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(b) Reviewer (Optional, Print/Sign):			
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To: [Girardot, Crystal L](#); [Dohse, Sandra R](#); [Britton, John C](#)
Cc: [Harlow, Donald G](#); [Kunz, Ashley C](#)
Subject: RE: Clearance of RPP-RPT-54910, Rev. 0
Date: Tuesday, November 19, 2013 5:45:00 PM

Crystal,

I have reviewed the photos in the document "RPP-RPT-54910, Rev. 0", as requested from an industrial safety point of view. Based on that review the photos in this document are **approved** for use.

Any question or comment, please ask.

Hugh Lawrence
WRPS Safety Programs
cell (208) 547-7334

From: Girardot, Crystal L
Sent: Tuesday, November 19, 2013 1:29 PM
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Cc: Harlow, Donald G
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Sandy and John,

I've uploaded a copy of RPP-RPT-54910, Rev. 0, Hanford Single-Shell Tank Leak Causes and Locations – 241-SX Farm, as well as the clearance form to the following link. Please initiate review for public release.

<http://idmsweb.rl.gov/idms/livelink.exe?func=11&objId=180018983&objAction=browse&viewType=1>

Hugh – Please review the report in the link above for safety and email your approval to me.

Please let me know when the review has been completed. If you have any questions, feel free to call me.

Thanks,

Crystal
376-0528

Hanford Single-Shell Tank Leak Causes and Locations - 241-SX Farm

C.L. Girardot, D.G. Harlow

Washington River Protection Solutions

Richland, WA 99352

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Abstract: This document identifies 241-SX Tank Farm (SX Farm) leak causes and locations for the 100 series leaking tanks (241-SX-107, 241-SX-108, 241-SX-109, 241-SX-111, 241-SX-112, 241-SX-113, 241-SX-114, and 241-SX-115) identified in RPP-ENV-39658, Rev. 0, Hanford SX-Farm Leak Assessments Report. This document satisfies the SX Farm portion of the target (T04) in the Hanford Federal Facility Agreement and Consent Order milestone M-045-91F.

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EXECUTIVE SUMMARY

This document identifies 241-SX Tank Farm (SX Farm) leak causes and locations for the leaking tanks in SX Farm. The leak causes and locations report for all of the single-shell leaking tanks is one of the targets (M-045-91-T04) in the Hanford Federal Facility Agreement and Consent Order milestone M-045-91F. The T04 target requires that the Department of Energy provide to the State of Washington, Department of Ecology (Ecology) a report on the single-shell tanks which have been or will be identified as having leaked in RPP-32681, Rev. 0, *Process to Assess Tank Farm Leaks in Support of Retrieval and Closure Planning*, leak assessment reports.

The leak assessment report for SX Farm, RPP-ENV-39658, Rev. 0, *Hanford SX-Farm Leak Assessments Report*, identified eight leaking tanks in SX Farm, 241-SX-107 (SX-107), 241-SX-108 (SX-108), 241-SX-109 (SX-109), 241-SX-111 (SX-111), 241-SX-112 (SX-112), 241-SX-113 (SX-113), 241-SX-114 (SX-114), and 241-SX-115 (SX-115). Two tanks, 241-SX-104 (SX-104) and 241-SX-110 (SX-110), were identified as requiring re-assessment of the classification per TFC-ENG-CHEM-D-42, *Tank Leak Assessment Process*. The tank SX-104 re-assessment, RPP-ASMT-48143, *Tank 241-SX-104 Leak Assessment Completion Report*, recommended that the classification be changed to “Sound.” Tank SX-110 re-assessment, RPP-ASMT-47140, *Tank 241-SX-110 Leak Assessment Report*, recommended that the classification be changed to “Sound.” The remaining five tanks in SX Farm are classified as “Sound.”

This SX Farm leak causes and locations document is part of a series of tank farm reports that identify leak causes and locations for 100-series leaking tanks. A summary and conclusions document will be issued, RPP-RPT-54909, *Hanford Single-Shell Tank Leak Causes and Locations – Summary*, that compiles the results from all of the leak causes and locations tank farm reports when they have been issued. The summary document will fulfill the T04 target requirements.

The identification of eight leaking SX Farm tank leak locations focused on the first indication of radiation detected in drywells and/or laterals as well as liquid level decreases as appropriate. For some of the tanks, direct pushes were installed in 2005 to further characterize the tank leaks which were used to collaborate with the drywell data. All of the leaking SX Farm tanks leaked at or near the bottom of the tank in one or more locations.

The SX Farm leaking tank liners were likely due to: tank design, thermal shock, chemistry-corrosion, liner behavior (bulging), and construction temperature. The SX Farm tank design included fillet welding of the orthogonal bottom-sidewall joint and waterproof membrane changes that could have resulted in trapping moisture that pressurized with rapid heat up of the tank contents upon filling. The resulting bulging of the tank bottom was present or possible in all eight of the leaking SX Farm tanks. In addition, a bulged bottom imparts stresses in the liner that could have predisposed it to stress corrosion cracking. Storage of REDOX high-level waste and nitrate leaching created chemical environments that promote nitrate-induced stress corrosion cracking and/or pitting. Not all the SX Farm tanks were nitrate leached; however, all of the SX Farm tanks that were nitrate leached and stored nitrate leachate waste at elevated temperatures leaked. Tank liner construction occurred in extreme cold weather conditions, below the ductile-to-brittle transition temperature which may have resulted in latent damage in some steel liners. Some or all of the factors can act serially or together to contribute to tank liner failure.

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Acronyms and Abbreviations

SX	241-SX
SX Farm	241-SX Farm
ALC(s)	air lift circulator(s)
ARHCO	Atlantic Richfield Hanford Company
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BGS	below grade surface
BPF	Blueprint File
B & PVC	Boiler & Pressure Vessel Code
c/m, cpm	counts per minute
c/s, cps	counts per second
CY	calendar year
DOE	Department of Energy
ECOLOGY	State of Washington, Department of Ecology
GM	gamma
GMP	gamma probe
HLM	Historical Leak Model
HLW	high level waste
LL	liquid level
NaI	sodium-iodide
NO ₂ ⁻	nitrite
NO ₃ ⁻	nitrate
OCP	open circuit potential
OH ⁻	hydroxide
ORP	Office of River Protection
PCSACS	PC Surveillance Analysis Computer System
PUREX	Plutonium Uranium Extraction (fuels reprocessing) Plant
REDOX	Reduction Oxidation Plant
RHO	Rockwell Hanford Operations
SCC	stress corrosion cracking
SGLS	Spectral Gamma Logging System
SP	scintillation probe
SRS	Savannah River Site
SSP	shielded scintillation probe
SST(s)	single-shell tank(s)
TD	total depth
WRPS	Washington River Protection Solutions, LLC

Units

Ci	curie
°F	degrees Fahrenheit
ft	feet
g	gram
gal	gallon

hr	hour
K	1000
kgal	kilogallon (10^3 gallons)
in	inches
L	liter
M	moles per liter
mm	millimeter
mo	months
mrem	millirem
mR/hr	milliroentgens per hour
pCi	picocurie (10^{-12} curies)
pCi/g	picocurie per gram
psi	pounds per square inch
rad	radiation adsorbed dose
rem	radiation equivalent in man
μ Ci	microcuries
yr	year

Waste Type Abbreviations

224	lanthanum fluoride finishing waste
B	B Plant High Level Waste
BL	B Plant Low Level Waste
BNW	Battelle Northwest Laboratory Waste
CPLX	complexant concentrate
CW	cladding waste
DSSF	dilute double-shell slurry feed
DW	decontamination waste
EB	Evaporator Bottoms
Evap	Evaporator feed (post 1976)
HLW	high-level waste
IX	ion exchange
leachate	sodium nitrate leached solution
LW	laboratory waste
N	N-Reactor waste
OWW	Organic wash waste from PUREX
PNF	Partial Neutralization Feed
PSS	PUREX sludge supernatant
R	REDOX High Level Waste
REDOX HLW	Reduction Oxidation High Level Waste
Resid	Residual evaporator liquor
RIX	REDOX ion exchange waste
TBP	Tri-butyl phosphate waste
TL	terminal liquor

1.0 INTRODUCTION

The Hanford Federal Facility Agreement and Consent Order target M-045-91F-T04 indicated that part of the RPP-32681, *Process to Assess Tank Farm Leaks in Support of Retrieval and Closure Planning*, reporting would include leak causes and locations reports for all of the 100-series single-shell leaking tanks. This document is part of a series of documents that identifies leak causes and locations of 100-series single-shell leaking tanks that have been identified in the individual RPP-32681 tank farm leak assessments. An overall leak causes and locations summary and conclusions document will be prepared along with background and common tank farm information when all of the 100-series single-shell leaking tanks have been addressed (RPP-RPT-54909, *Hanford Single-Shell Tank Leak Causes and Locations – Summary and Conclusion*, to be issued). The information from RPP-RPT-54909 will be incorporated into the summary conclusions report on leak integrity for the Hanford Federal Facility Agreement and Consent Order milestone M-045-91F.

The 241-SX Farm (SX Farm) tanks with leak losses are addressed in this document on an individual tank basis. The SX Farm assessment in RPP-ENV-39658, *Hanford SX-Farm Leak Assessments Report*, reported leak losses for the following tanks: 241-SX-107 (SX-107), 241-SX-108 (SX-108), 241-SX-109 (SX-109), 241-SX-111 (SX-111), 241-SX-112 (SX-112), 241-SX-113 (SX-113), 241-SX-114 (SX-114), and 241-SX-115 (SX-115). Two tanks, 241-SX-104 and 241-SX-110, were documented as tanks with unlikely leaks and were recommended to be further assessed using TFC-ENG-CHEM-D-42, Rev B-2, *Tank Leak Assessment Process*. The individual assessments of tanks 241-SX-104 and 241-SX-110 resulted in the recommendation that the tank integrity status be changed from “Assumed Leaker” to “Sound” (RPP-ASMT-48143, *Tank 241-SX-104 Leak Assessment Completion Report*; RPP-ASMT-47140, *Tank 241-SX-110 Leak Assessment Report*).

