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

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

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

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

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

In-Tank Data Liquid Observation Well - Part 3

Liquid Observation Well	p(LOW|L) (if no LOW, enter NA here and in Parts 4 and 5)	p(LOW|NL)	L(LOW)
	0.30	0.70	0.43

The ILL pattern indicates the tank is not re-leaking. The lower ILL feature is consistent with the installation water being absorbed into the waste.

From the July 7, 2008 video, there is a liquid-created surface in the LOW waste cavity from a recent liquid level. The appearance of the surface and its location influences the recomendation that the lower feature is the correct ILL.

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

Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

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

Considering that in-tank data sources may be interdependent:

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

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

L(SLM|LOW) = p(SLM|LOW,L)/p(SLM|LOW,NL) . If either surface level measurement data or LOW 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.

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

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

Considering that in-tank data sources may be interdependent:

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

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

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

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

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

The gross gamma drywell scans show no evidence of a leak. It is possible that a small leak could have occurred but been missed. The waste gels at ground temperature.

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

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

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

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

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

Spectral Gamma Drywell Logs	p(SGL|L) (if no SGL, enter NA here and in Parts 8 and 9)	p(SGL|NL)	L(SGL)
	0.25	0.75	0.33

The spectral gamma scans show no evidence of a leak. The compacted ground at the bottom of the tank level (due to the original construction activities) would encourage horizontal movement of the tank waste towards the dry wells.

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.

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

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

The spectral gamma drywell scans are more important because they use better equipment, and the data are recent, compared to the 1975 - 1995 gross gamma drywell scans.

Considering that ex-tank data sources may be interdependent:

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

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

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

Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

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

Considering that ex-tank data sources may be interdependent:

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

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

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

Combined Liklihood Ratios

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

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

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

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

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

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

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

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

Ex-Tank Liklihood Ratio		L(SGL,GGL)
		0.33

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
0.18	0.82	0.21

Ω_1 = posterior (post-leak assessment) odds in favor of leak hypothesis. Ω_1= L(in,ex) x Ω_O
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)

Expert Opinion: D. J. Washenfelder

Tank SX-104 Leak Assessment Expert Elicitation Form 2008-06-10-17
From HNF-3747, Rev. 0)

Elicitation Date:	7/15/2008
Elicitation from:	DJ Washenfelder
Eliciation by:	DA Barnes

Hypotheses:

Leaker:	“A leak from tank 241-SX-104 caused the decrease in the interstitial liquid level calculated from neutron monitoring scans in the Riser 7A Liquid Observation Well.”
Non-Leaker:	“Water used to install the tank 241-SX-104 Liquid Observation Well created an artificially high liquid level near the Liquid Observation Well and obscured the true interstitial liquid level feature. When the correct feature is monitored the data show a stable liquid level and no indication of a leak.”

Prior Probability - Part 1

True State		Liklihood Ratio
L	**NL**	**L:NL**
p(L)	p(NL)	Ω_0
0.40	0.60	0.67

10 of 15 tanks in SX Tank Farm are assumed leakers. SX-104 did not receive high-heat waste compared to higher numbered tanks in the farm. The tank was designated to be an "assumed leaker" based on an ILL decrease in 1988. In 1998 a similar ILL decrease was explained by changes in barometric pressure acting on interstitial liquid changes in waste porosity. The issue is whether it is re-leaking now or not?

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

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

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

Conditional Probabilities

In-Tank Data Surface Level Measurement - Part 2

Surface Level Measurement	p(SLM|L) (If no SLM, enter NA here and in Parts 4 and 5)	p(SLM|NL)	L(SLM)
	NA	NA	1.00

July 7, 2008 video shows ENRAF over solid surface. No meaningful data from ENRAF.

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

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

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

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

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

In-Tank Data Liquid Observation Well - Part 3

Liquid Observation Well	p(LOW|L) (if no LOW, enter NA here and in Parts 4 and 5)	p(LOW|NL)	L(LOW)
	0.30	0.70	0.43

After initial ILL drops in May, 2008, ILL has restabilized, both at the "primary feature" and also the latent "new feature". If the tank was re-leaking, then the ILL should continue to drop. When the "new feature" is tracked, the ILL behavior is consisten with the LOW installation water re-distributing through the waste.

Waste material is solid at ground temperature, so if it did leak from the tank, it probably would try to self-seal.

Video shows a large cavity around the Riser7A LOW, and a noticable change in material appearance from white and luminescent to dark and dull. There is a signicant narrowing of the cavity. If this is sludge material, then the permeability would be low, and not much liquid waste could be moving through it.

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

Surface Level Measurement - Liquid Observation Well Interdependence - Part 4

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

Considering that in-tank data sources may be interdependent:

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

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

L(SLM|LOW) = p(SLM|LOW,L)/p(SLM|LOW,NL) . If either surface level measurement data or LOW 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.

Liquid Observation Well - Surface Level Measurement Interdependence - Part 5

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

Considering that in-tank data sources may be interdependent:

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

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

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

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

Gross Gamma Drywell Logs	p(GGL|L) (if no GGL, enter NA here and in Parts 8 and 9)	p(GGL|NL)	L(GGL)
	0.50	0.50	1.00

Most of the historical gross gamma peaks 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.

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

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

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

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

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

Spectral Gamma Drywell Logs	p(SGL|L) (if no SGL, enter NA here and in Parts 8 and 9)	p(SGL|NL)	L(SGL)
	0.50	0.50	1.00

Spectral gammas measured in 1995, 1998, and 2008 showed no changes in baseline, consistent with earlier gross gammas.

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.

Gross Gamma Log - Spectral Gamma Log Interdependence - Part 8

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

Considering that ex-tank data sources may be interdependent:

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

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

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

Spectral Gamma Log - Gross Gamma Log Interdependence - Part 9

Spectral Gamma Log - Gross Gamma Log Interdependence	p(SGL|GGL,L)	p(SGL|GGL,NL)	L(SGL|GGL)
	0.50	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	0.43	1.00	1.00

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

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

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

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

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

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

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

Ex-Tank Liklihood Ratio	L(SGL,GGL)
	1.00

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

Combined Likelihood Ratio for Leak Hypothesis	L(in,ex)
	0.43

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
0.22	0.78	0.29

Ω_1 = posterior (post-leak assessment) odds in favor of leak hypothesis. $\Omega_1 = L(in,ex) \times \Omega_O$
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 C
REPORT ON DRYWELL INVESTIGATIONS AROUND SST SX-1O4
S. M. STOLLER CORPORATION

June 3, 2008

Stoller
Hanford Office

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.

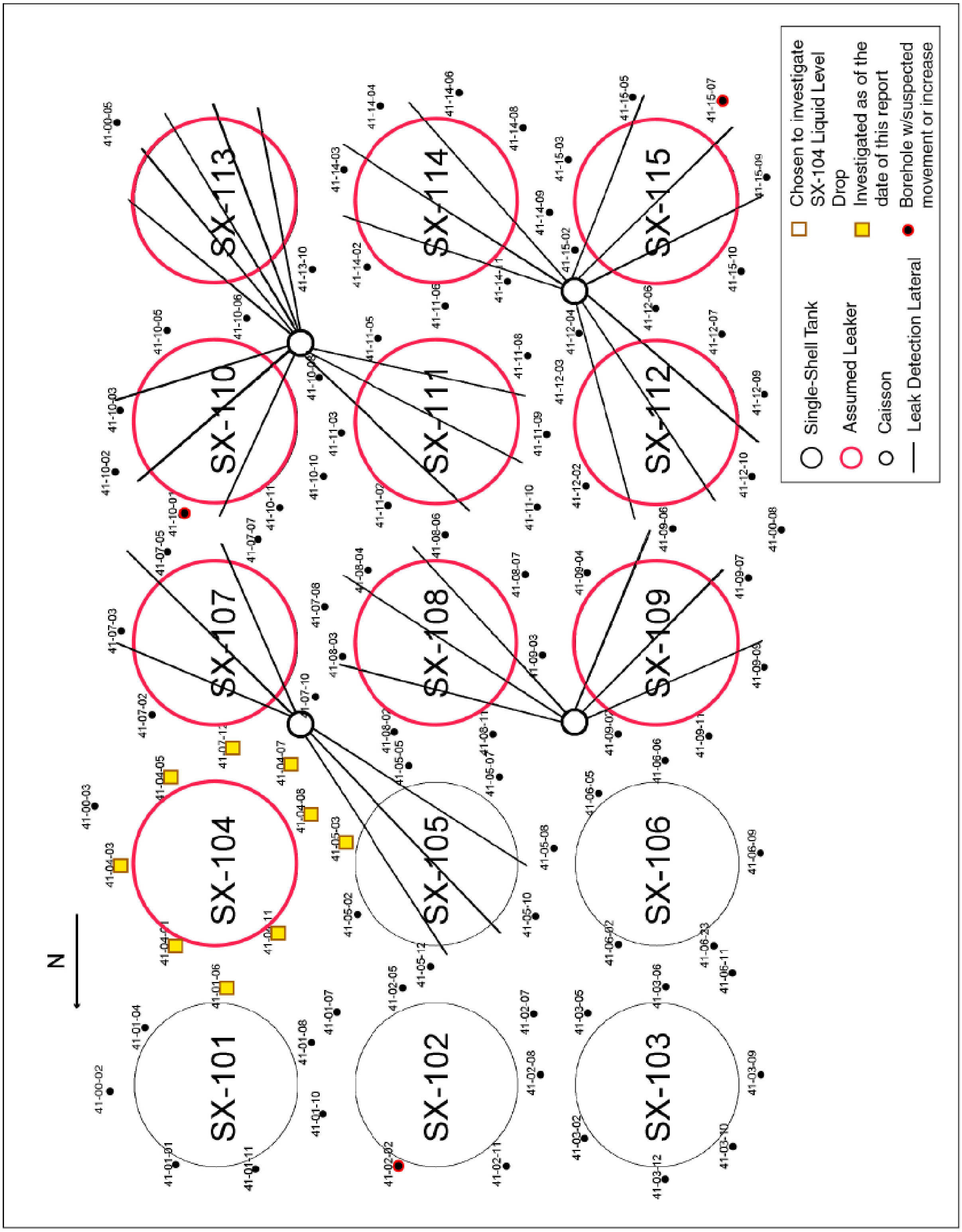
41-04-07 exhibits an apparent slight decrease in gross counts from about 80 to 100 ft between 1995, 1998, and 2008. This decrease cannot be attributed to the decay of previously observed gamma-emitting radionuclides. There are a number of other borehole and tool-related variables that can occasionally 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 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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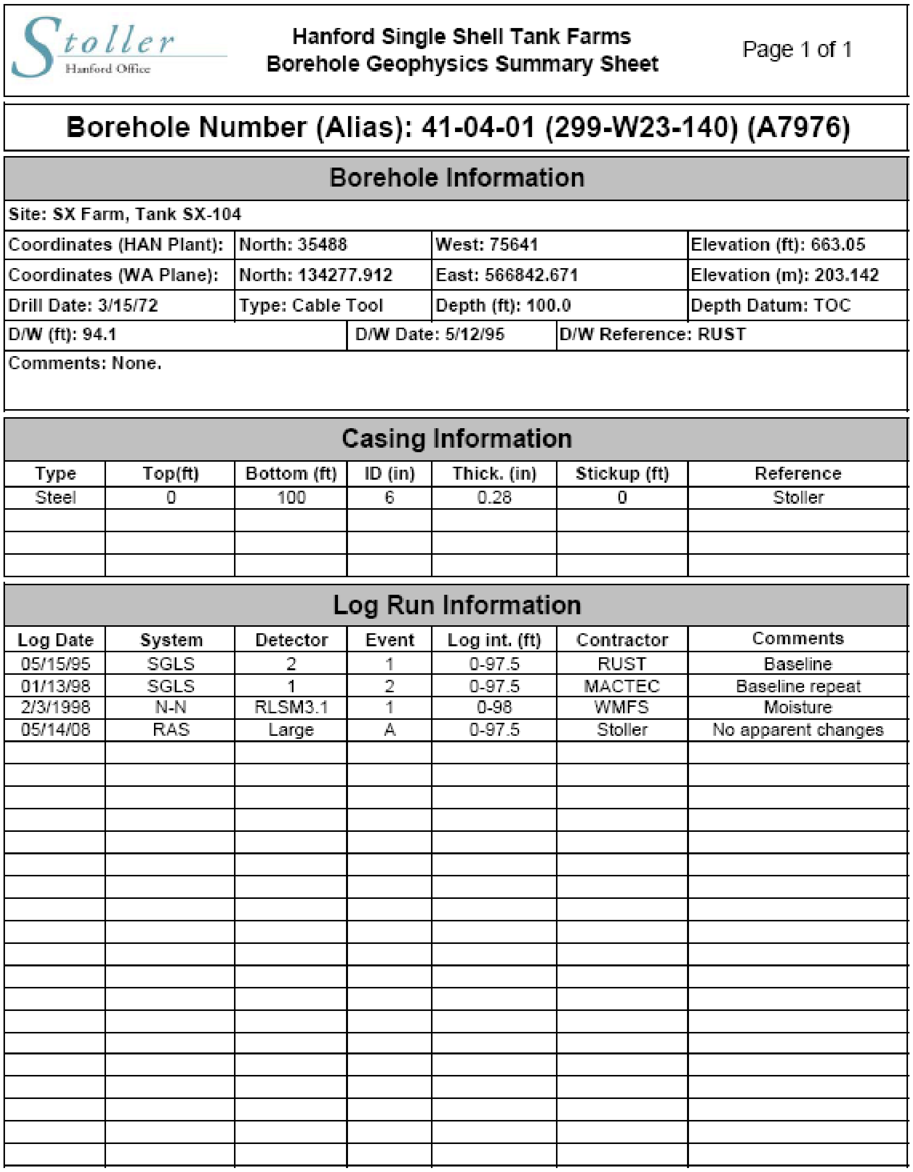
41-14-11
41-15-02
41-15-03
41-15-05
41-15-07
41-15-09
41-15-10
○ Single-Shell Tank
○ Assumed Leaker
○ Caisson
— Leak Detection Lateral
☐ Chosen to investigate SX-104 Liquid Level Drop
■ Investigated as of the date of this report
● Borehole w/suspected movement or increase



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Hanford Single Shell Tank Farms
Borehole Geophysics Summary Sheet

Page 1 of 1

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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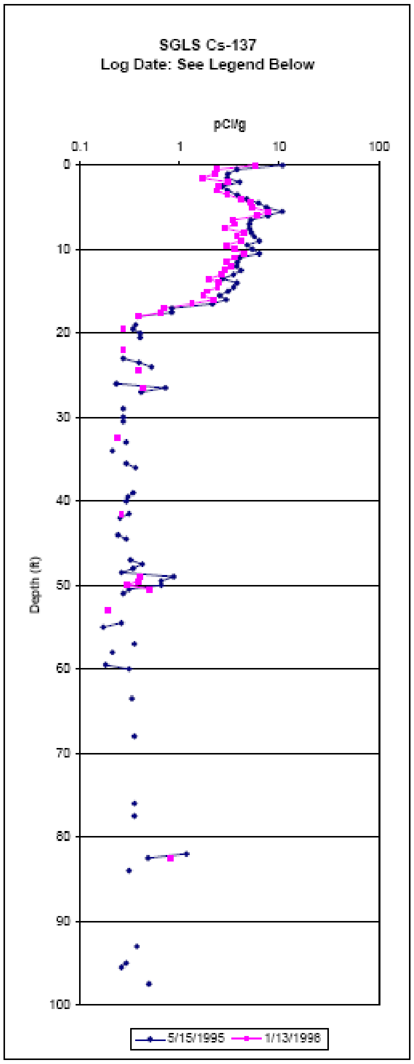
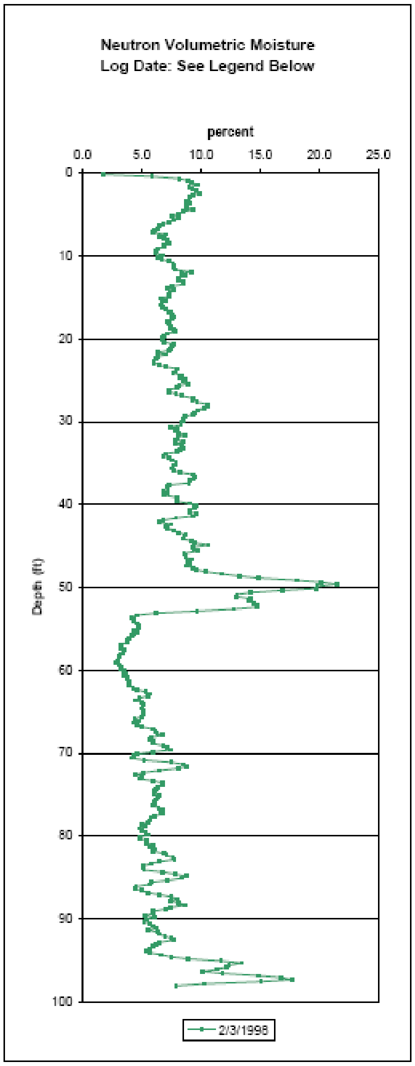
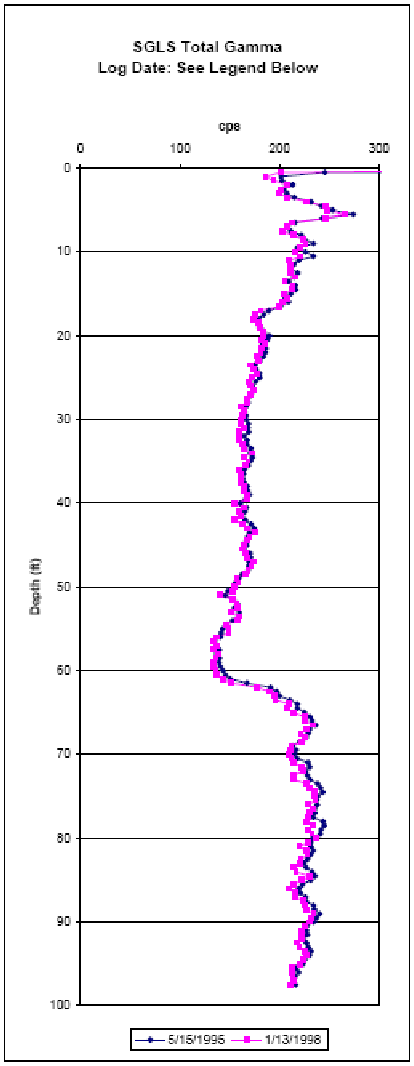
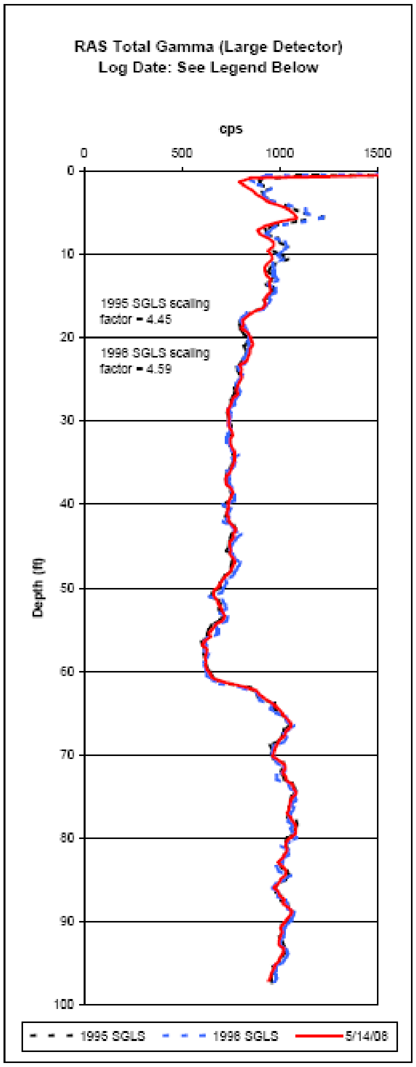
Borehole 41-04-01

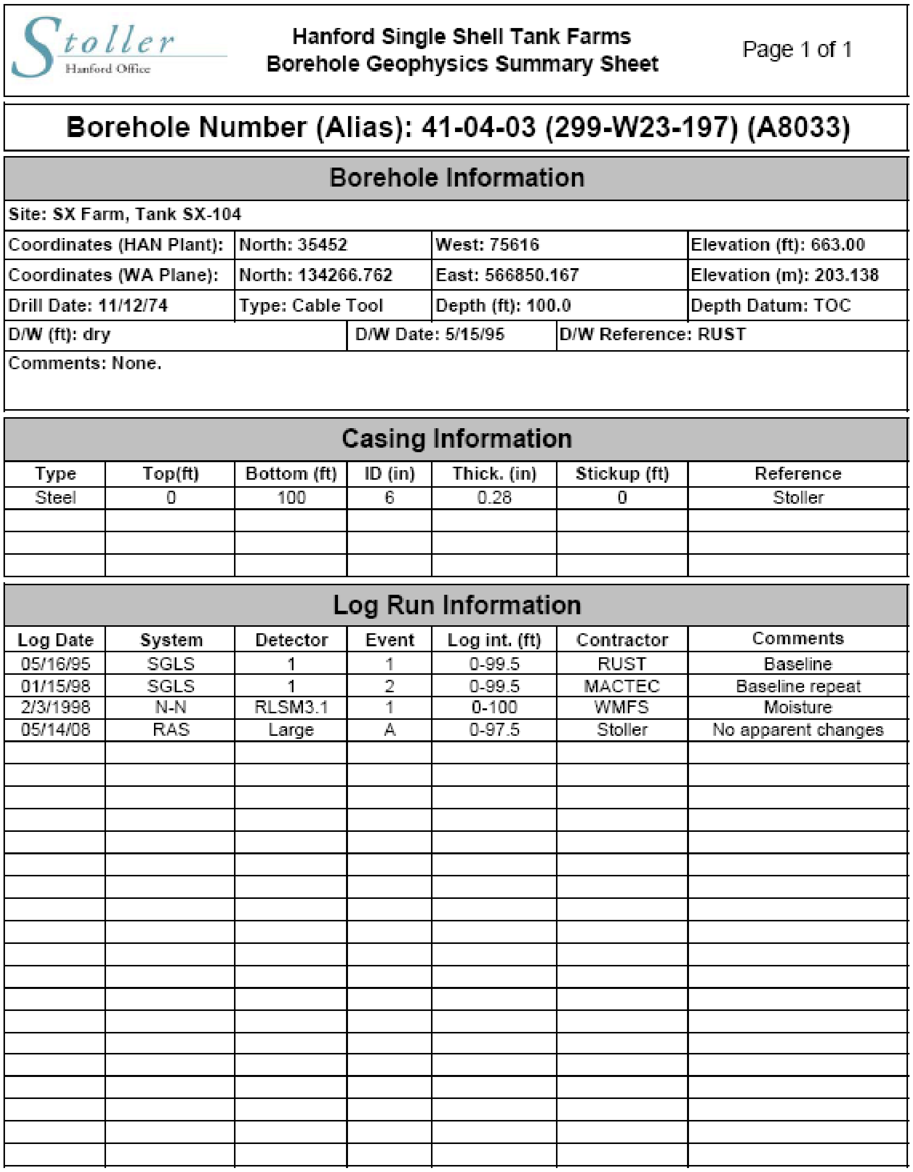




Borehole 41-04-01







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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

Stoller
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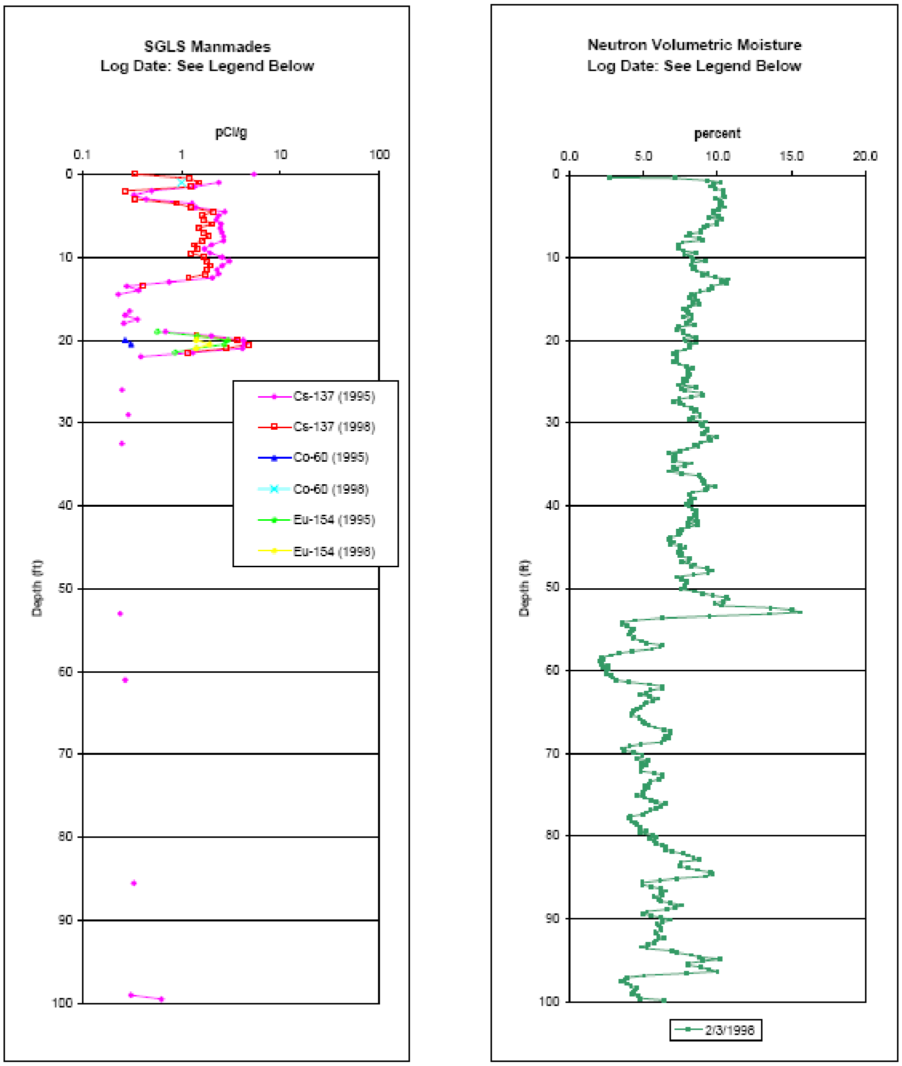
Borehole 41-04-03



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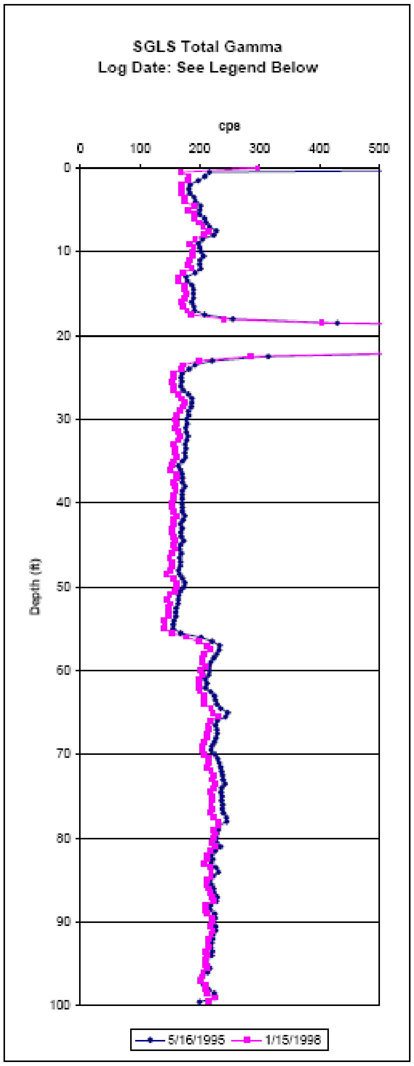
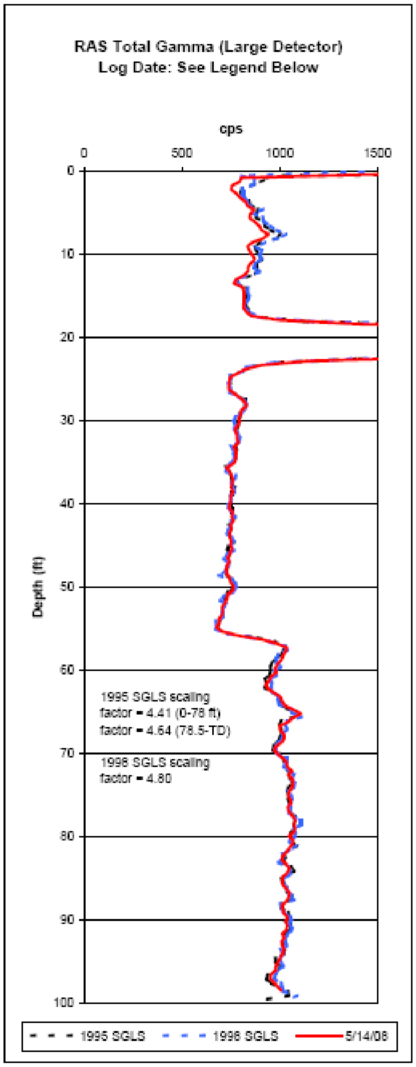
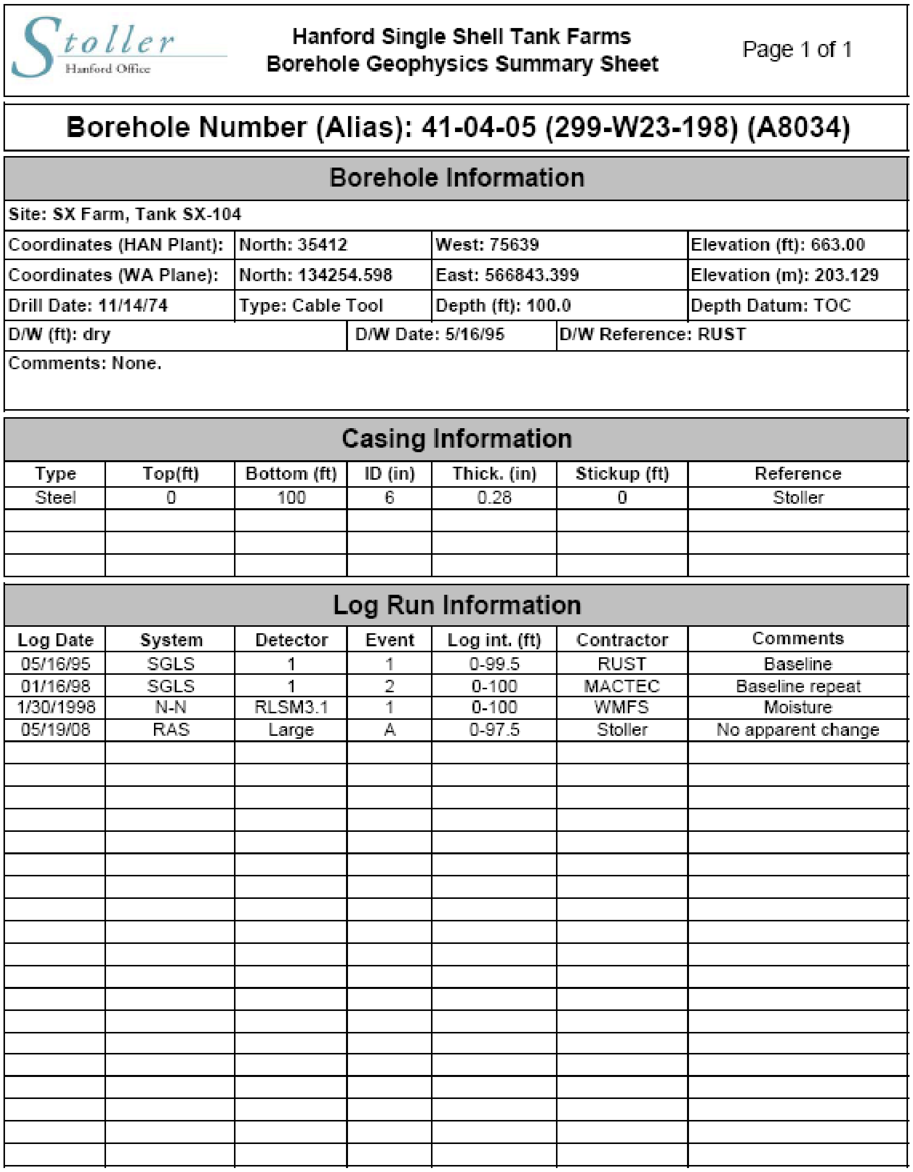
Borehole 41-04-03