The identification of SX Farm tank leak locations focused on the first indication of radiation detected in laterals and drywells as well as liquid level decreases as appropriate. For tanks SX-108 and SX-115 soil sample test wells were used to collaborate the data from laterals and drywells. The soil sample test wells were drilled primarily to identify the volume of the leaks for these two tanks.

The SX Farm leak causes were identified as tank design, thermal conditions, chemistry-corrosion, tank construction conditions, and in some cases stresses as a results of liner bulging or pressurization.

Ten meetings between January 2011 and July 2011 were held to review status of the assumed leakers in SX Farm with the Office of River Protection (ORP) and the State of Washington, Department of Ecology (Ecology) personnel (see Appendix A). Starting with the meeting minutes on June 14, 2011, comments were received and responses developed. Additions/revisions were made to the document and were included as an attachment to the meeting minutes. Earlier comments were not formally documented, but changes/additions/deletions were made in the appropriate sections of the individual tank segments and were reviewed and informally accepted.

2.0 SX FARM BACKGROUND

The SX Farm is comprised of fifteen Single-Shell Tanks (SSTs) built in 1953 – 1954. The tanks are arranged in rows of three tanks each, forming a cascade. Each of the SX Farm tanks has a nominal 1-million-gallon storage capacity. The SX Farm tank consists of a carbon steel liner inside a reinforced concrete shell. The concrete shell is a domed structure approximately 46.5-ft in height at the apex and ~83-ft in diameter at the footings. The steel tank liner covers the 75-ft inner diameter tank bottom and sidewalls to a height of ~32-ft as measured from the tank center. The tank bottom is dish shaped and slopes approximately 3.3% from the sidewall to the tank center (i.e., 14.875-in. elevation drop over 37.5-ft radius). The tank bottom connects orthogonally to the sidewall. Inside tanks SX-107 through SX-115 there are four air lift circulators (ALCs) located 18-in above the tank bottom and equally spaced on a 40-ft diameter circle (H-2-39951, *Arrangement Air-Lift Circulators*). Two ALCs are designated low ALCs (8-ft 6-in tall) and two are high ALCs (13-ft 6-in tall) (H-2-9950, *Details Air-Lift Circulator*).

Figure 2-1 shows a schematic of the leaking SX Farm tanks with location of the laterals and drywells.

Figure 2-1. SX Farm Leaking Tanks and Associated Laterals and Drywells
 Tank inner ring is steel liner, outer ring is outer edge of tank footing

Note: Sound tanks SX-101 to SX-106 lie to the north of tanks SX-107, SX-108, and SX-109

All of the leaking tanks in the SX Farm contained REDOX High Level Waste (HLW) (see Table 2-1). Tanks SX-111 and SX-114 contained REDOX ion exchange (RIX) waste in addition to the REDOX HLW (WHC-SD-WM-TI-614, *Waste Status and Transactions Record Summary (WSTRS)*). Some of the SX Farm tanks with REDOX HLW were nitrate leached as described in Section 3.2.4.

Table 2-1. Leaking SX Farm Tanks with Major Waste Type

Tank	Waste Type
SX-107	R, CW
SX-108	R
SX-109	R
SX-111	R, RIX
SX-112	R
SX-113	R
SX-114	R, RIX
SX-115	R

Waste types are listed in the List of Terms

The following sections describe some of the important common tank features and conditions that could have affected tank leak causes and locations. Affected tanks are noted where the features and conditions do not apply to all. This is followed by the individual tank analyses of the possible leak locations and causes and a comparison of leaking and non-leaking tanks in the conclusion section. The sections contain excerpts from RPP-ENV-39658.

3.0 SX FARM COMMONALITIES

3.1 TANK DESIGN/CONSTRUCTION

3.1.1 Tank Design

The SX Farm tanks had multiple design features that could contribute to stresses or possible leak paths when the tank was being operated including:

- Orthogonal intersection between the steel bottom and the sidewall
- Fillet weld used between the bottom and sidewall intersection
- Less rigorous weld inspection testing
- Partial asphaltic membrane waterproofing
- Keyed construction joints in the sidewall

These features are common to all SX Farm tanks.

The steel bottom of the SX Farm tanks intersects the sidewalls orthogonally similar to 241-A Farm tanks rather than the knuckle transitions (BPF-73550, Drawings D-2 and D-3, *Specification for Construction of Composite Storage Tanks (B, C, T, and U Tank Farms)*) in earlier designed tank farms. The SX Farm tank footing to the first keyed wall construction joint is shown on Figure 3-1 (H-2-39512, *75 FT. Tank Base Footing and Wall Reinforcing, Waste Disposal Facility, 241-SX*). This figure shows the orthogonal intersection between the dished bottom and the sidewall, water stop at the base footing to wall construction joint, and other details. The 7-in wide water stop at the footing construction joint extends 2 1/4-in above the joint and 4 3/4-in below the joint. The earlier 241-BCTU Farm tanks notched footing construction joint does not incorporate a water stop.

Figure 3-2 shows the detail of the orthogonal intersection between the bottom and the sidewall with a fillet weld between the bottom and sidewall orthogonal intersection (detail H-2-39511, Rev 3). Full penetration butt welds for BCTU Farm tanks are shown on BPF-73550 (Drawings D-2 and D-3) for the rounded knuckle configuration shown in Figure 3-3.

The three-ply asphaltic membrane waterproofing between the liner sidewall and the concrete shell was eliminated from the design of the SX Farm tanks (see Figure 3-2). An asphaltic membrane was incorporated between the concrete footing and the grout below the liner. The design for BCTU Farm is shown in Figure 3-3 which shows the rounded knuckle configuration with the bottom, knuckle, and sidewall three-ply water proofing.

Other design specification changes for the SX Farm tanks included less rigorous weld testing with the Vacuum Soap Test at 10-in of mercury or other Atomic Energy Commission approved methods (HW-4957, *SX Farm Specifications*). An example of an alternate method may have been full penetration X-Ray weld testing. Spot X-Ray testing of the welds was specified for SX Farm tanks per H-2-39511. Specifications required X-Ray of all welds for the BCTU Farm tanks (BPF-73550).

**Figure 3-1. SX Farm Base Footing and Wall Reinforcing
Drawing H-2-39512**

**Figure 3-2. SX Farm Tank Bottom Liner to Sidewall Design Detail
Drawing H-2-39511**

Note: The water stop at the construction joint between footing and middle of the concrete wall is to the left of the above detail

Figure 3-3. B C T U Tank Farm Knuckle Configuration with Three-Ply Waterproofing (BPF-73550, Sheet D-5)

The design of the SX Farm tanks was the first that diverged from the round bottom knuckle design used in the earlier waste tanks. A fillet weld was used to close the SX Farm tank orthogonal joint where the sidewall and tank bottom liners meet versus the butt welding of the knuckle transition of the earlier BCTU Farm tank design. A review of the basic differences between fillet and butt welds indicates that the superior butt welds would be preferred for the tank farm waste tanks (see Table 3-1).

Table 3-1. Basic Fillet and Butt Weld Differences
Some excerpts from Steel Designer and Steel Construction Handbooks

Attribute	Fillet Weld	Butt Weld
Preparation Costs	Inexpensive	Expensive
Welding Speed (Progress)	Fast	Slow
Load Bearing	Good for static loads (structures)	Good for dynamic loads (pressure vessels)
Quality	Inferior resistance to fatigue High potential for crack propagation More distortion and stress buildup	Greater resistance to fatigue Weld is stronger than base metal Minimal change in stress
Inspection	Harder to perform high quality inspection (unable to radiograph)	Easier to perform high quality inspection (radiograph)

A review of literature to compare historical failure rates for fillet welds and butt welds did not identify any relevant information that could be related to the tank farm waste tanks. There was recognition that the base of the SX Farm tanks was considered fixed and excessive steel stresses could be expected during pressure surges and elevated temperatures (LET-070357, *Commentary*

Report for Structural Review and Cost Estimate of the Tank Designs, Letter from H.W. Stivers addressed to J.B. Fecht, July 3, 1957). Tank farm experience indicates that several 241-SX tanks with fillet welds failed during service which was recognized by the expert panel as a factor in future tank use (RPP-RPT-45921, Recommendation ST-2, *Single-Shell Tank Integrity Expert Panel Report*).

The problem that the orthogonal joint design introduces including changes in asphaltic waterproofing is described in the following excerpt from HW-57274, *Instability of Steel Bottoms in Waste Storage Tanks*:

“A steel liner which fits tightly inside a concrete shell provides no means for differential thermal expansion. Such expansion can result in high compressive stresses in the steel which may produce elastic instability. Instability is particularly likely to occur in the flat bottom of the liner resulting in rippling of the bottom. This is more apt to occur in designs in which the junction at the lower corner is 90 degrees as in the SX Tanks than in designs in which a radius is used as in the BX and TX Tanks of earlier design. Empty tanks in the SX farm have been observed to have rippled bottom liners before filling.”

“A hydraulic head would tend to flatten the ripples but filling with hot waste would tend to increase the degree of rippling because of the restraint of the concrete shell. Under certain conditions this might cause rupture of a joint. The severity of the rippling is believed to have been demonstrated by the instability of the bottom of tank 113-SX after it was emptied. It is suggested that the restraint offered by the concrete shell be reduced by a return to the use of an asphalt expansion joint between the steel shell and the concrete shell.”