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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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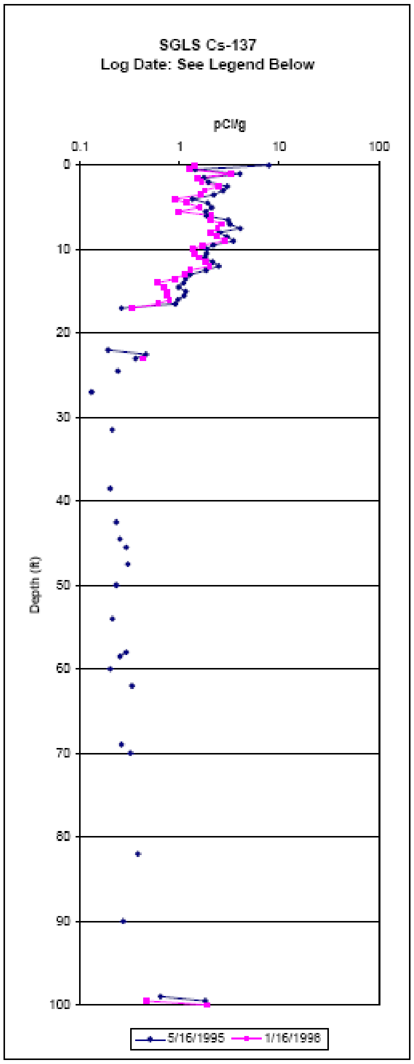
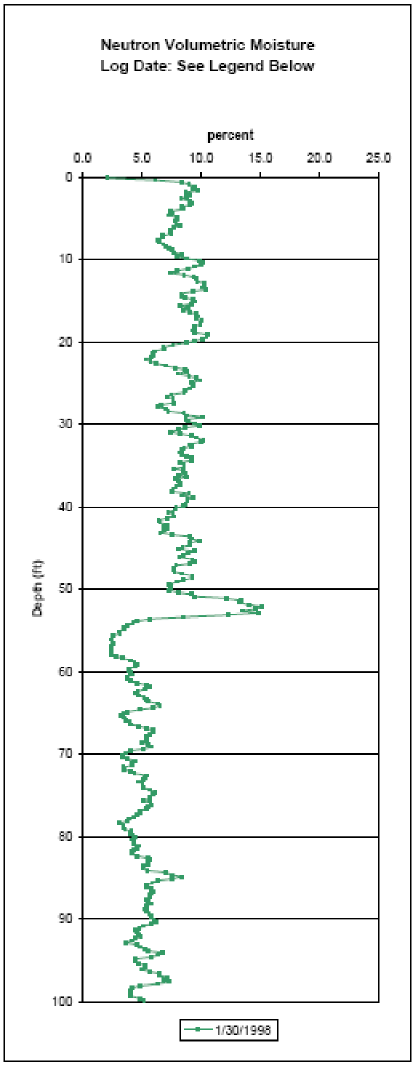
Borehole 41-04-05





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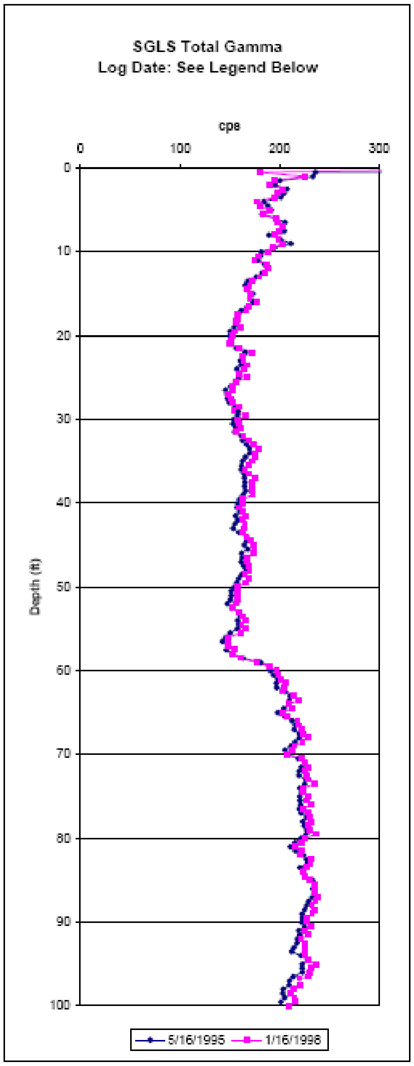
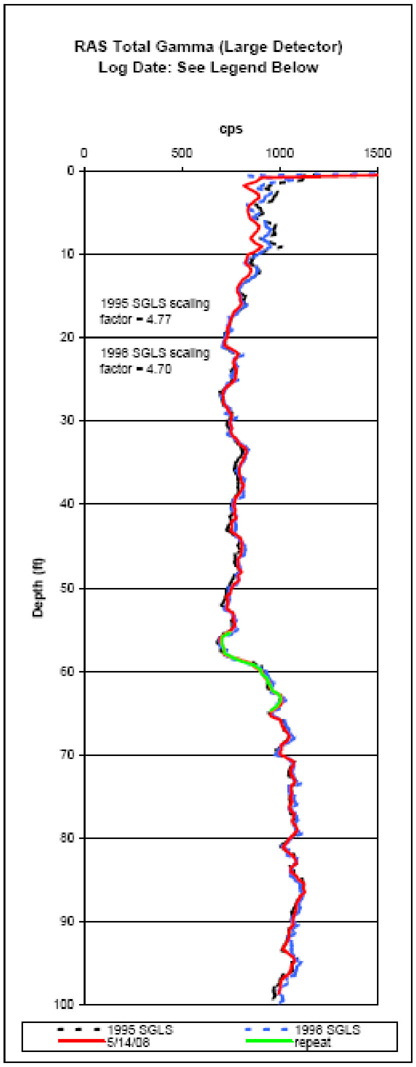
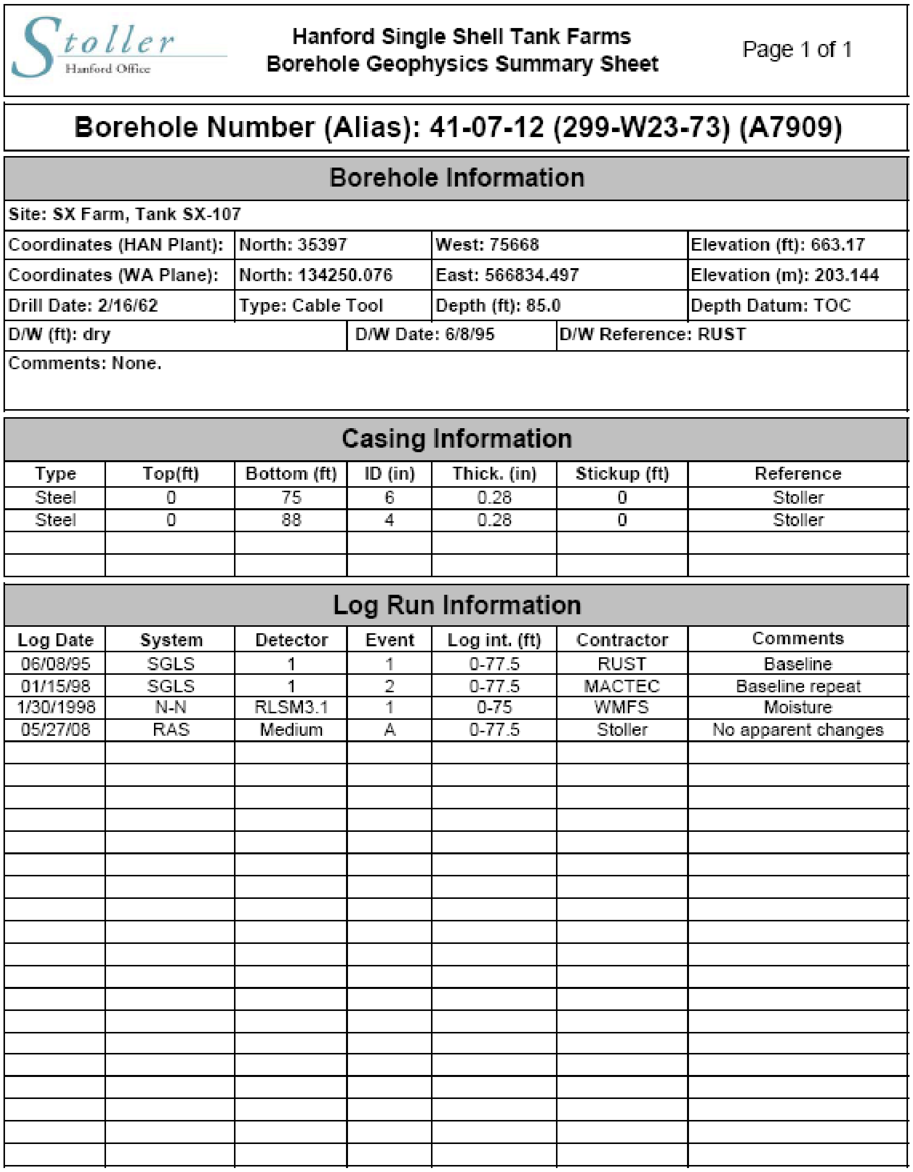
Borehole 41-04-05







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Hanford Single Shell Tank Farms
Borehole Geophysics Summary Sheet

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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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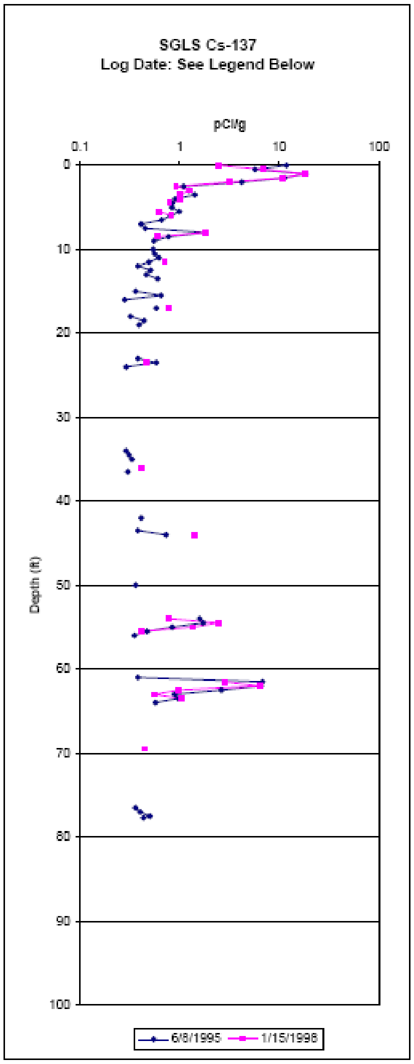
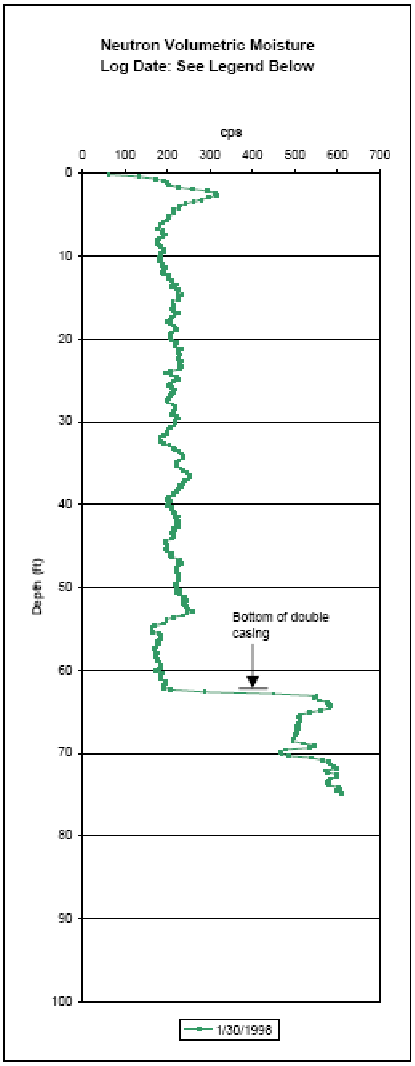
Borehole 41-07-12