The ripples identified in the preceding paragraphs probably refer to the visual effects of either the support structure for the bottom liner during construction or the overall stress inherent in the welding of multiple steel plates making up the bottom liner. Construction photographs were reviewed; however, no photographs were available to verify the presence of ripples in the tank bottom liner after hydrostatic testing. The small discontinuous ripples of probably less than a few inches in height observed during construction differ from bulging indicated in this report. Bulging is typically indicated by the degree of bottom liner uplift of more than several inches over a relatively larger area after the tank is being or has been filled. Ripples were required to be less than or equal to 2-in root to crown to limit stress for DSTs.

Filling with hot waste could heat any water in the grout at the bottom of the tank or organics from the asphalt existing below the grout potentially trapping pressurized vapor (HW-57274). The design of the orthogonal sidewall to bottom joint was postulated to trap the pressurized vapor under the liner because the liner edge was embedded in the structural concrete, preventing pressure release up the sidewalls. This in turn increased the temperature due to the lower vapor space heat transfer coefficient and decreased the heat transfer from the bottom of the tank which compounded the situation.

3.1.2 Tank Construction Conditions

The SX Farm construction temperatures were examined to determine if the tank liner fabrication occurred at or below the metal ductile-to-brittle temperature transition. The outside temperature between January 16, 1954 and January 30, 1954 ranged from an average high of 24°F to an

average low of 9°F. A picture of the SX Farm under construction (see Figure 3-4), taken January 20, 1954 (high 11°F low -6°F), shows several of the tanks full of water either undergoing leak testing or concrete wall pouring. During this cold period snow-covered ice is seen in the water filled tanks. There was also a delay on tank work pending installation of a high capacity vent system for tanks SX-107 through SX-115 based on tank 241-S-104 steam eruptions (HW-35962, *Vapor Handling Facilities for Project CG-539 and Some Comments on Waste Tank Eruptions*; LET-012554, “Project CA-539, Additional Waste Storage Facilities for REDOX Proposal for Revision of Project Required Change in Scope”). These tanks could have been exposed to the elements for a significant period of time.

**Figure 3-4. SX Farm Construction Photograph
January 20, 1954 (N1D00585052)**

The metallurgical factors that limited carbon steel's ability to resist impact at low temperature were perhaps not well understood when SX Farm was constructed under tank construction specification, HW-4957, *Specification for Waste Disposal Facility 241-SX*. The HW-4957 specification stated that the storage tank liner shall conform to ASTM A-283-52T, “*Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates*”, grade A or B (3/8-in thick plate). The current standard for construction of pressure vessels, ASME Boiler & Pressure Vessel Code (B&PVC), Section VIII, *Rules for Construction of Pressure Vessels*, provides for a minimum design metal temperature of 18°F for vessels constructed of carbon and low alloy steels of nominal thickness 10-mm (0.394-in). For the purposes of this report, it will

be assumed that the 18°F design temperature was applicable to the fabrication of ASTM A 283 carbon steel at the time of SX Farm construction.

The SX Farm Blue Print File (BPF) No. 4961 Chemical and Physical Test Reports for steel plate was reviewed and found to meet the carbon and magnesium limits defined in HW-4957; carbon 0.26% maximum and manganese 0.60% maximum. Carbon ranged from 0.07 to 0.15% with an average ~0.11%. Manganese ranged from 0.04% to 0.48% with an average ~0.43%. The one report of manganese at 0.04% appeared to be an outlier as the lowest above that was 0.39%. All of the 25 sheets with a total of 40 determinations were notarized and approved by the prime contractor.

A review of toughness and the ductile-to-brittle transition temperature for carbon steels (designated as “impact transition temperature”) in *Mark’s Standard Handbook for Mechanical Engineers, Tenth Edition*, indicates that carbon content can have a significant effect. Decreased carbon content not only raises the propagation energy needed for crack growth but also lowers the temperature for transition from ductile-to-brittle behavior (reference Fig 6.2.11 in *Marks*), suggesting that the B&PVC, Section VIII, low temperature service limit may be lower than what could be expected for steel of the vintage used in SX Farm construction. The concentrations of carbon and trace impurities and their effect on this property are not specifically known, and low temperature impact resistance could only be determined reliably by impact testing of actual tank liner specimens.

Below the transition temperature, the metal loses its ability to absorb forces such as induced loads, or the impact of falling objects without fracturing. In these circumstances it is possible for micro-fissures or hairline cracks to be created. Later, when the metal is subjected to high stress, it might be possible for the cracks to propagate through the metal, or possibly subject the weakened areas to increased corrosion.

Any low temperatures experienced during construction at or less than the 18°F allowable temperature where impact loading (e.g. a dropped tool or piece of equipment from scaffolding) had the potential for creating micro-fissures may have triggered fissures in the steel liner.

The possible variability of liner steel from either different runs from the same supplier, or because of multiple suppliers, could affect the resistance to low temperatures.

3.2 IN-TANK DATA

The general information in this section is further developed and applied to the leaking tanks in later sections of each tank segment to understand implications of the conditions that could affect liner leaks and identify possible liner leak locations.

3.2.1 Liquid Level

The following is an excerpt from RPP-ENV-39658:

“Originally liquid levels were measured using pneumatic dip tubes (HW-10475-C, *Hanford Technical Manual Section C*, page 908). This practice was later replaced and a manual tape with a conductivity electrode was used to detect the liquid surface (H-2-

2257, *Conductor Reel for Liquid Level Measurement*). The biggest limitations of the manual tape measurements were failures of the electrodes, solids forming on the electrode and measurement precision. The statistical accuracy of the manual tape and electrode measurement technique was 0.75 in. (~2,060 gal), as determined in July 1955 (HW-51026, *Leak Detection – Underground Storage Tanks*, page 4). Later, liquid-level determinations were automated in many of the SSTs to provide more accurate and reliable measurements. However, surface-level measurements remain highly uncertain in the waste tanks that contained boiling wastes (e.g., 241-A, 241-AX and 241-SX Tank Farms), when supernatant has been removed from tanks leaving solids or precipitated salts, or where solid crusts have formed on the waste surfaces.”

Only two of the eight leaking SX Farm tanks (tanks SX-113 and SX-115) experienced significant liquid level decreases. Neither of the tanks’ contents was self-boiling at the time of the liquid level decreases and was therefore within the statistical accuracy of the measurement system (see Sections 9.0 and 11.0).

3.2.2 Temperature

Document HW-59919, *Limitations for Existing Storage Tanks for Radioactive Wastes from Separations Plants*, issued October 22, 1959 indicated that the self-boiling waste operating temperature should be maintained between 50°F and 220°F. The maximum sludge temperature should not exceed 300°F. Document HW-59919 contained the first boiling waste limitations on temperature. Thermal shock creates stress both from rapid temperature rise as well as waste-induced high temperatures.

The same document states that tank contents should also be heated slowly to not exceed the recommended rate of 2°F per day. The temperature requirements upon initial filling with waste were designed to provide enough time at controlled temperatures and other waste parameters (specific gravity and liquid depth) to remove grout moisture gradually so that the grout moisture vapor pressure does not exceed the hydrostatic pressure. An attempt was apparently made in one tank (SX-115) to control the rate of rise basically by dilution. Water and/or condensate were added to the tank prior to receiving waste; however, the tank exceeded the 2°F per day rate of rise in spite of the thermal dilution effect.

Temperature data used for the SX Farm evaluations were taken from RHO-CD-1172 and temperature data sheets and were designated as “Bulb” temperatures. The “Bulb” temperature nomenclature designation for sludge was first found in HW-83906-C-RD, *Chemical Processing Dept 200 W Area Tank Farm Inventory & Waste Reports 01/1957 Thru 12/1958*, page 000126, as an annotation on the Status of Waste Farms form for February 1958. This was stated as “S = Bulb Temp of Sludge @ 2” off bottom.” The liquid temperature was stated as “L=Liquid Temp @ 5 ft off bottom.” There was another annotation in HW-83906-C-RD (page 000185) that indicated the sludge temperature was designated as “Bulb” and the liquid temperature was designated as “SCAN”. Typed in at the bottom of this page was the following: S – Temperature of sludge approximately three inches off of the tank bottom and L - Temperature of liquid approximately five feet off of the tank bottom. However, the SX Farm “Bulb” temperature design and the degree of data uncertainty are unclear as no other documentation for this information has been located.

Waste storage tanks have observed a phenomenon called bumping, which is a series of abrupt pressure surges and the more severe cases referred to as steam eruptions (HW-37207, *Storage of High Activity Wastes*). Bumping is believed to be the result of rapid evaporation of water by stored heat with the sudden release of steam due to gradients in the waste temperatures. Prior to May 1955, bumping was only observed in tanks S-101, S-104, SX-101 and later observed in tank SX-104. All of these pressurizations occurred when either the tank contents were not being agitated or when an agitator was initially started. Tests were conducted in tanks SX-107, SX-108, and SX-109 prior to February 1957 to develop operating conditions to minimize bumping. Once one of the short ALCs in tank SX-107 was placed into service on February 18, 1957, no pressure surges or signs of a temperature gradient formation in the SX-107 supernatant occurred (HW-50216, *Current Status of REDOX Waste Self-Concentration*). However, a steam eruption leading to ground contamination occurred in August 1958 in tank SX-114. This event was believed to be the result of turning off the air supply to the ALC and replacing with water (WHC-MR-0135, *Radiation Occurrence- Spread of Contamination from a Radiation Zone*).

There doesn't seem to be a correlation between bumping and leaking tanks. Even in the most severe bumping (pressure surge) incident with tank SX-114, the pressurization did not appear to affect the piping seals into or out of the tank. Therefore, bumping which is an effect of thermal conditions has not been considered in the overall factors that cause tank liner failure.

3.2.3 Liner Observations

A bulge, typically caused by rapid vaporization of moisture under the tank liner, may result in the direct failure of the liner or cause enough stress or thinning on the steel liner plates and welds that they become more susceptible to the effects of corrosion. Experience indicates that bulging tends to be a dynamic phenomenon, and it is possible that a tank with no measured bulge at one point in time may actually have had a displaced liner that was not detected at another time. A possible indicator of a bulge may be broken ALC turnbuckle guy rods and/or bent piping which can be seen in some photographs (see Section 3.2.5). Multiple flexing of the tank liners as a bulge forms and returns to normal may set up stresses that even though the liner does not reach the elastic limits could result in locations that are more susceptible to corrosion.

Tank vacuum could influence bulging to a degree if there is no hydrostatic head in the tank and the vacuum is high enough. The tank SX-113 butterfly valve on the SX Farm vent system was opened one day before adding waste to the tank exposing the tank to the vent system vacuum (6 to 7-in of water). The tank experienced a bulge shortly after boiling. There was a second bulging incidence in tank SX-113 when the tank was emptied and the bulge reappeared (see Sections 9.4.1 and 9.4.3). Other SX Farm tanks may have been subjected to the vent system vacuum before receiving waste but information was not available.

Documents RHO-R-39, *Boiling Waste Tank Farm Operational History*, and ARH-R-43, *Management of Radioactive Wastes Stored in Underground Tanks at Hanford*, contain tables that list the SX Farm tanks that were inspected for a bulge as well as the tanks where a liner bulge was confirmed. There are some conflicts between these two documents and production reports regarding the presence of bulging.

3.2.4 Chemistry-Corrosion

The types of corrosion that may occur in the Hanford Site SSTs include uniform corrosion, stress corrosion cracking (SCC), pitting, crevice, and liquid-air interface corrosion which were identified in HNF-3018, *Single-Shell Tank Sluicing History and Failure Frequency*.

Uniform corrosion rates for SSTs are reported to be generally less than 1 mil/year (HNF-3018) for the SSTs. Carbon steel exposed to alkaline solutions has a low general corrosion rate (PNL-5488, *Prediction Equations for Corrosion Rates of A-537 and A-516 Steels in Double Shell Slurry*). However, the presence of the nitrate ion may induce various forms of localized attack (i.e., SCC, pitting, etc.).

Nitrate Ion-Induced Stress Corrosion Cracking

Stress corrosion cracking is the growth of cracks in a corrosive environment. It can lead to unexpected sudden failure of normally ductile metals subjected to a tensile stress, especially at elevated temperatures. The chemical environment that causes SCC for a given alloy is often one which is only mildly corrosive to the metal but the condition for SCC is highly dependent on specific waste chemistries.

Nitrate ion-induced SCC is the predominant threat to the integrity of the steel liners in the SSTs and double-shell tanks (DSTs) at the Hanford Site and many investigations have been performed to establish the parameters under which the tanks can be protected from this threat. This work, together with the efforts of many others, led to the adoption of the waste chemistry control limits for SCC prevention in 1983 (OSD-T-151-00017, *Operating Specifications for the Aging Waste Operations in Tank Farms 241-AY and 241-AZ*).

The factors governing the rates of nitrate ion-induced SCC by Hanford Site DST wastes were recently reviewed (RPP-RPT-47337, *Specifications for the Minimization of the Stress Corrosion Cracking Threat in Double-Shell Tank Wastes*). In brief, the test results led to the conclusion that the magnitude of nitrate ion-induced SCC depended on the properties of the steel, the applied potential versus the open circuit potential (OCP), the temperature, and the concentrations of aggressive substances such as nitrate ion, and the potential inhibitors such as hydroxide and nitrite ion.

The technical work has shown that SCC is promoted by high temperatures, high nitrate ion concentrations, low hydroxide ion concentrations, low nitrite ion concentrations, and low nitrite ion/nitrate ion concentration ratios. Tanks with maximum temperatures less than 122°F (50°C) would not be expected to experience significant SCC damage regardless of waste types (HNF-3018, Rev. 0). Tanks with the maximum temperatures above 122°F and a ratio of nitrate concentration to the sum of nitrite and hydroxide concentrations greater than 2.5 would be expected to suffer SCC-related damage (HNF-3018, Rev. 0). The concentration of nitrate and temperature are parameters that have the most effect on SCC. However, the pH (hydroxide) and nitrite can inhibit SCC. The current DST operating specifications for chemistry are reported in OSD-T-151-00007, Rev. 10, *Operating Specifications for the Double-Shell Storage Tanks*. While the chemistry specifications stated in this document were prepared for the DSTs, corrosion

mechanisms and corrosion protection mechanisms applicable to DST primary tank metal liners, are equally applicable to the older SST metal liners and provide possible SST liner leak causes.

Localized Corrosion: Crevice, Pitting, and Liquid-Air Interface Corrosion

Crevice corrosion can occur in regions where a small volume of solution cannot readily mix with the bulk solution such as under deposits, between metal flanges, and other confined areas. Once initiated, crevice corrosion proceeds by the same mechanism as pitting corrosion (RPP-RPT-33306, *IQRPE Integrity Assessment Report for the 242-A Evaporator Tank System*).

Pitting corrosion is the localized corrosion of a metal surface confined to a point or small area that takes the form of cavities. Pitting corrosion in dilute solutions ($\text{NO}_3^- < 1\text{M}$) of waste has been studied at the Savannah River Site (SRS). Pitting has been determined to not be a problem at hydroxide concentrations greater than 1M for any of the diluted waste solutions tested (WSRC-TR-90-512, *Effect of Temperature on the Nitrite Requirement to Inhibit Washed Sludge*; Oblath and Congdon 1987, *Inhibiting Localized Corrosion during Storage of Dilute Waste*). Nitrate ion was determined to be the usual controlling aggressive species when its concentrations ranged between 0.01M and 1M (WSRC-TR-90-512). The presence of hydroxide ion and nitrite ion has shown to inhibit pitting corrosion due to the aggressive nitrate ion. This work led to the conservative recommendation that the concentration of nitrite ion be greater than 0.033M for the avoidance of pitting in dilute solutions of nitrate ion at pH 10 and 40°C (104°F) (RPP-ASMT-53793, Rev. 0).

The chemical compositions required for prevention of pitting corrosion can also be applied as limits for prevention of liquid-air interface corrosion at the surface of the supernatant.

Crevice, pitting, and liquid-air interface corrosion are types of localized corrosion possible in the SSTs; however, historically SCC is the more predominant type of corrosion of concern.

Historical Corrosion Control

The earliest chemical specifications for SSTs addressing pH, nitrite, nitrate, and hydroxide are listed in Table 3-2 (ARH-1601, Section D, *Specifications and Standards for the Operation of Radioactive Waste Tank Farms and Associated Facilities*, 1973).

Table 3-2. ARH-1601 Specifications 1973

Waste Tank Farms and Associated Facilities Specifications	
Variable	Specification
pH	Minimum 8.0
NO_2^-	500 ppm
NO_3^-	< 6M
OH^-	< 7M

There was no similar specification found that addressed all of these parameters during the operation of SX Farm prior to 1973. However, if the ARH-601 specifications were in effect during SX Farm waste storage, the storage of undesirable concentrations of NO_2^- , NO_3^- , and OH^- would result in vulnerability to SCC and/or localized corrosion if temperatures were elevated.

Nitrate Leaching

The process of nitrate waste leaching first involved pumping the supernatant from the tank down to the apparent sludge depth. The tank would then be filled with condensate to a liquid level of about 10-ft and the sludge would be dissolved using ALCs for mixing. The dissolution process would take between one and three months, at which time the nitrate solution would be pumped to the feed tank for the REDOX plant and the leached tank would be returned to service to receive REDOX waste for self-concentration.

Nitrite and hydroxide are known as nitrate-induced SCC inhibitors. One key characteristic for inhibiting SCC is to maintain a high nitrite concentration to nitrate concentration ratio. Prior to nitrate leaching the nitrite and hydroxide would have been removed from the tank when the supernatant was pumped out. Leaching the sludge with condensate after the supernatant had been pumped out would result in a nitrate ion-rich waste with a low nitrite to nitrate ratio which, at the temperature of the tank, would be conducive to SCC. All the tanks in SX Farm that were nitrate-leached and stored nitrate leachate waste at elevated temperatures leaked.

Table 3-3 shows examples of waste sample chemical composition results for the important factors in SCC. The supernatant samples taken in April 1961 represent the supernatant waste compositions shortly before the nitrate leaching process began. While the nitrite concentration to nitrate concentration ratio is very low in the supernatant layers, the nitrate leachate samples show that the concentration ratio is even smaller in the leachate samples from tanks SX-105 and SX-113. The nitrate leaching process to retrieve nitrate would have produced a nitrate ion rich solution that contained insufficient nitrite and hydroxide concentrations to inhibit SCC at the tank temperatures. Also, increasing temperature accelerates SCC (*Principles and Prevention of Corrosion* (Jones 1996)). See individual tank section for details on effect of nitrate leaching.

Table 3-3. Waste Sample Chemical Composition Results for SX Farm Tanks during the 1960s

Source	Layer	Date	[OH ⁻] M	[NO ₂ ⁻] M	[NO ₃ ⁻] M	[NO ₂ ⁻]/[NO ₃ ⁻]
SX-101 ¹	Supernatant	April 1961	4.58	2.48	6.03	0.41
SX-107 ¹	Supernatant	April 1961	1.27	0.65	8.65	0.08
SX-108 ¹	Supernatant	April 1961	1.32	0.61	8.35	0.07
SX-114 ¹	Supernatant	April 1961	1.53	0.45	8.15	0.06
SX-114 ²	Sludge	November 1961	0.16	0.05	1.64	0.03
SX-114 ²	Sludge	November 1961	0.22	0.07	3.47	0.02
SX-113 ³	Leachate	October 1962	0.4	0.1	4.2	0.02
SX-105 ⁴	Leachate	February 1967	0.52	0.18	4.23	0.04

¹ Results were obtained from HW-69443, p. G-5.

² Results were obtained from HW-71895, p. G-4.

³ Results were obtained from HW-75714, p. 4.

⁴ Results were obtained from ISO-708-DEL, p. G-4.