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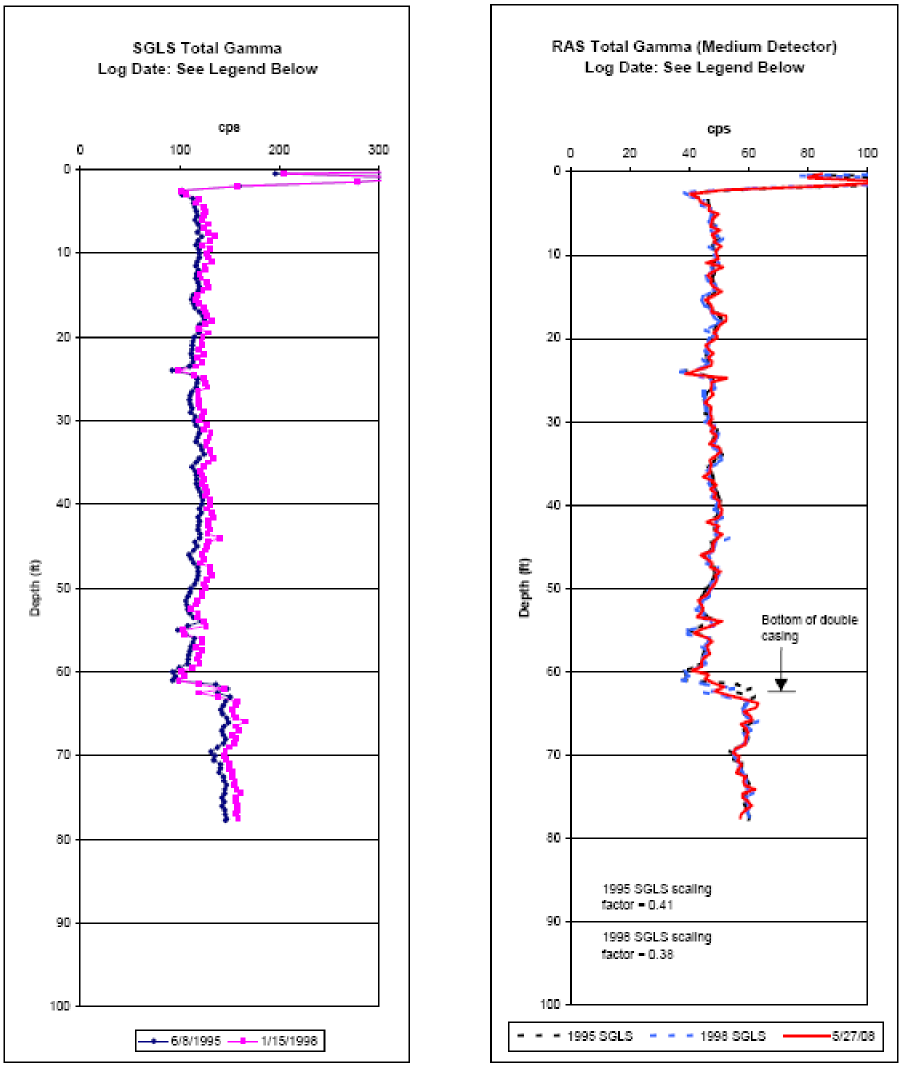
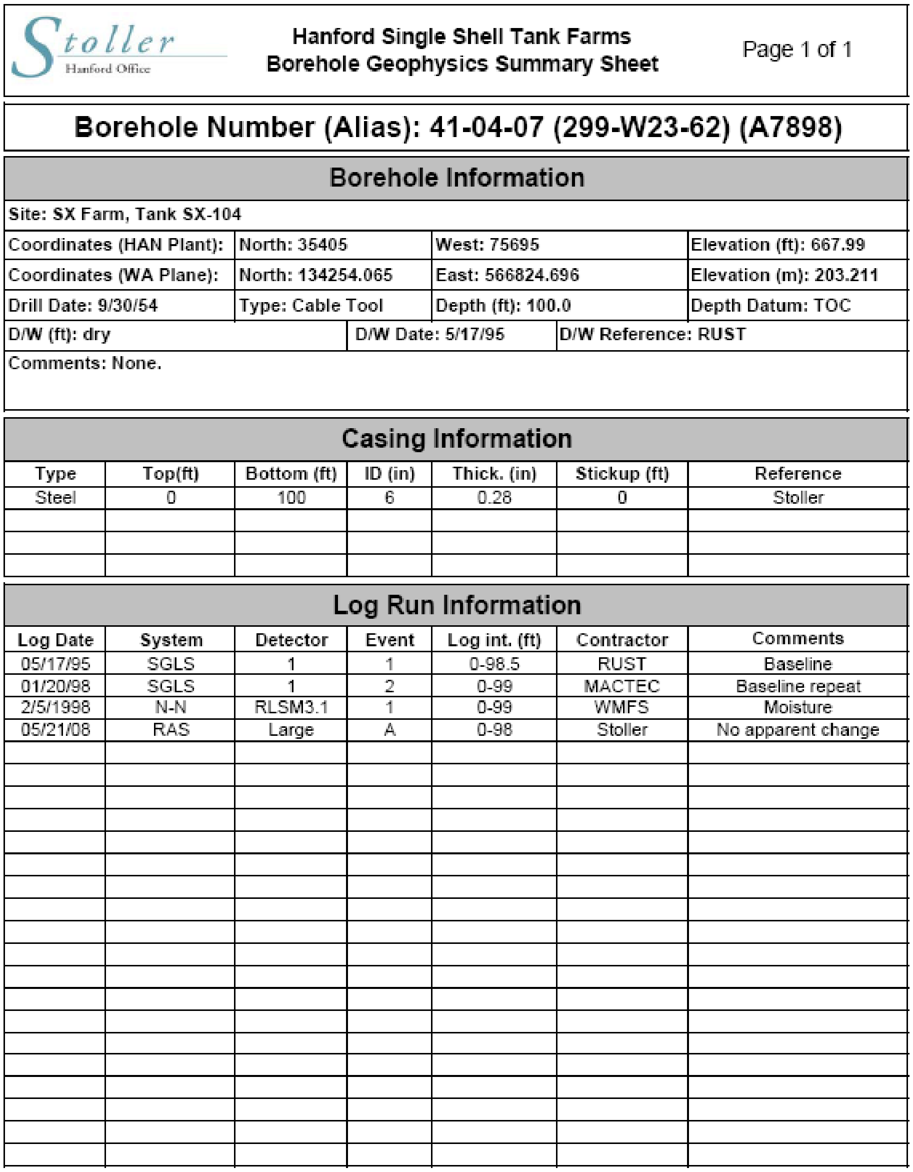
Borehole 41-07-12





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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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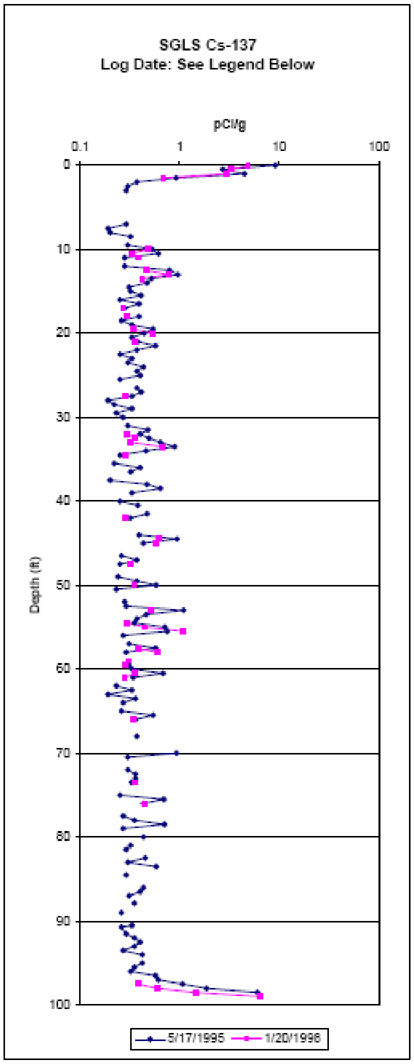
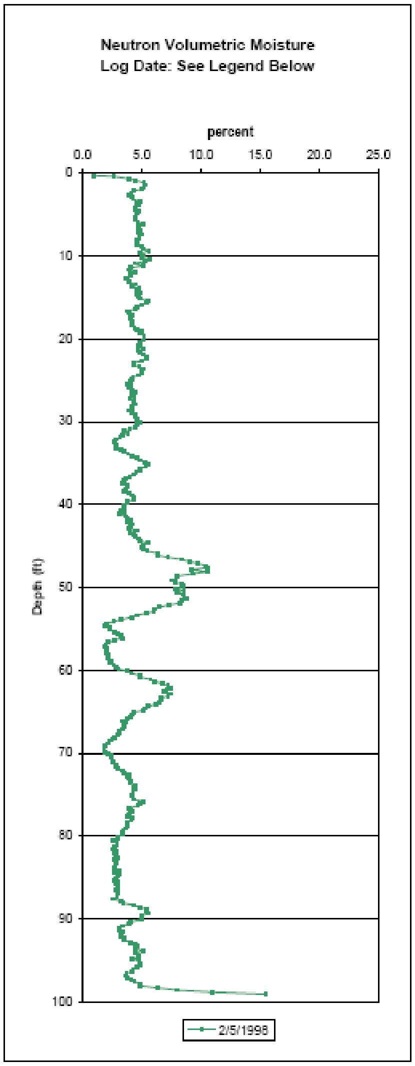
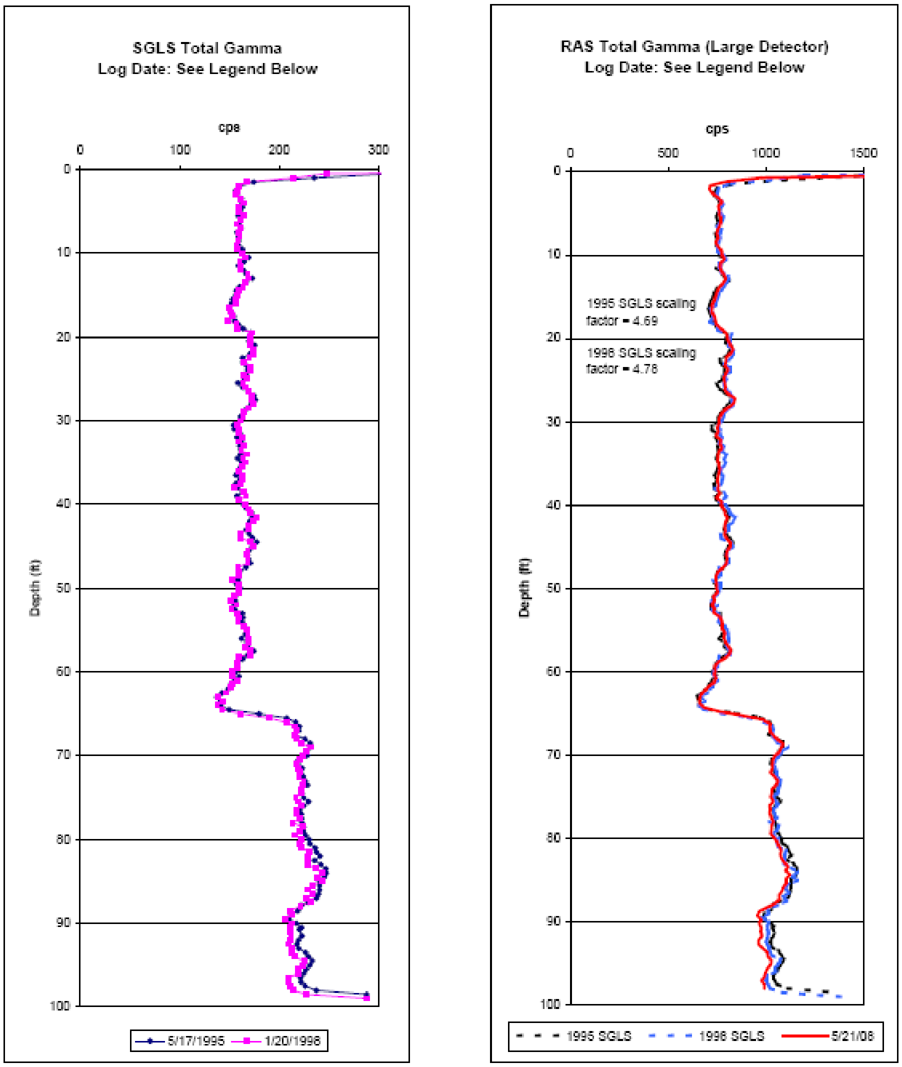
Borehole 41-04-07


SGLS Cs-137
Log Date: See Legend Below


Neutron Volumetric Moisture
Log Date: See Legend Below

Borehole 41-04-07

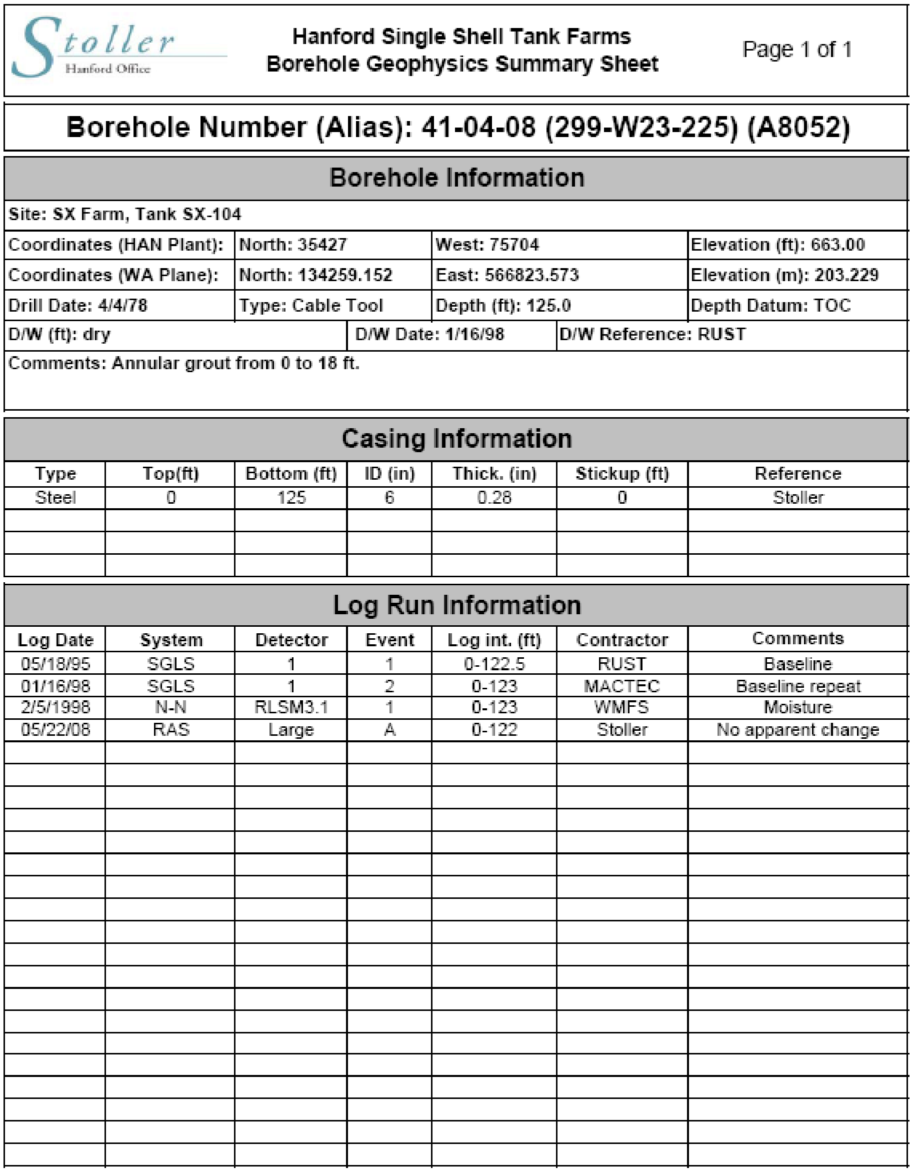


SGLS Total Gamma
Log Date: See Legend Below

RAS Total Gamma (Large Detector)
Log Date: See Legend Below

1995 SGLS scaling factor = 4.69

1998 SGLS scaling factor = 4.78



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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

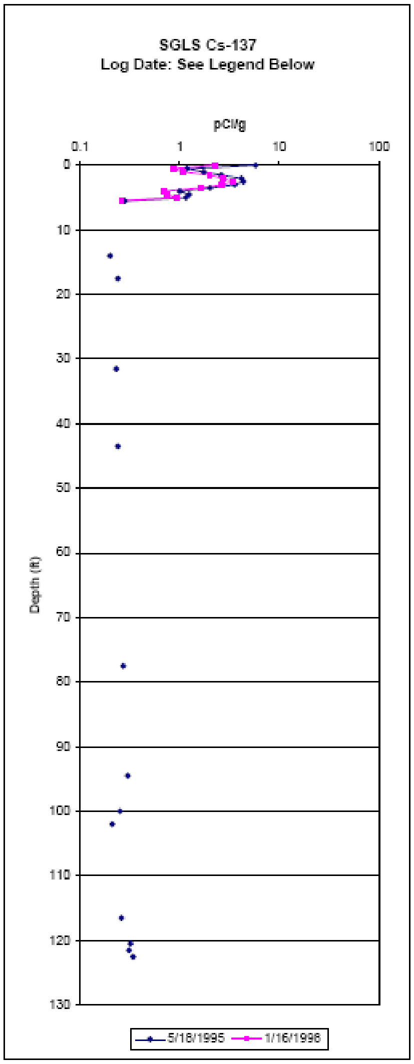
Type	Top(ft)	Bottom (ft)	ID (in)	Thick. (in)	Stickup (ft)	Reference
Steel	0	125	6	0.28	0	Stoller