3.2.5 Photographs

Available photographs of the SX Farm leaking tanks were reviewed. Photographs were reviewed to identify beachlines possibly indicating previous operations of overfilling the tank, damaged equipment, possible liner bulges, and any other anomalies that could be indicative of a tank liner leak, and/or possible leak location. Missing or disconnected ALC turnbuckle guy rods

could indicate that there was bulging of the bottom liner sufficient to cause the upper connection to fail with the guy rod sinking below the liquid surface (missing). Some ALC turnbuckle guy rods were also hanging free attached only at the upper connection as it had apparently become disconnected from the bottom connection either at the attachment plate or the plate itself pulled away from the bottom of the tank.

Some SX Farm tank photos show equipment damage that may be linked to liner bulges. Each ALC was anchored to the tank floor by three ½-in diameter guy rods. In several tanks, broken ALC turnbuckle guy rods and/or bent ALC or thermocouple piping are visible.

All of the leaking tanks as well as some of the sound SX Farm tanks contained ALCs that had one or more disconnected turnbuckle guy rods with the possible exception of tank SX-109 which could not be determined because of solids encrusted ALCs.

3.3 EX-TANK DATA

The general information in this section is further developed and applied to the leaking tanks in later sections of each tank segment to understand implications of the conditions that could affect liner leaks and identify possible liner leak locations.

3.3.1 Laterals

A prototype five lateral leak detection system was installed under tank SX-113 after indications of a >4-ft liner bulge in 1958. The tank SX-113 prototype laterals were to be installed 10-ft under the tank but varied between 6-ft and 12-ft below the bottom of the tank over the course of a lateral. The horizontal alignment was calculated to be within ~2-ft (HW-60749, *Leak Detection System for Active Tanks Interim Report*). The alignment was addressed in HW-60749 and included the following: “The subcontractor was permitted to complete the five laterals to the best of his ability without official alignment checks because of the short time limit of the construction schedule.” In addition, the document included future specifications to control alignment.

In 1962, a three lateral leak detection system was installed underneath tanks SX-105, and SX-107 through SX-115. The procedure for drilling the laterals was stated in document HW-68661, *Proposed Leak Detection System for Existing Storage Tanks Containing Self-Boiling Radioactive Wastes (Scope and Design Criteria)*. The driller was required to check the alignment of the laterals every 20-ft during the installation according to this document. It was assumed installation of the laterals were improved as no records of vertical or horizontal variation were found after the original tank SX-113 lateral installation.

Each lateral is a 3-in pneumatic stainless steel tube enclosed in 4-in carbon steel pipe. The laterals are horizontal and extend radially from a large caisson (12-ft diameter) that is located between up to four tanks. A “lateral shack” was constructed over each caisson. The access to each lateral is through a separate vertical tube (also made of 3-in pneumatic stainless steel) that extends up to the floor of the lateral shack. The lateral tube transitions from vertical to horizontal at the bottom of the caisson through a 90° elbow with a 4-ft bend radius. The laterals are numbered clockwise from 1 to 3. Probes are inserted into each lateral, driven to the end of the lateral with compressed air, and slowly withdrawn to monitor for gamma radiation that could

indicate waste leakage from the tank. Operation of the laterals and details of the probes and data are described in RPP-RPT-27605, *Gamma Surveys of the Single-Shell Tank Laterals for A and SX Tank Farms*. The criteria for lateral monitoring frequency are defined in SD-WM-TI-356, *Waste Storage Tank Status and Leak Detection Criteria*.

3.3.2 Drywells

Fifteen of the original SX Farm drywells were drilled around the tanks between 1954 and 1958 (H-2-36942, *Well Information As-Built 200 W Area*). The remainder of the SX Farm drywells were drilled starting in 1962 (H-2-36942). Drywells were drilled vertically from the surface and drywell coordinates and detailed drywell information, e.g. pipe dimensions and configuration, for the leaking SX Farm tanks are addressed in references cited in the individual tank segments. Drywells will not be useful to detect releases that enter the soil from the tank unless the volume released is sufficiently large to facilitate lateral transport to typically within ~1-ft of the drywell. The vertical height of a tank liner leak may not be directly related to the point of detection in the drywell. This is especially true for small leaks that may flow downward some distance before encountering a drywell. Some soil sampling test wells were drilled for specific leak volume determinations for tanks SX-108 and SX-115.

The “00” series drywells (e.g., drywell 41-00-08) were installed shortly after tank construction, usually around the periphery of the farm and most extend to 150-ft BGS. Others with tank numbers embedded in the drywell number (41-12-02) were constructed later, sometimes after tank operations had ceased and generally to 100-ft BGS (or less). The usual number of drywells surrounding a tank is one to four. If there are more, then there likely was some concern regarding a release which was being investigated. The last number corresponds to the clocked position of the drywell with respect to north.

Four gamma ray probe types were used to monitor gamma in drywells to detect leaks (HNF-3136, *Analysis Techniques and Monitoring Results, 241-SX Drywell Surveillance Logs*). The most widely used probe was the unshielded gross gamma sodium-iodide (NaI) probe (or probe 04 and the shielded NaI probe is also referred to as probe 14). The NaI probe (04) is very sensitive and able to record gamma ray activity from 30 counts per second (cps) up to about 40,000 cps (15mR/hr) before the data becomes unreliable (RHO-RE-EV-4P, *Supporting Information for the Scientific Basis for Establishing Dry Well Monitoring Frequencies*). The next most commonly used probe was the Red-GM (or probe 02) which is less sensitive but can reliably record gross gamma at much higher levels of activity (up to ~500R/hr). Operation of these and other probes are discussed in HNF-3136, *Analysis Techniques and Monitoring Results, 241-SX Drywell Surveillance Logs*. A scintillation probe (SP) was also used to measure low levels of radiation in the drywells. Leak location identification is primarily focused on the first indication of a leak and is therefore typically concerned with the lower levels of gross gamma detection and migration. The earliest drywell data sheets found (1969) did not list readings below 50K counts per minute (cpm), it is not clear why the apparent lower level of detectability was at 50K cpm during the earliest drywell data sheets.

The individual tank drywell sections contain gross gamma figures taken from HNF-3136 showing continuing or new contamination in the drywells based on BGS depth from 1975 to 1995. However, these figures do not indicate the amount of radioactivity found at these depths.

In 1995 and 1996, a baseline characterization of the gamma-ray-emitting radionuclides distributed in the vadose zone sediments beneath and around SX Farm was performed using the Spectral Gamma Logging System (SGLS) and documented in GJO-HAN-4, *Vadose Zone Characterization Project at the Hanford Tank Farms SX Tank Farm Report*. Individual vadose zone characterization summary data reports were issued in 1995 and 1996 for the SX Farm tanks with results reported in the leaking tank segments. The gross gamma probes and the SGLS can detect equivalent Cs-137 at concentrations down to ~10 pCi/g and ~0.1 pCi/g, respectively. Therefore, radioactivity ≤ 10 pCi/g does not appear on the gross gamma figures (GJO-HAN-4). SGLS logging can identify Cs-137 and other gamma ray-emitting radioisotopes which can assist in the leak location analysis. The SGLS data is weighted more heavily on interpreting drywells. This is especially true where radioactivity was detected early but decayed away and did not return. The criteria for drywell monitoring are defined in RHO-ST-34, *A Scientific Basis for Establishing Drywell-Monitoring Frequencies*, with the monitoring frequency found in SD-WM-TI-356, *Waste Storage Tank Status and Leak Detection Criteria*.

All of the radiation readings in drywells are assumed to be maximum or peak readings unless otherwise noted and are from the Red-GM probe unless otherwise indicated. The individual tank segments report the available drywell data in the drywell section and in some cases the more recent direct push drywells installed to detail soil radioactivity. The drywell summary section provides the analyses of the associated drywells and any direct pushes with the tank that is of concern.

3.4 LINER LEAK LOCATIONS

Liquid level decreases, if detected, are normally the first indication of a tank liner leak in non-boiling tank conditions and are typically confirmed by drywell and/or lateral radioactivity. Liquid level decreases can be used for sidewall as well as bottom liner leaks but need to be analyzed in relationship with the vertical level of the tank drywell radioactivity, evaporation and drywell contamination from pipeline leaks and other non-tank sources.

Drywell and lateral radioactivity when first detected can indicate a radial or depth location of a tank leak, migration of the tank leak, or the possible migration of an adjacent tank leak. The location of a liner leak, however, is not necessarily the same as the location where radiation is detected. The radial drywell radioactivity is dependent on any possible flow paths from the actual tank liner leak location to the drywell itself as well as the waste viscosity and distance to the drywell. Drywells can also be an indication of the tank liner sidewall leak depending on the vertical location. The location needs to be analyzed relative to non-tank liner leaks associated with pipe lines or other sources.

A bottom liner leak detected by lateral or drywell radioactivity may have penetrated the waterproof membrane at any location or pooled on the waterproof membrane and followed concrete cracks to a different location including the top of the tank footing. Therefore, the point of waste egress from the tank liner may not be the point of entry of the leaking waste to the soil. Also, if the drywell radioactivity is detected above the footing there could be a possibility of a sidewall leak or leaks associated with pipe lines or other sources. Later indications of radioactivity in the drywells with improved detector capabilities could indicate additional

leakage but the location of the leak could not be pinpointed without some additional information. Lateral radioactivity almost always indicates a leak at or below the footing.

The lack of radioactivity above background in a drywell indicates that if there was a liner leak it either occurred at another location or the leak flow was insufficient to be detected with the probes used in the drywell. When there is no radioactivity detected in a drywell or no recoverable data for a drywell it is not included as part of the leak location analysis.

Soil sample test wells can help further characterize the leak location by supporting earlier data and/or providing additional information.