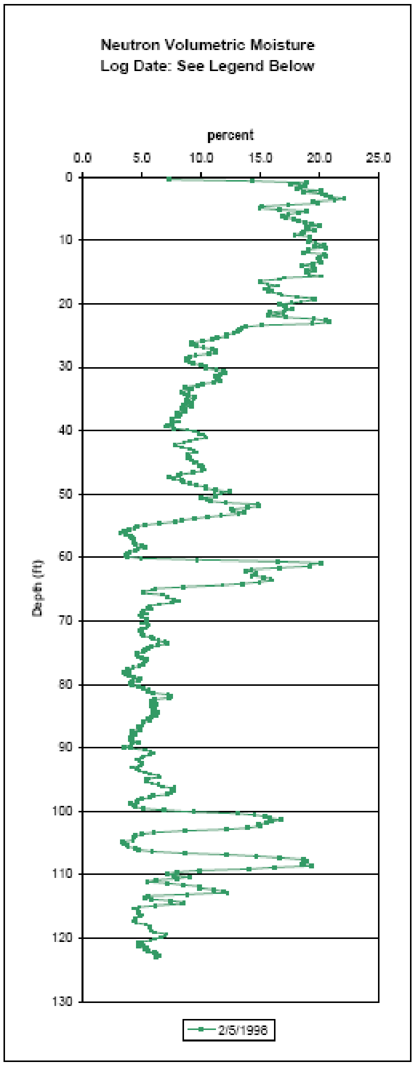
Log Run Information

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

Stoller
Hanford Office

Borehole 41-04-08





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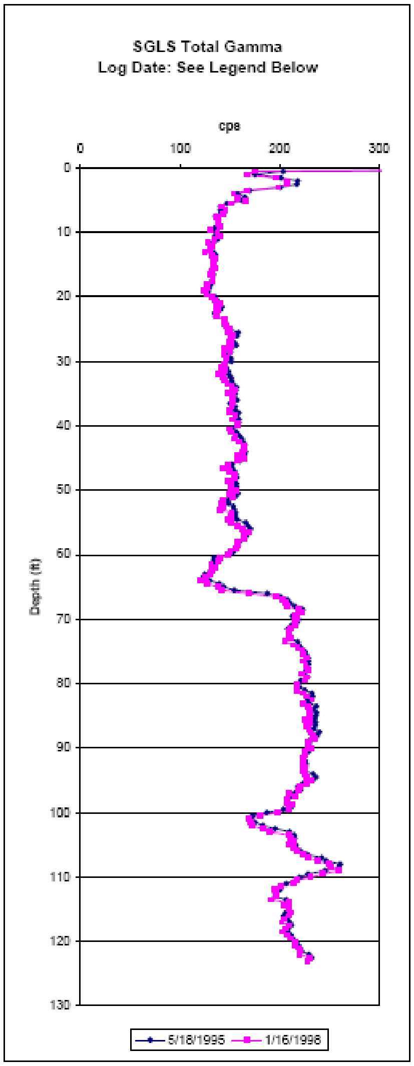
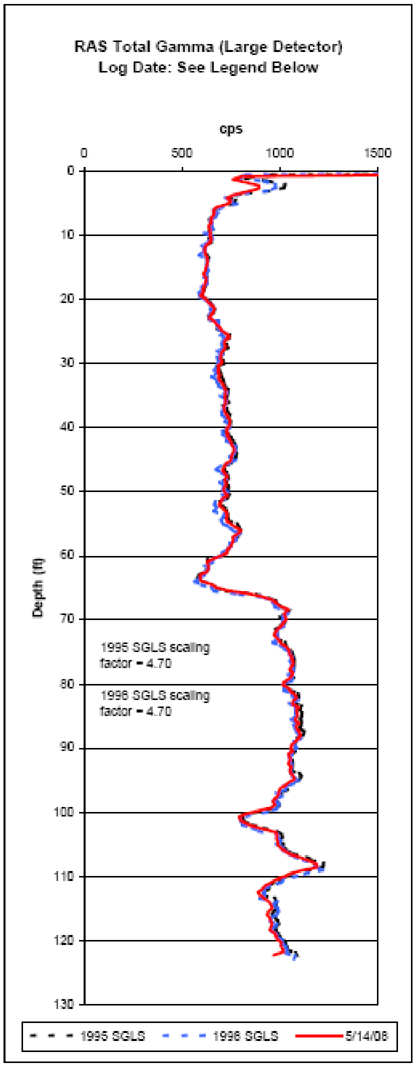
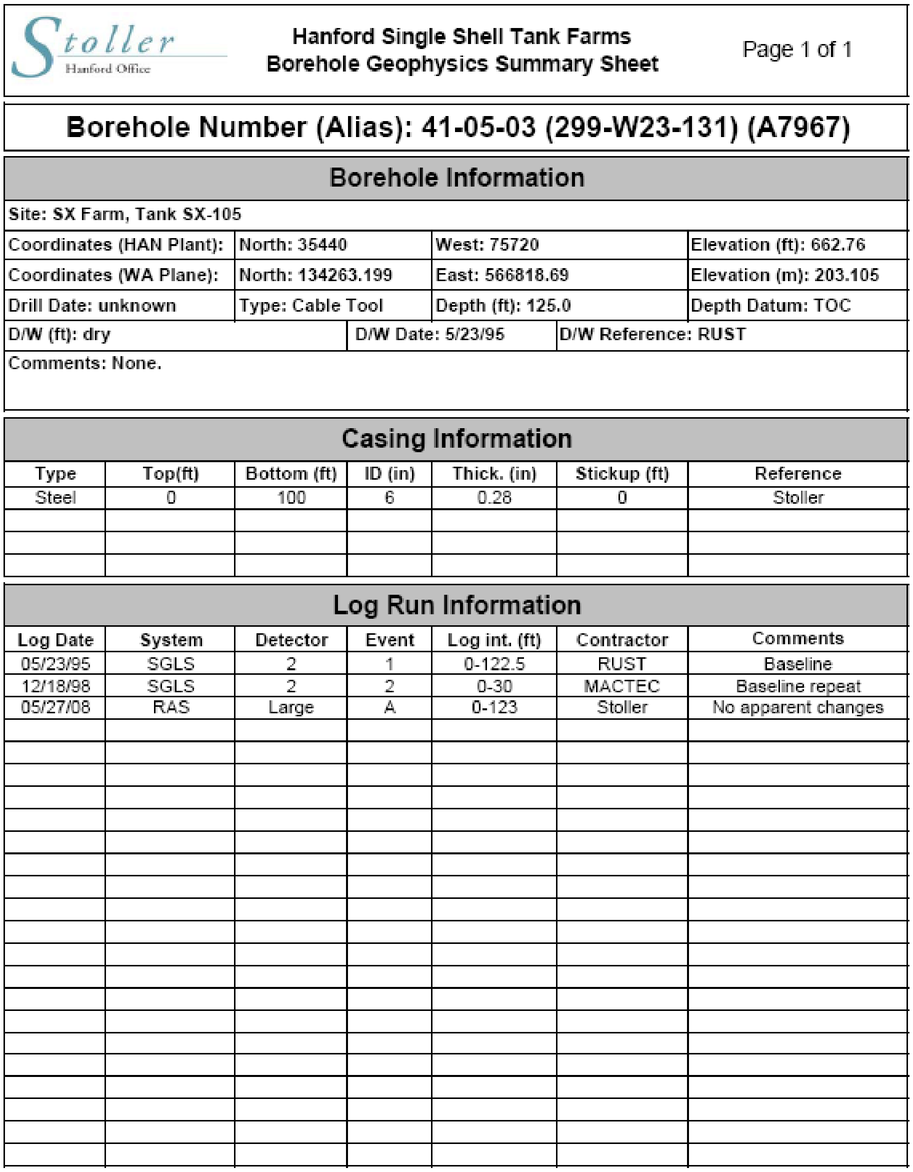
Borehole 41-04-08







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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
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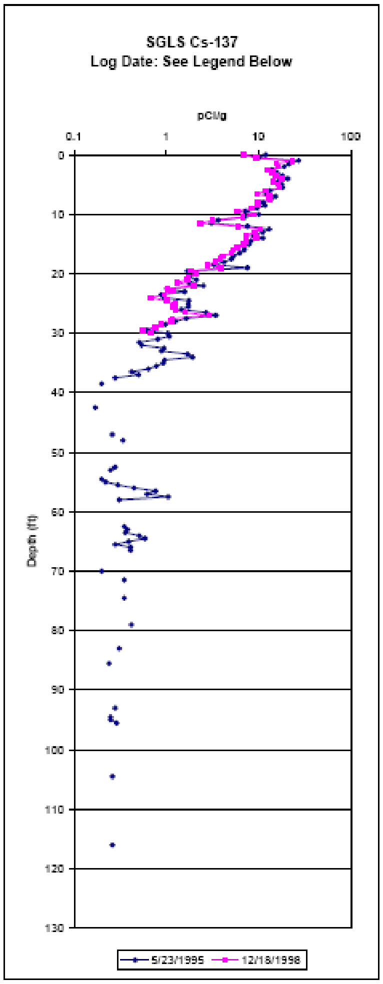
Borehole 41-05-03



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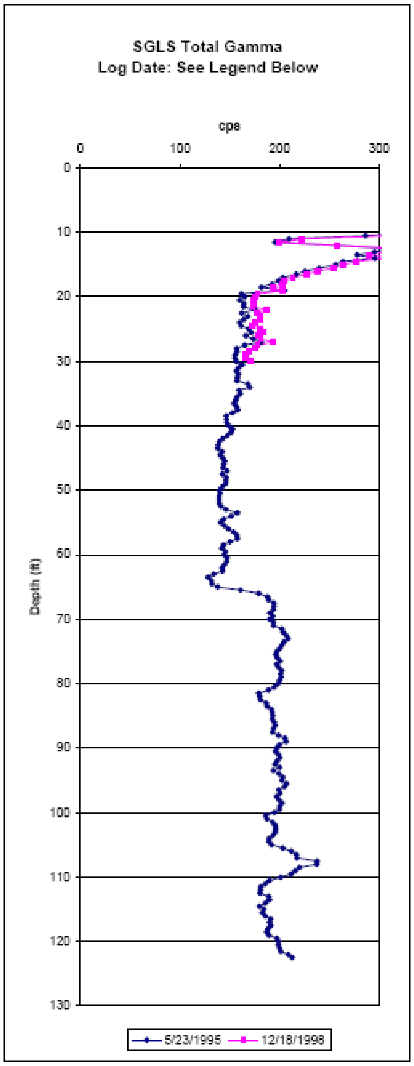
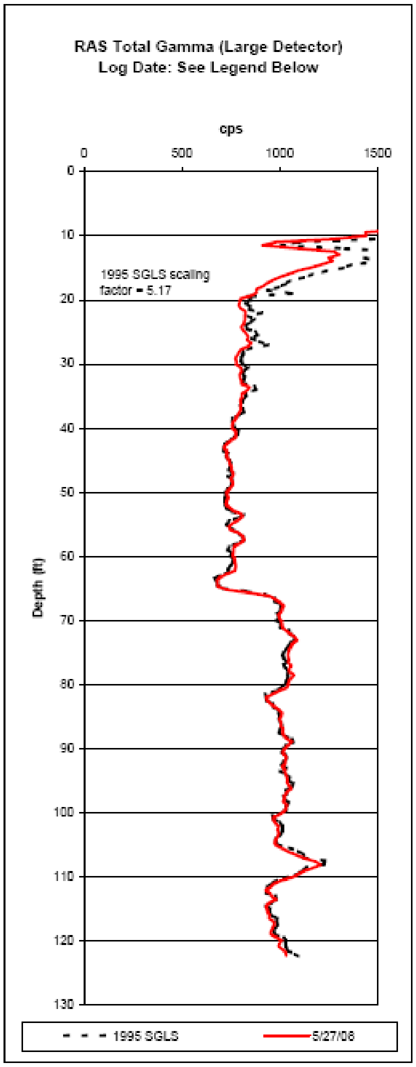
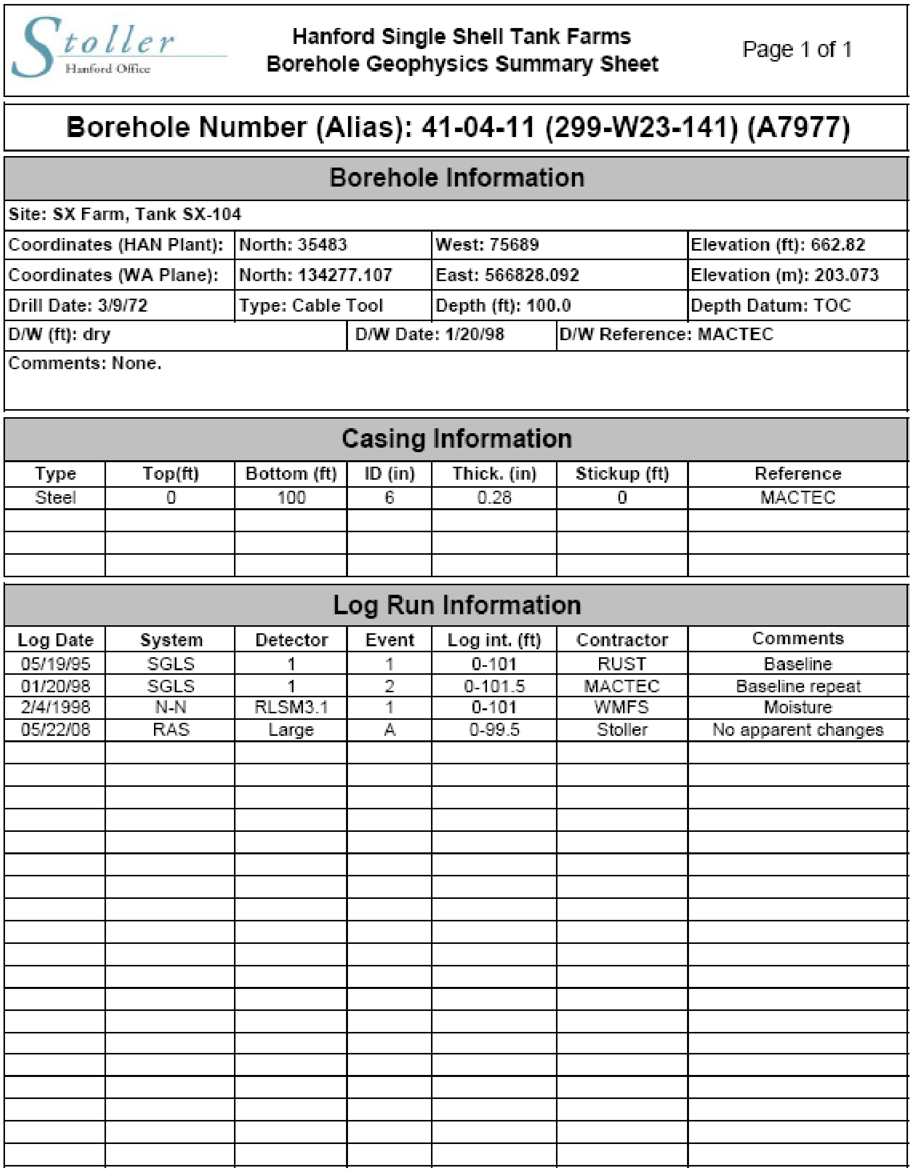
Borehole 41-05-03







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Hanford Single Shell Tank Farms
Borehole Geophysics Summary Sheet

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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

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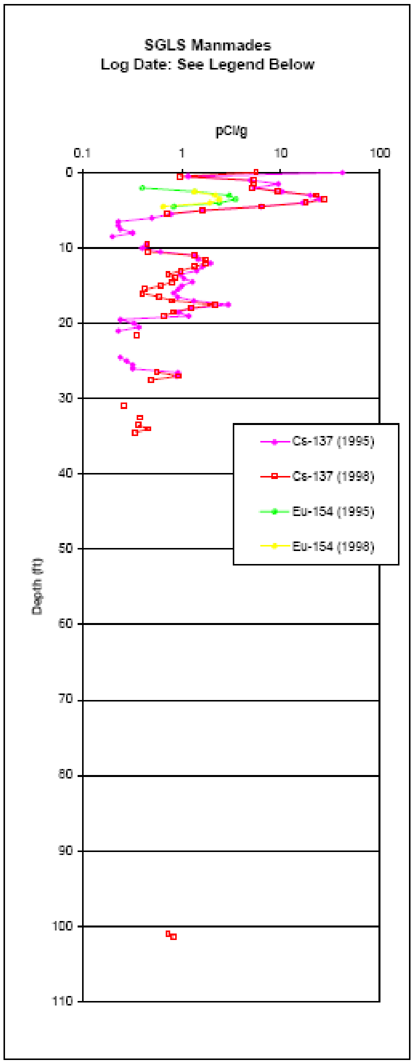
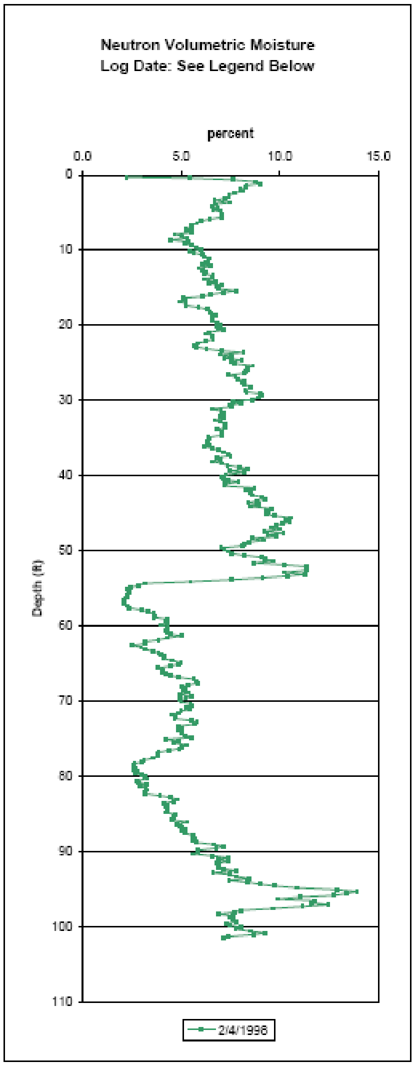
Borehole 41-04-11





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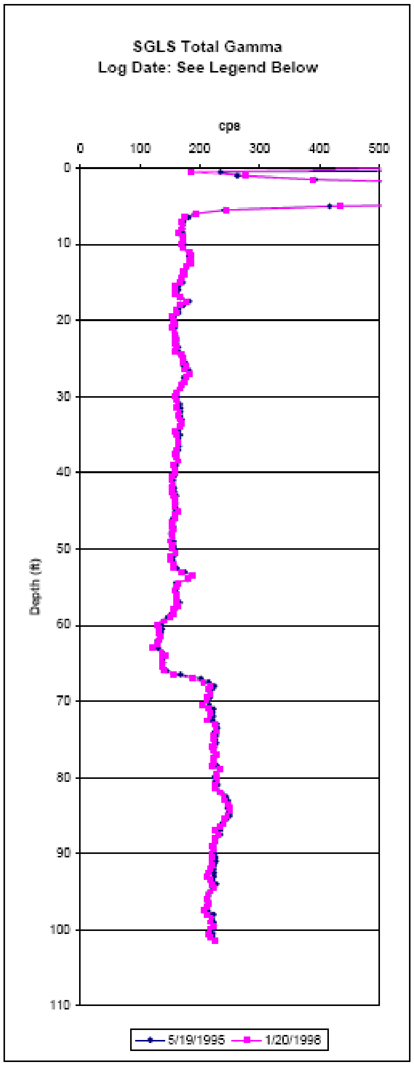
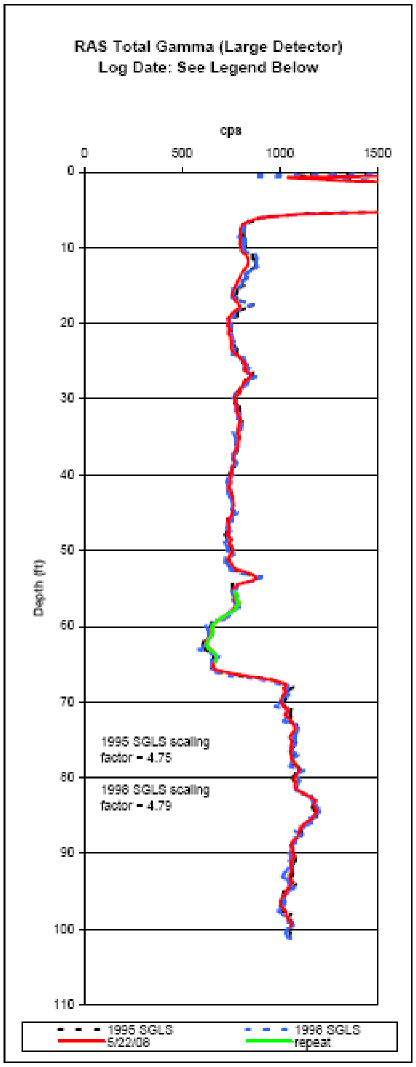
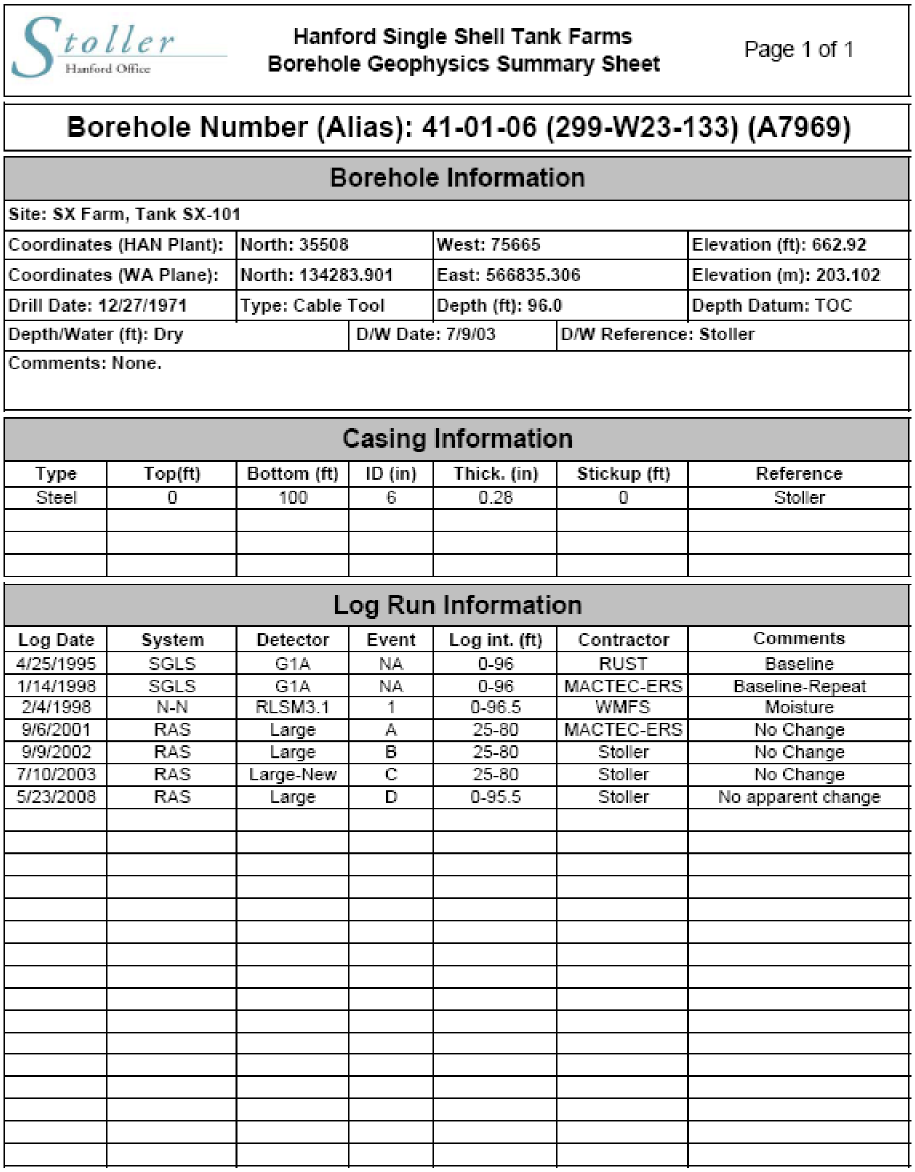
Borehole 41-04-11







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Hanford Single Shell Tank Farms
Borehole Geophysics Summary Sheet

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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.			

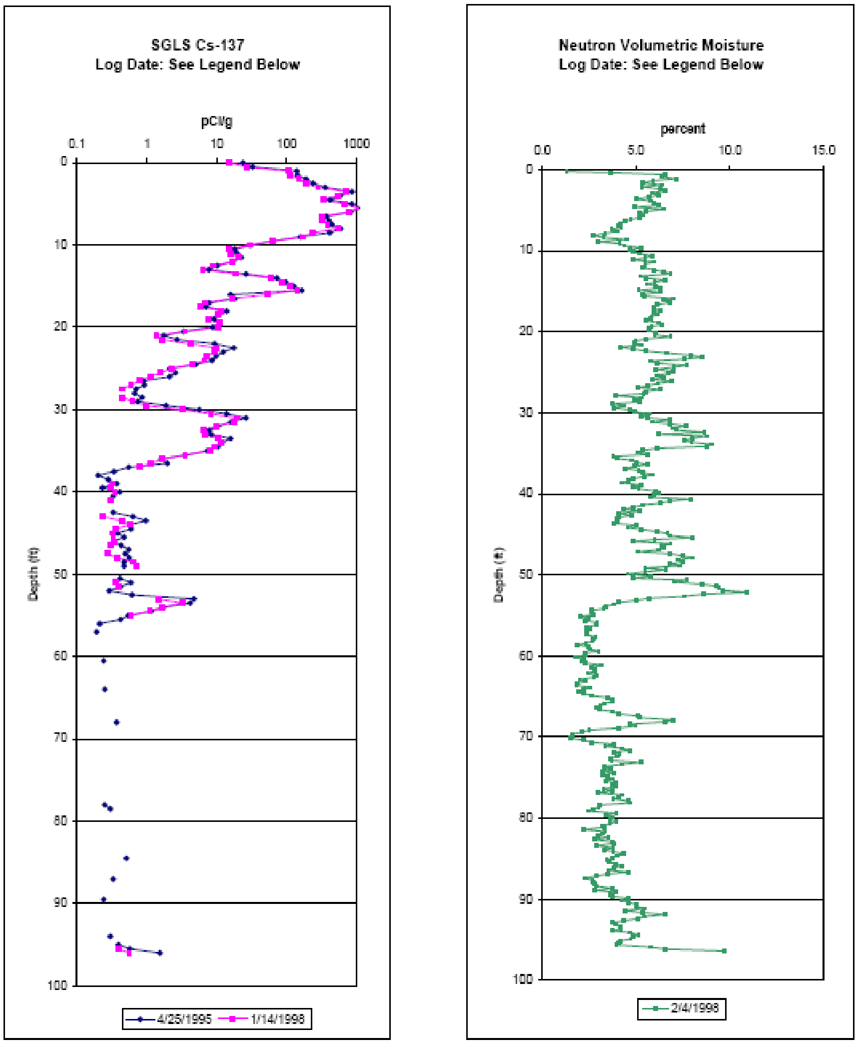
Casing Information

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

Borehole 41-01-06



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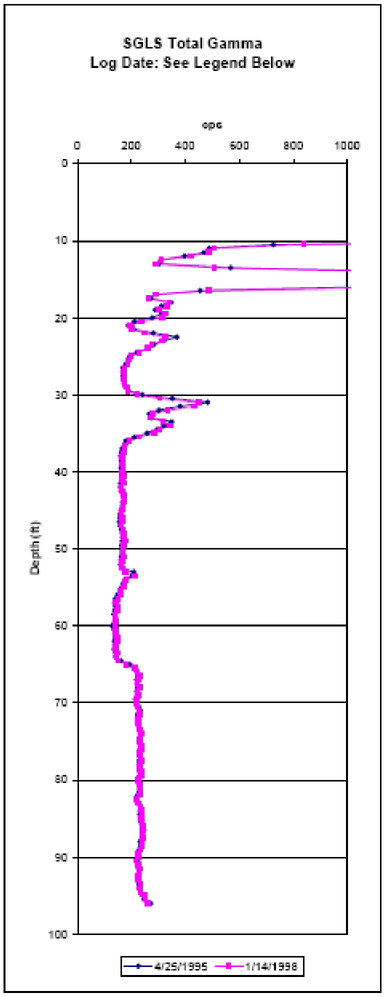
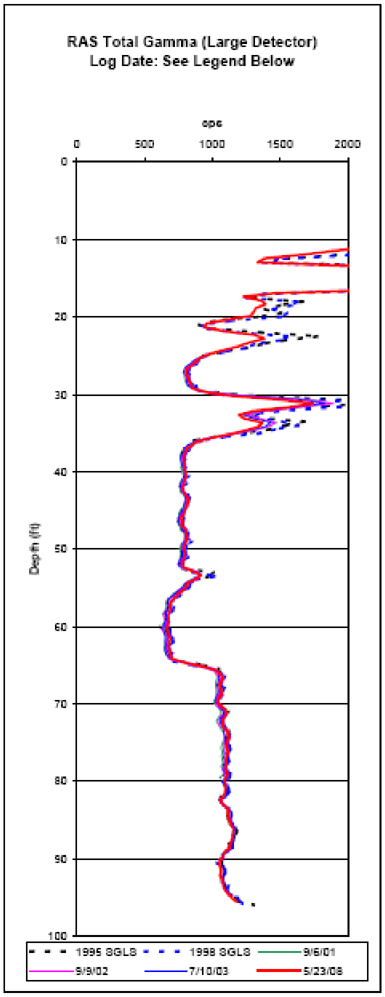
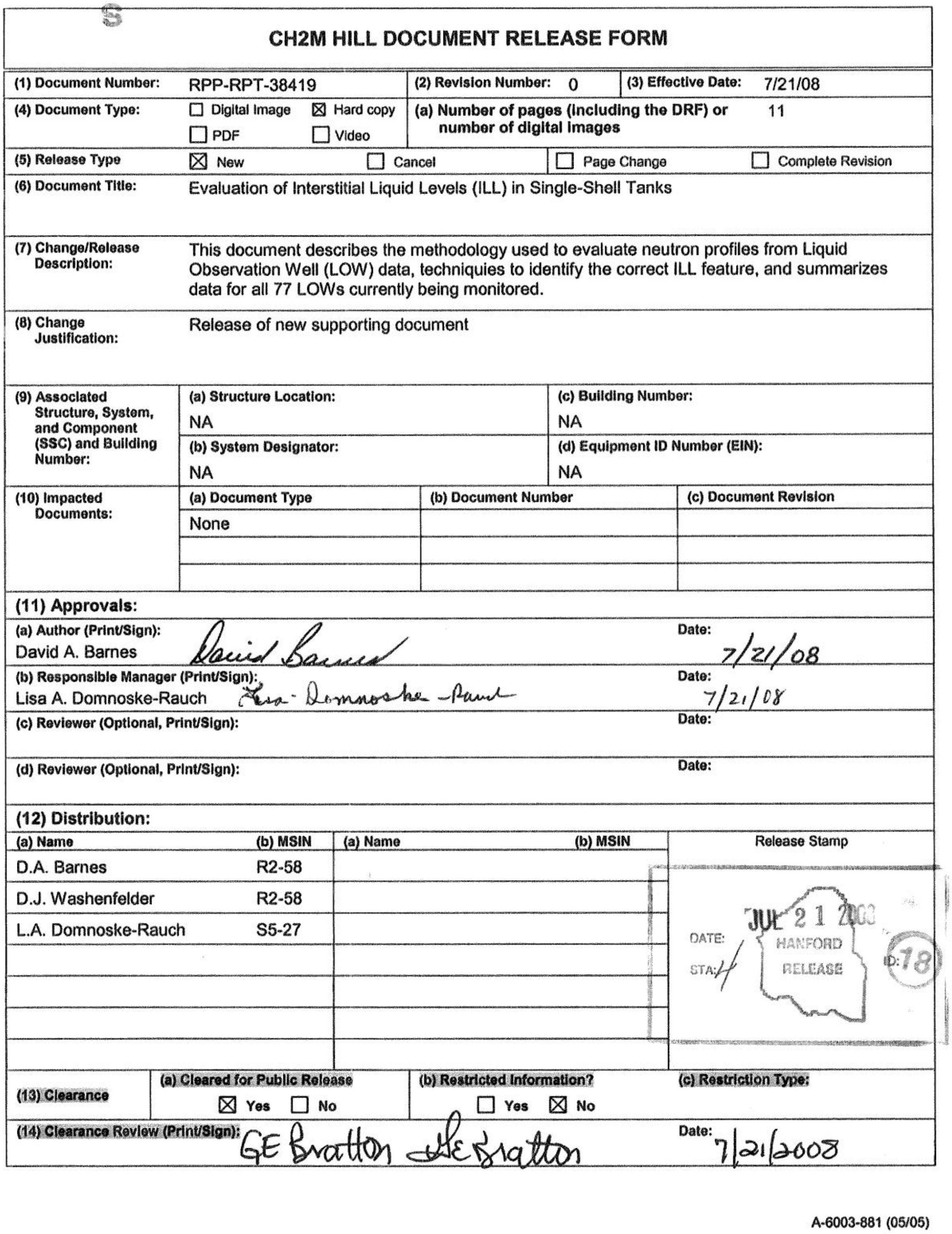




APPENDIX D
RPP-RPT-38419, REV. 0 EVALUATION OF INTERSTITIAL LIQUID LEVELS IN SINGLE SHELL TANKS,

July 21, 2008



CH2M HILL DOCUMENT RELEASE FORM

(1) Document Number: RPP-RPT-38419
(2) Revision Number: 0
(3) Effective Date: 7/21/08

(4) Document Type: ☐ Digital Image ☒ Hard copy ☐ PDF ☐ Video
(a) Number of pages (including the DRF) or number of digital images 11

(5) Release Type ☒ New ☐ Cancel ☐ Page Change ☐ Complete Revision

(6) Document Title: Evaluation of Interstitial Liquid Levels (ILL) in Single-Shell Tanks

(7) Change/Release Description: This document describes the methodology used to evaluate neutron profiles from Liquid Observation Well (LOW) data, techniquies to identify the correct ILL feature, and summarizes data for all 77 LOWs currently being monitored.