3.5 POSSIBLE LINER LEAK CAUSE(S)

Analysis which centered on tank design/construction, in-tank data, and ex-tank data indicates that there were up to five SX Farm tank conditions that could contribute to a failed liner: tank design, thermal conditions, chemistry-corrosion (waste chemistry and nitrate leaching), liner bulging, and tank construction temperature. Some or all of the factors can act serially or together to contribute to tank liner failure. The following sections provide a tank by tank review of these conditions as they relate to liner leak causes.

Other general tank construction factors such as the quality of materials and fabrication could also contribute to tank liner failure. Because no evidence has been found to substantiate quality defects, these are not included as a leak cause.

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4.1 TANK SX-107 BACKGROUND HISTORY

This section provides information on the historical waste loss event associated with SST 241-SX-107 (SX-107). Tank SX-107 has three laterals installed in December 1962 about 10-ft under the tank (see Figure 4-1). There are eight drywells located around tank SX-107: 41-07-02, 41-07-03, 41-07-05, 41-07-07, 41-07-08, 41-07-10, 41-07-12, and 41-10-01 installed in 1962.

The bottom of the tank footing is ~52-ft 9-in below grade surface (BGS) with ~6-ft 6-in soil cover over the dome (WHC-SD-WM-TI-665, *Soil Load above Hanford Waste Storage Tanks*). Inside tank SX-107 there are four ALCs 18-in above the tank bottom and equally spaced on a 40-ft diameter circle as shown in Figure 4-1 (H-2-39951). Two ALCs are designated low ALCs (8-ft 6-in tall) and two are high ALCs (13-ft 6-in tall) (H-2-9950).

Figure 4-1. Tank SX-107 Associated Drywells and Laterals
Tank inner ring is steel liner, outer ring is outer edge of tank footing

4.2 TANK SX-107 OPERATIONS SUMMARY

Construction of tank SX-107 was completed in 1954 and put into service March 3, 1956 (RHO-R-39, *Boiling Waste Tank Farm Operational History*). Tank SX-107 first received REDOX high-level waste (HLW) on April 13, 1956 and started to self-concentrate in June 1956. The tank was not preheated prior to filling (HWN-1991-DEL, *CPD Waste Storage and Experience January 1955 to December 31, 1965*). The tank continued to receive REDOX HLW until December 1957. The REDOX HLW in tank SX-107 self-boiled and the off gas condensate was sent to tank SX-106 from June 1956 throughout the life of the tank. The maximum temperature experienced in tank SX-107 (390°F) was reported on February 5, 1958 and starting in July 1958 and throughout the life of the tank, caustic makeup water (from a 241-S Farm catch tank) and cooling water were added to maintain the waste temperature and pH within operating limits. No additional transfers occurred until January 1960 when a small amount of REDOX cladding removal waste (CW) was transferred to the tank. No additional transfers occurred until December 1962.

The supernatant from tank SX-107 was transferred to tank SX-102 in December 1962 and the remaining solids were sodium nitrate leached using condensate (see Section 4.4.4 for additional details). The leachate was then sent to tank SX-114 in January 1963. REDOX HLW was again added one week later from January through June 1963 and early 1964. In March 1964, REDOX HLW additions were stopped due to increased radioactivity detected in lateral 44-07-01 and the tank was first suspected of leaking (HW-81620, *Chemical Processing Department Monthly Report March 1964*). Radioactivity continued to increase in July 1964 (HW-83508, *Chemical Processing Department Monthly Report for July, 1964*) but no significant increases were observed in October 1964 and no material losses were observed in tank SX-107 (RL-SEP-52, *Chemical Processing Department Monthly Report for October 1964*). In 1968, the tank was connected to an exhaustor, which was used at the end of the tank's service life to aid in the air-cooling of the waste in the tank.

New evidence of leakage in tank SX-107 was identified in September 1968 due to radioactivity being detected in lateral 44-07-02 and increased radioactivity reported in lateral 44-07-03, thus, supernatant was sent to tanks SX-110 and SX-111 (ARH-308-DEL, *200 Areas Operation Monthly Report September 1968*). Air drying of sludge was initiated December 19, 1968 (ARH-1061, *Chemical Processing Division Waste Status Summary October 1, 1968 Through December 31, 1968*).

Steel liner and sludge elevations were obtained in June 1969 which indicated no bulge in the tank (ARH-1105, *107-SX Steel Liner Measurements*); however, actual data was not recovered. Two subsequent documents RHO-R-39 (December 1969) and ARH-R-43, *Management of Radioactive Wastes Stored in Underground Tanks at Hanford*, April 1970, both contain tables that list tank SX-107 with a bulged liner, but provided no reference for the information (see Appendix A1). See Section 4.4.3 for additional information.

Tank SX-107 was administratively interim stabilized in October 1979 and is estimated to contain 94 kgal of sludge, 7 kgal of drainable interstitial liquid, and no supernatant (HNF-EP-0182, Rev. 303, *Waste Tank Summary Report for Month Ending June 30, 2013*). The operational history of tank SX-107 leak related details including temperature and liquid level is charted in Figure 4-2.

Figure 4-2. Operational Leak History of Tank SX-107

4.3 TANK DESIGN/CONSTRUCTION

4.3.1 Tank Design

The SX Farm tanks had multiple design features that could contribute to stresses or possible leak paths when the tank was being operated including:

- Orthogonal intersection between the steel bottom and the sidewall
- Fillet weld used between the bottom and sidewall intersection
- Less rigorous weld inspection testing
- Partial asphaltic membrane waterproofing
- Keyed construction joints in the sidewall

These features are common to all SX Farm tanks and additional details are discussed in Section 3.1.1.

4.3.2 Tank Construction Conditions

The outside temperature between January 16, 1954 and January 30, 1954 ranged from an average high of 24°F to an average low of 9°F. A picture of the SX Farm under construction (see Figure 3-4) taken January 20, 1954 (high 11°F low -6°F), shows several of the tanks full of water either undergoing leak testing or for concrete wall pouring. During this cold period snow covered ice is seen in the water filled tanks.

As described in Section 3.1.2, cold weather affects the ductile-to-brittle steel transition temperature, with 18°F being the assumed unrestricted low temperature construction limitation for the carbon steel liner, which could result in a fracture upon impact. Low temperatures experienced during construction at or less than the 18°F allowable temperature could cause impact loading (e.g. a dropped tool or piece of equipment from scaffolding) and result in the potential for creating micro-fissures weakening the steel liner.

4.4 TANK SX-107 IN-TANK DATA

4.4.1 Liquid Level

The tank SX-107 liquid level was apparently not reviewed for a decrease when radioactivity was first detected in the lateral in March 1964 as no mention was found in any of the monthly reports, individual letters, or previous leak assessment reports examined for this report. The near constant transfers into and out of the tank including caustic for pH control and water for cooling probably interfered with any meaningful liquid level analysis for a tank leak (see Figure 4-3). In addition, the liquid level measurement under self-boiling conditions (evaporation) coupled with ALC operation results in data uncertainties that render the results unusable for determining liquid level losses associated with a tank leak.

The liquid level plot in Figure 4-3 indicates the transfer activity into and out of tank SX-107. The liquid levels are end of quarter levels so this figure may not reflect all transfers into and out

of the tank that occurred during the operational history of the tank. See Figure 4-2 for historical monthly liquid level readings.

Figure 4-3. Tank SX-107 End of Quarter Surface Level

WHC-SD-WM-ER-352, Rev 0, June 30, 1994, Historical Tank Content Estimate for the Southwest Quadrant of the Hanford 200 West Area

4.4.2 Temperature

Tank SX-107 was not preheated prior to receiving waste from REDOX. The first waste was received on April 13, 1956 (HWN-1991-DEL). The temperature immediately rose upon receiving the waste on April 13, 1956 from a conservative assumed ambient ground temperature of 55°F to 100°F (see Appendix A1), and then increased gradually to an equivalent boiling temperature of 240°F by May 30, 1956 (HW-18700-DEL, *REDOX Technical Manual*).

Temperature plots reproduced from RHO-CD-1172 (see Appendix B1) show tank SX-107 sludge temperature reached a maximum of 390°F in February 1958. The waste temperature gradually decreased to between 240°F and 260°F in August 1961 after REDOX HLW additions stopped. Temperatures remained relatively stable until October 1964 when REDOX HLW additions were resumed and the temperature increased to a peak of 310°F in February 1966. Temperature then dropped to ~280°F in May 1966 and remained between 280°F and 290°F until June 1968. These relatively high tank waste temperatures were typical with the operating

practices for tanks that contained boiling REDOX HLW. See Appendix C1 for the thermal history for SX-107 from 1956 to 1958.

On January 15, 1957, the first pressurization (or bumping) of tank SX-107 was recorded (HW-50216). These pressure surges continued for approximately one month at about three-day intervals and maximum pressures ranged from 0.2 to 0.6 psig. On February 18, 1957, one of the short ALCs in tank SX-107 was placed into service which eliminated bumping and the formation of a temperature gradient in the supernatant of tank SX-107 (HW-50216, page 4). Tank SX-107 was used as part of the testing, which was documented in HW-50216, to determine the frequency and severity of bumping in the tanks filled with REDOX HLW (see Section 3.2.2).

4.4.3 Liner Observations

The ARH-1100 (*200 Areas Operation Monthly Report*, page G-5) report indicates that photographs taken in December 1968 revealed bent piping in tank SX-107 confirming the presence of a bulged tank liner.

Subsequently in June 1969, the ARH-1105, page G-6, report states the following:

“Liner and sludge elevations have been obtained in the 107-SX tank; and data indicate that no bulge exists at present in the liner. This is the first time that efforts to map a bulge in a previously leaking tank have proven negative. It has been theorized that the tank liners lose integrity as a result of flexure of the steel plate due to bulging or shortly thereafter due to stress corrosion or cracking. In all other leaking tanks in which efforts to identify a bulge have been made, liner displacements of varying magnitudes have been mapped; however, experience in other tanks (113-SX) has shown that a bulge can subsequently relax after a leak has been created.”

A liner elevation measurement may have been obtained after June 1969; however, no other documentation was found to confirm the determination of the tank SX-107 bulged liner.

Conflicting liner bulge documentation raises the level of uncertainty as to whether the liner bulged or not and as mentioned above, some bulged liners can exhibit a dynamic flexing phenomena.

4.4.4 Chemistry-Corrosion

Waste Chemistry

Tank SX-107 began receiving REDOX HLW (R) in April 1956 and mostly stored only this waste type throughout operation except for a small addition of REDOX CW (see Table 4-1). The typical concentrations for nitrite, nitrate, and hydroxide for these waste types are shown in Table 4-2. Nitrite and hydroxide are known as nitrate-induced SCC inhibitors. One key characteristic for inhibiting SCC is to maintain a high nitrite concentration to nitrate concentration ratio (see Section 3.2.4).

Table 4-1. Tank SX-107 Waste Storage Chronology

Date	Waste Type	Length of Storage
April 1956 to January 1960	REDOX HLW	~ 3 years 8 months
January 1960	REDOX CW ¹	-
January 1960 - September 1968	REDOX HLW, REDOX CW	~ 8 years

¹The amount of REDOX CW added to the tank is unknown but is considered small. This CW was added on top of the REDOX HLW heel

Table 4-2. Waste Chemistries for Waste Types Stored in Tank SX-107

Waste Type	[NO ₃] ¹	[NO ₂] ¹	[OH] ¹	Meets Current DST Specification ²
CW ¹	0.6	0.9	1.0	Yes
R ³	4.83	0.74		No ⁴

1. Reference WHC-EP-0449, 1991, *The Sort on Radioactive Waste Type Model: A Method to Sort Single-Shell Tanks into Characteristic Groups*.
2. Reference OSD-T-151-00007, Rev. 12, (2013), *Operating Specifications for the Double-Shell Storage Tanks*.
3. Reference WHC-EP-0772, 1994, *Characterization of the Corrosion Behavior of the Carbon Steel Liner in Hanford Site Single-Shell Tanks*.
4. Does not meet the current DST specification since the hydroxide and nitrite concentrations are not greater than or equal to 1.2M.

Tank SX-107 stored mostly REDOX HLW throughout operation for approximately 12 years total. REDOX HLW does not meet the current DST specification for waste chemistry due to low concentrations of the nitrate-induced SCC inhibitors, nitrite and hydroxide. Thus, these conditions of the REDOX HLW would likely create an environment conducive to SCC and/or pitting (see Section 3.2.4). Tank SX-107 also received a small amount of REDOX CW on top of the REDOX HLW heel. REDOX CW should not increase the propensity for corrosion and probably would not have affected the tank chemistry as the ratio of REDOX HLW to CW would have been very high.

Supernatant samples results from March 1961 are shown in Table 4-3 which were obtained before the tank underwent sodium nitrate sludge leaching. These results indicate the supernatant would not meet the current DST specification since nitrate concentrations must be below or equal to 5.5 M (OSD-T-151-00007, Rev. 12). Under these conditions, the tank would be vulnerable to SCC and/or pitting.

Table 4-3. Tank SX-107 Supernatant Sample Results March 1961

Temperature	[OH] ⁻ M	[NO ₂] M	[NO ₃] M
271.4°F	1.27	0.65	8.65

Referenced from HW-64993, *Chemical Processing Department Monthly Report April, 1961*, page G-5

Nitrate Leaching

As discussed in Section 3.2.4, tank SX-107 was listed as one of the tanks that underwent sodium nitrate sludge leaching. Supernatant from tank SX-107 was transferred to tank SX-102 in December 1962 (see Table 4-4), and condensate (approximately 194 kgal) was added to tank

SX-107 from December 16-19, 1962 to start the sodium nitrate leaching process (see Table F1-1). Additional water (approximately 37 kgal) was added to the tank on December 29, 1962. The leaching period lasted ~37 days with the liquid level at ~230-in. Temperatures during the nitrate leaching period ranged from 200°F to 245°F. The nitrate leachate waste (approximately 219 kgal) was transferred out of tank SX-107 on January 22, 1963 to tank SX-114 leaving the liquid level at ~54-in. A total of approximately 71 kgal of condensate was added to tank SX-107 from tank SX-106 from January 23-25, 1963. On January 29, 1963, REDOX HLW was transferred to the tank, approximately one week after removal of the nitrate leachate waste (see Table F1-1). The first indication of a leak in tank SX-107 was detected in lateral 44-07-01 on March 9, 1964, approximately 14 months after initially starting the sodium nitrate leaching process.

Table 4-4. Tank SX-107 Nitrate Leaching Chronology

Date	Transfers/Comments	Duration	Reference
December 1962	Transferred ~580 kgal supernatant from tank SX-107 to tank SX-102 leaving ~114 kgal heel	N/A	See Table F1-1
December 16-19, 1962	Transferred ~194 kgal condensate to tank SX-107 from tank SX-106	3 days	
January 22, 1963	Transferred ~219 kgal nitrate leachate waste from tank SX-107 to tank SX-114	Leached for ~37 days	
January 1963	Transferred condensate from tank SX-106 and REDOX HLW to tank SX-107	Nitrate leachate heel stored 1 week	
March 1964	Earliest indication of a tank SX-107 leak	14 months from start of leaching	Current analysis

Sodium nitrate leaching reduces nitrite and hydroxide concentrations which would increase the propensity for corrosion especially at the relatively high temperatures experienced in tank SX-107.

4.4.5 Photographs

Photographs were reported in ARH-1100 to have been taken 24 hours after the start of air cooling in tank SX-107 and that the photographs show bent piping confirming the presence of a bulged tank liner. Air drying of sludge was reported to have been initiated December 19, 1968 (ARH-1061).

Earliest available photographs taken on December 26, 1968 for tank SX-107 were reviewed. There were no photographs that indicated the presence of bent piping as stated in the ARH-1100 document. However, photographs indicating ALCs with free hanging (unattached) turnbuckle guy rods are shown in Figure 4-4 and Figure 4-5. Figure 4-4 shows ALC #2 with a turnbuckle guy rod hanging free in the northwest quadrant of the tank and Figure 4-5 shows ALC #3 also with a turnbuckle guy rod hanging free in the southwest quadrant of the tank. This may also be an indication of a liner bulge that could have resulted in failure of the turnbuckle guy rod bottom liner attachment.

**Figure 4-4. Tank SX-107 ALC #2 Photograph 0684792-CN7
December 26, 1968**

Turnbuckle guy rod
hanging free

**Figure 4-5. Tank SX-107 ALC #3 Photograph 0684792-CN4
December 26, 1968**

The locations of all ALCs in tank SX-107 are shown in Figure 4-6 with the two ALCs (#2 and #3) located in the tank possibly showing evidence of a liner bulge. These are the only ALCs that have visible detached turnbuckle guy rods during this time.

Figure 4-6. Tank SX-107 Air Lift Circulator (ALC) Locations

4.5 TANK SX-107 EX-TANK DATA

4.5.1 Laterals

The first indication of a leak in tank SX-107 was recorded March 9, 1964 when radioactivity was detected in lateral 44-07-01; ~15-ft from the outer edge of the tank toward the center (see Appendix D1). The lateral radioactivity was initially indicated in March 1964 to be 5-ft long (HW-81620, *Chemical Processing Monthly Report March 1964*) and was subsequently reported to be 1-ft wide in April and May 1964 (HW-82089, *Chemical Processing Dept Monthly Report For April 1964*; HW-82526). Activity levels in the lateral continued to increase to a peak of 1,600K counts per minute (cpm) in August 1964 (HW-80202, *REDOX Weekly Process Reports January through December 1964*). No further change was detected until October 1965 when the radioactivity increased to 1,700K cpm (RL-SEP-297, *REDOX Weekly Process Reports January through December 1965*) and was then stable at that level through June 1966.

No lateral data were recovered from July 1966 until September 1968 when radioactivity was reported in lateral 44-07-02 and near the end of lateral 44-07-03 (ARH-308-DEL, *200 Areas Operation Monthly Report September 1968*). The specific location was not identified. The lateral 44-07-02 radioactivity location was assumed to be near the end of the lateral, similar to lateral 44-07-03. See Appendix D1 for tank SX-107 lateral data from December 1962 through June 1987.

Later lateral scans from June 11, 1986 are shown in Figure 4-7. It appears radioactivity was present along the entire portion underneath the tank shadow of lateral 44-07-02. It is possible radioactivity was similarly distributed in August 1968, when first detected in this lateral, since the location where the peak radioactivity was detected was not reported.

Figure 4-7. Tank SX-107 Lateral Scans June 11, 1986

Referenced from RPP-RPT-27605, Rev. 0, *Gamma Surveys of the Single-Shell Tank Laterals for A and SX Tank Farms*

The tank SX-107 laterals were surveyed in May 2005 and reported in RPP-RPT-27605. The 2005 gamma surveys indicate radioactivity was present in all three laterals and maximum Cs-137 was reported to be 5,500K, 69,000K, and 8,200K pCi/g in laterals 44-07-01, 44-07-02, and 44-07-03, respectively. See Figure 4-8 through Figure 4-10 for the 2005 lateral scans, which the locations of radioactivity correlate well with the historical data.

Figure 4-8. Summary Gamma Survey for Lateral 44-07-01 on Logarithmic Scale
May 2, 2005
(RPP-RPT-27605, Rev. 0)

Figure 4-9. Summary Gamma Survey for Lateral 44-07-02 on Logarithmic Scale
May 2, 2005
(RPP-RPT-27605, Rev. 0)

**Figure 4-10. Summary Gamma Survey for Lateral 44-07-03 on Logarithmic Scale
May 3, 2005
(RPP-RPT-27605, Rev. 0)**

4.5.2 Drywells

There are seven drywells located around tank SX-107: 41-07-02, 41-07-03, 41-07-05, 41-07-07, 41-07-08, 41-07-10, 41-07-12, and 41-10-01 installed in 1962. All of the radiation readings in drywells are assumed to be maximum values or peak readings unless otherwise noted and are from the Red-GM probe unless otherwise indicated (see Section 3.3.2). The bottom of the tank footing is ~52-ft 9-in BGS. The following subsections report the available drywell information and the drywell summary section provides the analyses of the associated drywells with tank SX-107.