(8) Change Justification: Release of new supporting document

(9) Associated Structure, System, and Component (SSC) and Building Number:
(a) Structure Location: NA
(c) Building Number: NA
(b) System Designator: NA
(d) Equipment ID Number (EIN): NA

(10) Impacted Documents:

(a) Document Type	(b) Document Number	(c) Document Revision
None		

(11) Approvals:
(a) Author (Print/Sign): David A. Barnes David Barnes **Date:** 7/21/08
(b) Responsible Manager (Print/Sign): Lisa A. Domnoske-Rauch Lisa Domnoske-Rauch **Date:** 7/21/08
(c) Reviewer (Optional, Print/Sign): **Date:**
(d) Reviewer (Optional, Print/Sign): **Date:**

(12) Distribution:

(a) Name	(b) MSIN	(a) Name	(b) MSIN
D.A. Barnes	R2-58		
D.J. Washenfelder	R2-58		
L.A. Domnoske-Rauch	S5-27		

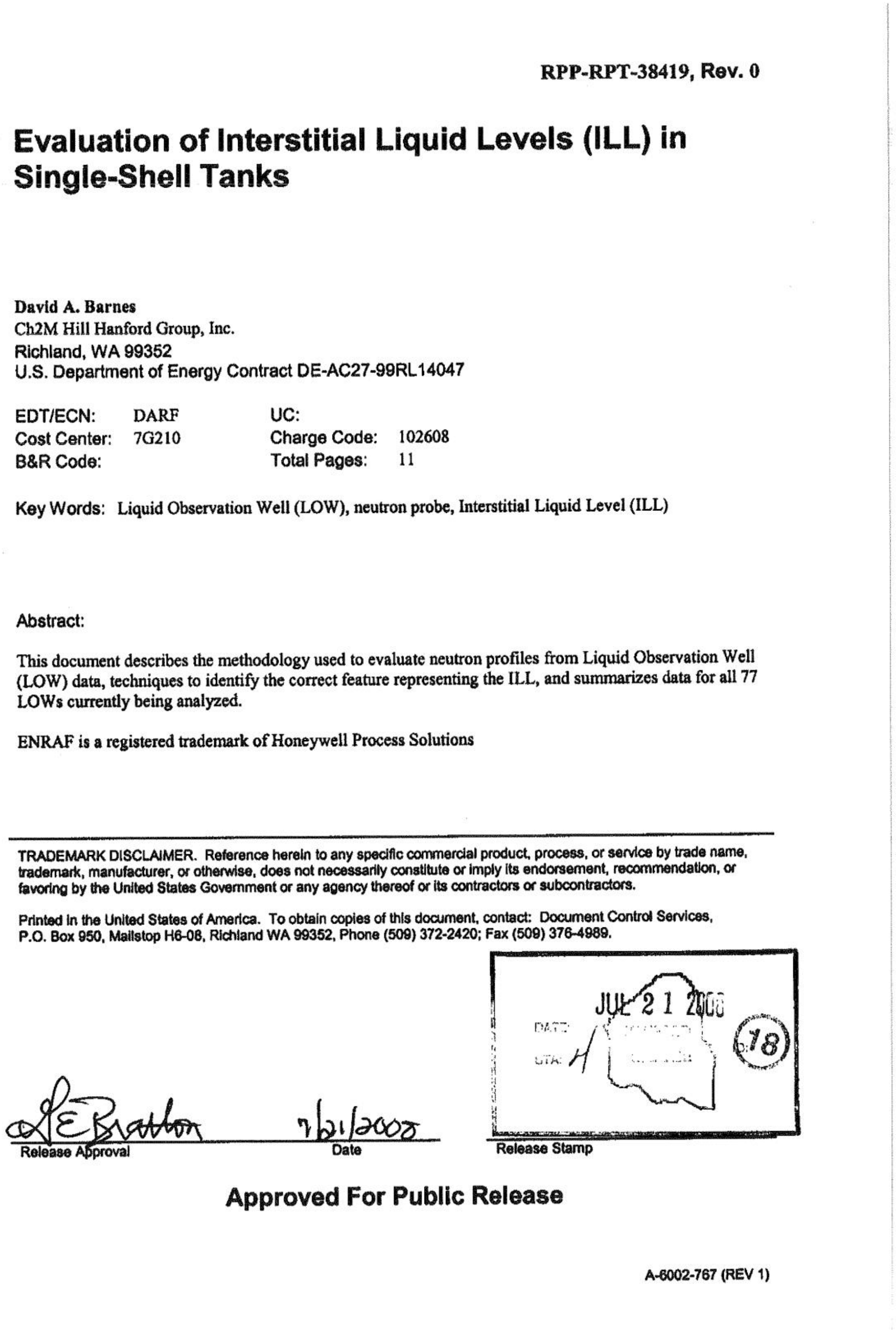
Release Stamp

DATE: JUL 21 2008
STA: 4
HANFORD RELEASE
ID: 18

(13) Clearance
(a) Cleared for Public Release ☒ Yes ☐ No
(b) Restricted Information? ☐ Yes ☒ No
(c) Restriction Type:

(14) Clearance Review (Print/Sign): GE Bratton GE Bratton **Date:** 7/21/2008

A-6003-881 (05/05)



RPP-RPT-38419, Rev. 0

Evaluation of Interstitial Liquid Levels (ILL) in Single-Shell Tanks

David A. Barnes
Ch2M Hill Hanford Group, Inc.
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Key Words: Liquid Observation Well (LOW), neutron probe, Interstitial Liquid Level (ILL)

Abstract:

This document describes the methodology used to evaluate neutron profiles from Liquid Observation Well (LOW) data, techniques to identify the correct feature representing the ILL, and summarizes data for all 77 LOWs currently being analyzed.

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EVALUATION OF INTERSTITIAL LIQUID LEVELS (ILL) IN SINGLE-SHELL TANKS

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Evaluation of Interstitial Liquid Levels (ILL) in Single Shell Tanks
by David A. Barnes, July 2008

Introduction

During the SX-104 leak assessment performed from May to July 2008 it was determined that the major neutron feature originally assumed to be the interstitial liquid level (ILL) was actually an interface between adjacent sludge and saltcake layers, and the true ILL was a smaller neutron feature about 16 inches deeper. Once the correct neutron feature was tracked the data did not indicate a leak. In order to determine the extent of condition a review of all liquid observation wells (LOWs) currently being monitored was undertaken.

Since completing interim stabilization of the Single-Shell Tanks (SSTs) most of the tanks no longer have a liquid surface and the primary means of leak detection is a neutron scan taken inside a LOW to monitor the liquid interface in the tank waste or interstitial liquid level (ILL). As of July 2007, LOWs installed in 77 SSTs are monitored quarterly for intrusion and/or leakage. The LOW scans and ILL depths for each of the 77 tanks were recently re-evaluated to ensure that the correct neutron feature was being tracked as the ILL. The evaluation methods and results are documented in this report..

In summary, for most of the tanks evaluated conclusive evidence was available to demonstrate high confidence in the ILL determination for all but one of the tanks. In tank U-103 there is an extended “transition zone” that has been partially re-saturated after saltwell pumping (SWP). It is unclear whether the correct ILL is at the top or bottom of this transition zone. The correct interpretation is being further reviewed, and no change to the analysis has been made at this time.

How to determine the ILL –

The best method to clearly determine the ILL from a neutron scan is to monitor the neutron profile prior to, during, and after a liquid volume change. By far the most common event to determine the correct depth of the ILL was saltwell pumping (SWP). If the neutron profile is monitored prior to, during, and after SWP, then the inflection point of the feature on the neutron scan that is moving up and down in response to liquid additions and withdrawals is easily identified as the correct ILL. Once that feature has been conclusively identified during and after SWP, the same feature may be analyzed to monitor for intrusion or leakage with confidence. Most of the existing LOWs collected data during and after SWP, so the correct ILL can be identified with confidence.

As a general rule, saltcakes have significantly higher porosity and permeability than sludges, and the free liquid forms a very clear, definitive liquid interface. Sludges, on the other hand, often contain such high levels of residual water (undrainable) that the entire waste column from the tank bottom to the waste surface appears to be saturated on the neutron scan. In these cases the only major feature that can be identified from the data is the waste surface, and the resulting ILL values are usually very near the depths obtained from the surface level gauge, (Enraf or Manual Tape). One notable exception to this is saltcake that has been processed through an evaporator and returned to the tank as a concentrate. Processing saltcake through the evaporator results in significant particle size reduction. This waste typically displays high surface tension and poor drainage characteristics. These saltcakes behave very much like sludges in their drainage characteristics and look very similar to sludge on the neutron profile. A clear ILL below the waste surface is not normally discernable in this type of waste.

If the ILL resides in a zone of high porosity and permeability, (typically saltcake), the fluid can flow through the waste matrix fairly easily. If the tank also contains trapped gas, then the gas will compress and expand in response to changing barometric pressure (BP), and the ILL movement will correlate very well to the inverse of the barometric pressure. Only the true ILL will move up and down in response to BP changes, so if the feature tracks the inverse of the barometric pressure there is a high degree of confidence that the feature being monitored is the true ILL.

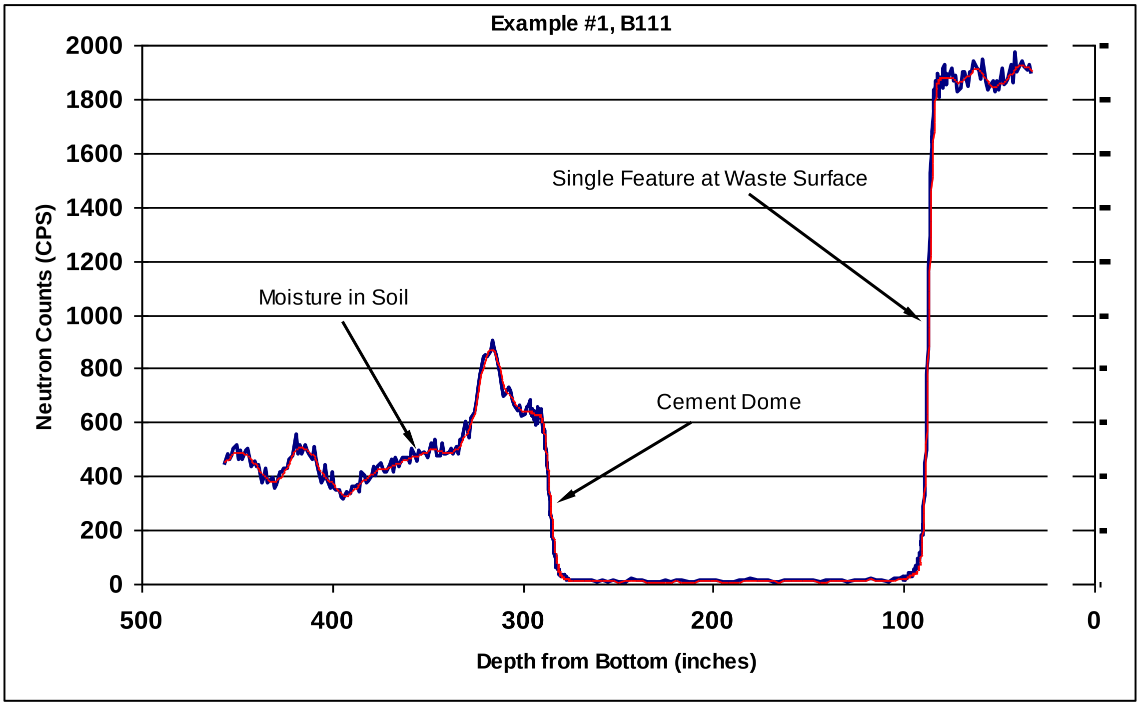
Grouping Neutron Profiles by Type –

Many of the 77 neutron profiles evaluated display similar characteristics. Each LOW was placed into one of three major groups: A single interface, multiple interfaces using the major feature as the ILL, and multiple interfaces using a secondary feature. After the LOW was placed in the appropriate group comments were added to explain what data was available to support the choice of feature as the ILL, (track change during SWP and/or recharge, confirmed barometric pressure correlation, etc.). See Table 1 for specific results for each of the 77 tanks evaluated.

Group 1, Single Feature Only –

If there is only one feature available to evaluate, then the correct feature is easily identified. In most cases this occurs when the tank contains primarily sludge and the waste profile is very near saturation from tank bottom to the waste surface. The only discernable feature is the top of the waste, where the counts drop from near saturation to near zero in the vapor space over a short distance. There are 32 tanks in this category. In most cases the ILL value determined is near the level obtained from the Enraf or Manual Tape. See Figure 1 for a typical example.

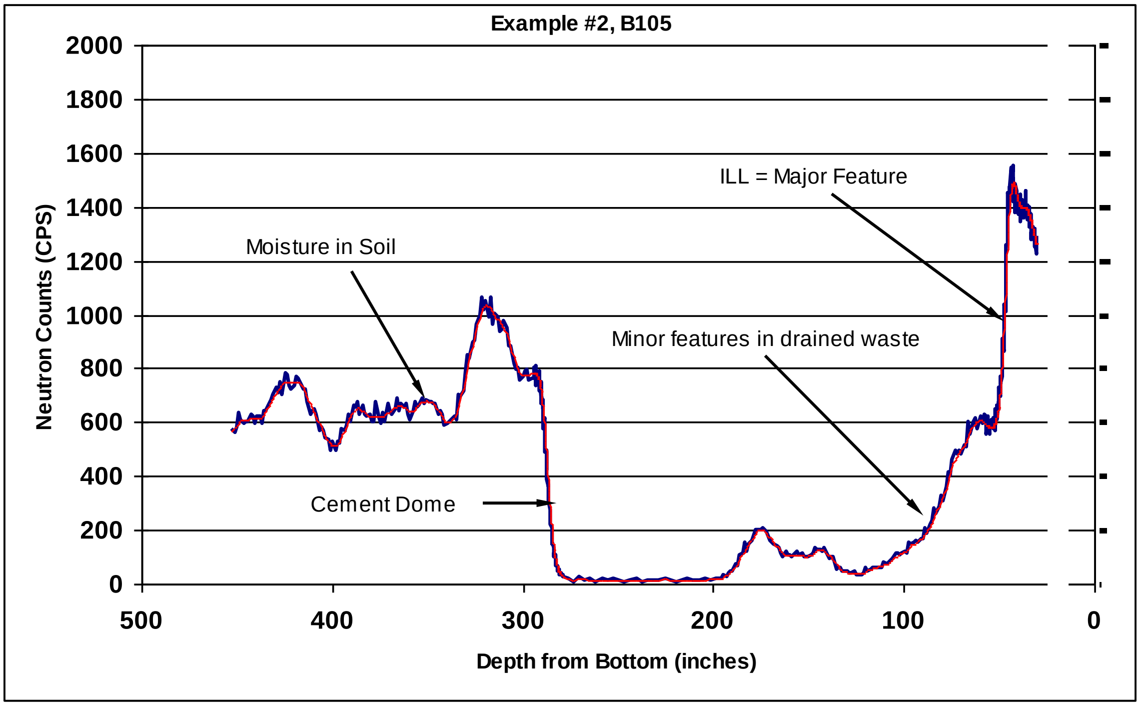
Figure 1 – Illustrates single neutron feature, (at waste surface)



Group 2, Multiple Features, Use Major Feature as ILL

In waste with good drainage characteristics, (typically saltcakes or layered saltcake/sludge mixes), a series of neutron features can be identified from the profile. The neutron moisture profile changes in response to the volume of undrainable moisture that remains in the waste after SWP, which can vary dramatically with the porosity and particle size of the waste. If multiple features are apparent, identifying the correct ILL feature can be difficult unless the liquid level is tracked during major waste changing activities such as SWP. If the ILL resides in a saltcake interval it is usually clear and easy to identify. If it resides in a sludge or near a saltcake/sludge boundary, the interpretation is more difficult. In this category the most prominent feature has been identified as the ILL, and the lesser features are attributable to variations in porosity and/or waste type. There are 29 tanks in this category. See Figure 2 for a typical example.

Figure 2 – Illustrates using major neutron feature as ILL



Group 3, Multiple Features, Use Secondary Feature as ILL

Tanks in this group exhibit multiple neutron features similar to group 2, however the major feature is typically responding to changes in waste composition such as porosity, permeability, particle size, and chemical constituents rather than a true ILL. In this group the true ILL is actually one of the lesser features. This group is the most difficult to interpret, and the analyst must rely heavily on observed changes during waste changing operations such as SWP. If the major feature in the profile does not move as liquid is added or removed, then it cannot be the true ILL. More subtle changes can occur immediately after SWP as the waste above the ILL continues to slowly drain and the true ILL slowly rises. These subtle changes help identify which feature is the true ILL and which feature should be tracked in the future to monitor for leakage or intrusion.

In the case of SX104 a new LOW was installed about seven years after completion of SWP, so the fluid changes available to aid in identification of the correct ILL were minimal. About 200 gallons of water was used to install the LOW, which temporarily created a local saturation around the LOW. Over the next 6 months this liquid equalized with the existing drainable liquid below the ILL and a secondary feature became better defined. The primary feature originally thought to be the ILL was in fact a saltcake/sludge interface. There are 16 tanks in this group. See Figure 3 for an example.

In general, if one overlays the saturated profile (prior to or during SWP) with the lowest ILL obtained at the completion of SWP the waste that has been drained by SWP operations can be

easily identified. If one starts at the bottom of the tank and assumes 100% saturation, then moves up until the profiles start to diverge, then the point at which the profiles start to separate is usually the ILL. Everything below that level is still at 100% saturation, while waste above that level has been at least partially drained. Comparing subsequent profiles to the lowest level obtained will show which waste is re-saturating over time and help identify the true ILL.
If the permeability is good, the ILL feature will move up vertically as the waste above it continues to drain, and everything below that point should overlay the pre-SWP saturated curve. In sludges the liquid typically does not drain at all, so no changes are apparent. There is a narrow range of permeabilities between those extremes where an entire zone will slowly re-saturate without forming a clear interface. As the zone saturation increases, the entire interval, (sometimes several ft), will increase neutron counts, but may not achieve full saturation as seen in the pre-SWP profile. This zone is not fully drained, but is not fully saturated either. The ILL can be picked at the base of such a zone, or at the top. Tank U-103 displays this characteristic, and is being reviewed. Picking the ILL at the base is probably more indicative of the ILL elsewhere in the tank. See Figure 4 for an example.

Figure 3 – Illustrates using minor neutron feature as ILL

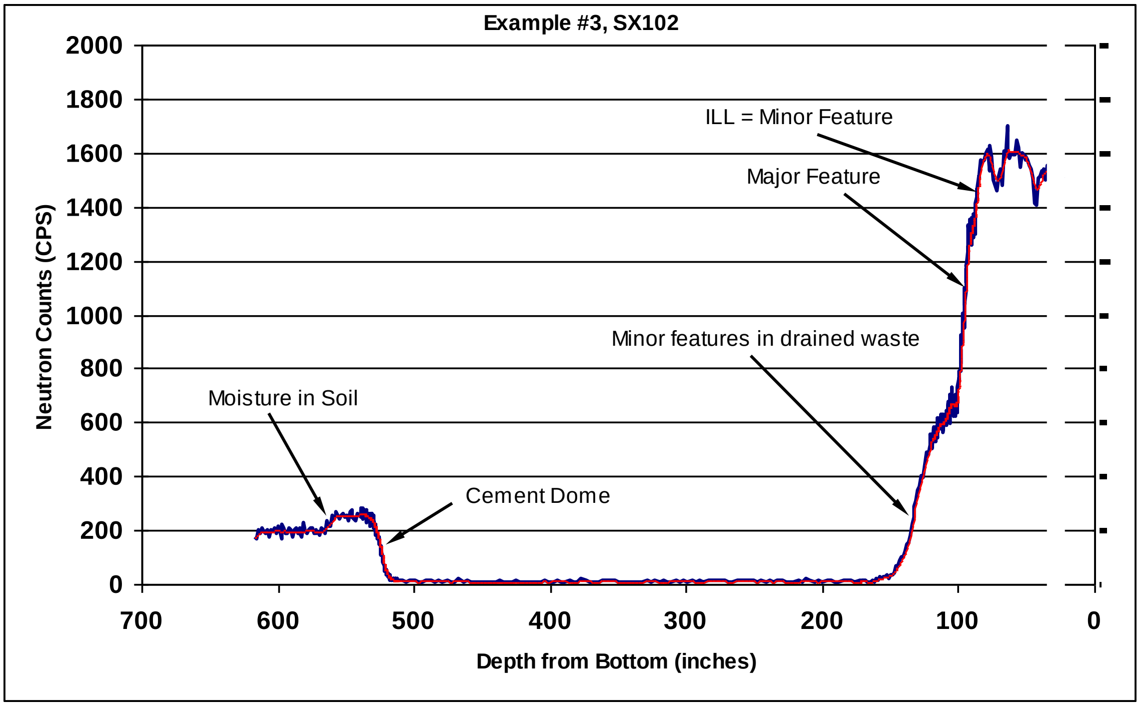
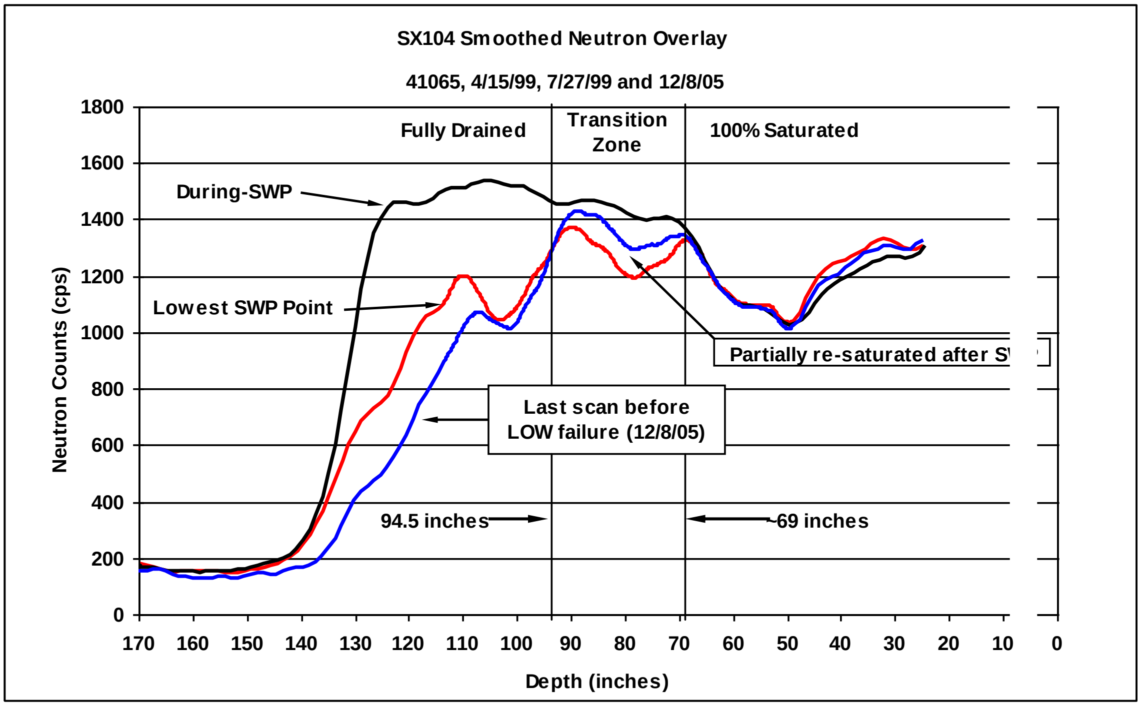


Figure 4 – Illustrates partially re-saturated transition zone



Conclusions –

All of the current LOW profiles (77) have been re-evaluated to determine if the correct neutron feature is being tracked as the ILL. Group 1, (single feature only, usually waste surface), contains 32 tanks. Group 2, (multiple features, major feature is the ILL), contains 29 tanks. Group 3, (multiple features, secondary feature is the ILL), contains 16 tanks. See Table 1 for a summary of all tanks, including evidence supporting the ILL choice.

Most tanks displayed conclusive evidence that the correct ILL was being tracked. Only U103 requires further evaluation. U103 has an extensive transition zone, similar to Figure 4, and it is unclear whether the ILL is at the top or bottom of this transition zone.

The SX104 analysis that prompted this investigation was complicated by a sludge-saltcake interface very near the ILL and the localized moisture from 200 gallons of fresh water used during LOW installation. Additionally, there were no major waste changing processes (such as saltwell pumping) performed after LOW installation to help clarify the true ILL. This was a unique situation, and the rest of the LOW scans do not share these problems.

Table 1 – LOW Analysis Summary

Tank	Single Feature	Multiple Features, Use Major as ILL	Multiple Features, Use Secondary as ILL	Comments
A101	X			Slumping surface, no ILL apparent
A103	X			Monitor waste surface, no ILL apparent
A106	X			Monitor waste surface, no ILL apparent
AX101			X	Uses Gamma probe, monitor interface of two slurries
AX103	X			Monitor waste surface, no ILL apparent
B101	X			Monitor waste surface, no ILL apparent
B104	X			Monitor waste surface, no ILL apparent
B105		X		Sharp ILL feature below surface
B107	X			Slumping surface, no ILL apparent
B108	X			Monitor waste surface, no ILL apparent
B109	X			Monitor waste surface, no ILL apparent
B110	X			Monitor waste surface, no ILL apparent
B111	X			Monitor waste surface, no ILL apparent
BX109	X			Monitor waste surface, no ILL apparent
BX110	X			Monitor waste surface, no ILL apparent, gas pockets forming
BX111	X			Sharp ILL feature below surface, moderate BP correlation
BY101		X		Surface collapsed, Enraf now on ILL, both track
BY102			X	Confirmed by recharge after SWP
BY103			X	Confirmed by recharge after SWP
BY104		X		Confirmed by recharge after SWP
BY105		X		Confirmed by recharge after SWP
BY106		X		Confirmed by recharge after SWP
BY107		X		Sharp ILL feature below surface, moderate BP correlation

Table 1 – LOW Analysis Summary

Tank	Single Feature	Multiple Features, Use Major as ILL	Multiple Features, Use Secondary as ILL	Comments
BY108	X			Monitor waste surface, no ILL apparent
BY109	X			Monitor waste surface, no ILL apparent
BY110		X		Sharp ILL feature below surface, moderate BP correlation
BY111		X		Confirmed by recharge after SWP
BY112			X	History of water buildup inside LOW, ILL very low, (around 2.5 ft)
S101	X			Monitor waste surface, followed ILL during SWP
S103	X			Monitor waste surface, followed ILL during SWP
S104	X			Monitor waste surface, no ILL apparent
S105		X		Sharp ILL feature below surface, moderate BP correlation
S106			X	Confirmed by recharge after SWP, good BP correlation
S107	X			Monitor waste surface, followed ILL during SWP
S108		X		Confirmed by recharge after SWP, good BP correlation
S109		X		Confirmed by recharge after SWP
S110	X			Monitor waste surface, followed ILL during SWP
S111		X		Confirmed by recharge after SWP
SX101			X	Confirmed by drop during SWP
SX102			X	Deeper ILL formed after LOW installation
SX103			X	Confirmed by recharge after SWP
SX104			X	Deeper ILL formed after LOW installation, gamma confirms
SX105		X		Confirmed by recharge after SWP
SX106		X		Confirmed by recharge after SWP
SX111		X		ILL extremely deep, about 13 inches
SX112		X		ILL extremely deep, about 20 inches
T101	X			Monitor waste surface, no ILL apparent
T104	X			Monitor waste surface, no ILL apparent, dropped during SWP

Table 1 – LOW Analysis Summary

Tank	Single Feature	Multiple Features, Use Major as ILL	Multiple Features, Use Secondary as ILL	Comments
T109		X		ILL extremely deep, about 22 inches
T110	X			Monitor waste surface, no ILL apparent, dropped during SWP
T111	X			Monitor waste surface, no ILL apparent, dropped during SWP
TX102		X		Sharp ILL feature below surface, moderate BP correlation
TX103	X			Monitor waste surface, no ILL apparent
TX104	X			Monitor waste surface, no ILL apparent
TX105		X		Sharp ILL feature below surface, good BP correlation
TX106	X			Monitor waste surface, no ILL apparent
TX109	X			Monitor waste surface, no ILL apparent, dropped during SWP
TX110		X		Sharp ILL feature below surface, moderate BP correlation
TX111		X		Sharp ILL feature below surface, good BP correlation
TX112			X	Sharp ILL feature below surface, good BP correlation
TX113		X		Sharp ILL feature below surface, good BP correlation
TX114		X		Sharp ILL feature below surface, good BP correlation, recharge after SWP
TX115		X		Sharp ILL feature below surface, good BP correlation, recharge after SWP
TX116		X		Sharp ILL feature below surface, good BP correlation
TX117		X		Sharp ILL feature below surface, good BP correlation
TX118		X		Sharp ILL feature below surface, confirmed by recharge after SWP
TY103	X			Monitor waste surface, no ILL apparent
TY105	X			Monitor waste surface, no ILL apparent, level drop after initial install
U102			X	Sharp ILL feature below surface, confirmed by recharge after SWP
U103			X	Multiple small features, Re-evaluate
U105			X	Multiple small features, confirmed by recharge after SWP
U106	X			Monitor waste surface, no ILL apparent, monitor drop during SWP
U107		X		Sharp ILL feature below surface, monitor drop during SWP
U108			X	Sharp ILL feature below surface, monitor drop during SWP

Table 1 – LOW Analysis Summary

Tank	Single Feature	Multiple Features, Use Major as ILL	Multiple Features, Use Secondary as ILL	Comments
U109			X	Multiple small features, confirmed by recharge after SWP
U110			X	Multiple small features, monitor changes after LOW install
U111		X		Confirmed by recharge after SWP