4.5.2.1 Drywell 41-07-02 (N44°E)

Drywell 41-07-02 was drilled February 19, 1962 with the first recoverable reading on March 19, 1969 reported as less than 50K cpm. Radioactivity continued to be reported as less than values through June 1987 (see Appendix E1).

In November 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-07-02 (GJ-HAN-9). Cs-137 was detected from the ground surface to 24-ft BGS and from 57-ft to 76.5-ft BGS with the maximum concentration of 6 pCi/g detected at the surface. It was reported in GJ-HAN-9 that the Cs-137 detected from the ground surface to 24-ft BGS was the result of downward migration of surface contamination. Also stated in GJ-HAN-9, *“The zone of Cs-137 contamination from 57-ft to TD,”* [i.e., total depth of 76.5-ft], *“may have originated from a subsurface source. Although the activity is low, it is fairly continuous over an interval of almost 20 ft. This Cs-137 occurrence may represent the outer extent of a contamination plume originating from a distant source. This Cs-137 zone correlates with a change in the lithology.”*

Since the Cs-137 concentrations are so low, these zones cannot be identified on the gross gamma-ray log in Figure 4-11 (GJ-HAN-9). Figure 4-11 shows the depths of radioactivity from 1975 to 1995 (HNF-3136). Since historical records report little radioactivity in this drywell, drywell 41-07-02 is not included as part of the leak location for tank SX-107.

Figure 4-11. Tank SX-107 Drywell 41-07-02 (HNF-3136)

Note: Bottom of the tank footing is ~52-ft 9-in BGS

4.5.2.2 Drywell 41-07-03 (S85°E)

Drywell 41-07-03 was drilled February 20, 1962 with the first recoverable reading on March 19, 1969 reported as less than 50K cpm. Radioactivity continued to be reported as less than values through June 1987 (see Appendix E1).

In November 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-07-03 (GJ-HAN-9). Cs-137 was detected from the surface to 16.5-ft BGS, intermittently throughout the drywell, and at the bottom of the drywell. The maximum Cs-137 concentration of 4 pCi/g was reported at the surface and the maximum subsurface activity of 1.5 pCi/g occurred at 15-ft BGS. Document GJ-HAN-9 states, *“The Cs-137 contamination from the surface to a depth of 10.5 ft appears to have originated from a surface spill or near-surface leak; the Cs-137 activity decrease with depth. The low activity of the contamination suggests either a small spill or that the source is some distance from the borehole.”*

Since historical records report little radioactivity in this drywell, drywell 41-07-03 is not included as part of the leak location for tank SX-107. Figure 4-12 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 4-12. Tank SX-107 Drywell 41-07-03 (HNF-3136)

Note: Bottom of the tank footing is ~52-ft 9-in BGS

4.5.2.3 Drywell 41-07-05 (S33°E)

Drywell 41-07-05 was drilled February 28, 1962 with the first recoverable reading on January 24, 1968 which reported a peak at 50-59-ft BGS with the scintillation probe, but radioactivity levels are unclear. Radioactivity in this drywell was reported to have increased in activity in August 1968 (ARH-308-DEL), but radiation levels were not reported. The next recoverable reading on March 27, 1969 reported a peak of 790K cpm at 56-ft BGS (see Appendix E1). Radioactivity remained relatively stable at this depth through June 1987.

In November 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-07-05 (GJ-HAN-9). Cs-137 was reported from the ground surface to 12-ft, from 47.5 to 61-ft, and from 66.5 to 75-ft BGS. The detector was saturated from 53 to 59.5-ft BGS, where the total gamma-ray count rate exceeded 250K counts per second (cps). It was stated in GJ-HAN-9 that, *"The zone of Cs-137 contamination from 48.5 to 61 ft is located near the base of the tank and is the result of a leak from tank SX-107. The zone was observed on the earliest (1971) Tank Farm gross gamma-ray log data on file."* Figure 4-13 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 4-13. Tank SX-107 Drywell 41-07-05 (HNF-3136)

Note: Bottom of the tank footing is ~52-ft 9-in BGS

4.5.2.4 Drywell 41-07-07 (S19°W)

Drywell 41-07-07 was drilled February 28, 1962 with the first recoverable reading on January 24, 1968 reported as less than 50K cpm (see Appendix E1). Radioactivity was reported to have increased in activity in August 1968 (ARH-308-DEL), but radiation levels were not reported. The next recoverable reading on March 27, 1969 reported two peaks at 59-ft and 63-ft BGS at 170K cpm and 122K cpm, respectively. Readings remained relatively stable for these two peaks through January 1970. Beginning in February 1970, only one peak at 515K cpm was reported at 59-ft BGS. Radioactivity remained relatively stable through June 1987 (see Appendix E1).

In November 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-07-07 (GJ-HAN-9). Cs-137 was identified from the ground surface to 74.5-ft BGS (total depth). The detector was saturated from 54.5 to 67-ft BGS and the maximum Cs-137 concentration was greater than 400 pCi/g which was reported just below the detector saturation region. It was reported in GJ-HAN-9 that, *“The Cs-137 contamination from approximately 53 to 69 ft is the result of leakage from tank SX-107.”* Figure 4-14 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 4-14. Tank SX-107 Drywell 41-07-07 (HNF-3136)

Note: Bottom of the tank footing is ~52-ft 9-in BGS

4.5.2.5 Drywell 41-07-08 (S71°W)

Drywell 41-07-08 was drilled February 22, 1962 with the first recoverable reading on March 19, 1969 reported as less than 50K cpm and radioactivity continued to be recorded as less than values through August 1, 1974 (see Appendix E1). From January to March 1976, radioactivity was reported as 3K cpm at approximately 57-ft BGS until November 1976 when radioactivity increased to 51K cpm at 56-ft BGS. Radiation levels continued to increase significantly from November 1976 through June 1987 (see Appendix E1).

In November 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-07-08. Cs-137 was detected from the ground surface to 12.5-ft BGS and from 52.5 to 77-ft BGS with the maximum concentration of 900 pCi/g reported at 59-ft BGS. Document GJ-HAN-9 states, *“The zone of Cs-137 contamination occurring from about 55 ft to TD,”* [i.e. total depth of 77-ft BGS], *“is the result of leakage from tank SX-107. The top of the contamination zone is near the tank base. The zone of Cs-137 contamination from 55 to 62 ft developed rapidly from 1976 to 1980; however, since 1980, the intensity has remained high but stable.”* Figure 4-15 shows the depths of radioactivity from 1974 to 1995 (HNF-3136).

Figure 4-15. Tank SX-107 Drywell 41-07-08 (HNF-3136)

Note: Bottom of the tank footing is ~52-ft 9-in BGS

4.5.2.6 Drywell 41-07-10 (N58°W)

Drywell 41-07-10 was drilled February 23, 1962 with the first recoverable reading on March 19, 1969 reported as less than 50K cpm and radioactivity continued to be recorded as less than values through June 1987 (see Appendix E1).

In November 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-07-10 (GJ-HAN-9). Cs-137 was detected from the ground surface to 12.5-ft BGS and from 37 to 53-ft BGS with the maximum concentration of 5 pCi/g detected at the ground surface. Document GJ-HAN-9 states, *“The Cs-137 contamination from 37 to 53 ft has a maximum activity of less than 1 pCi/g. It may be the result of contaminated sediments that were driven downward from the surface during borehole drilling.”* Also stated in this document is that contamination from the ground surface to 12.5-ft BGS is the result of downward migration of a surface spill or leak.

Since historical records report little radioactivity in this drywell, drywell 41-07-10 is not included as part of the leak location for tank SX-107. Figure 4-16 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 4-16. Tank SX-107 Drywell 41-07-10 (HNF-3136)

Note: Bottom of the tank footing is ~52-ft 9-in BGS

4.5.2.7 Drywell 41-07-12 (N4°W)

Drywell 41-07-12 was drilled February 16, 1962 with the first recoverable reading on March 19, 1969 reported as less than 50K cpm and radioactivity continued to be recorded as less than values through July 1987 (see Appendix E1).

In November 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-07-12 (GJ-HAN-9). Cs-137 was detected from the ground surface to 20-ft, from 54 to 56-ft, and from 61 to 65-ft BGS with the maximum concentration of 18 pCi/g reported at 1-ft BGS. Document GJ-HAN-9 states, *“The Cs-137 contamination from the surface to a depth of 20 ft is the result of a surface spill or leak. The Cs-137 contamination from 61 to 65 ft is clearly related to a lithologic change at about 63 ft. This contamination is most likely the outer extent of the contamination plume caused by leakage from tank SX-107.”* Also stated in this document, *“The contamination from 54 to 56 ft may have surface or subsurface sources. Being located near the tank base, it may be related to the leakage from tank SX-107. However, because of the low activity of the contamination, it may be redistribution of contaminated sediments during borehole drilling.”*

Since historical records report little radioactivity in this drywell, drywell 41-07-12 is not included as part of the leak location for tank SX-107. Figure 4-17 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 4-17. Tank SX-107 Drywell 41-07-12 (HNF-3136)

Note: Bottom of the tank footing is ~52-ft 9-in BGS

4.5.2.8 Drywell 41-10-01 (S19°W)

Drywell 41-10-01 was drilled in February 22, 1962 with the first recoverable reading on March 26, 1969 reported peak radioactivity of 315K cpm at ~66-ft BGS (see Appendix E1). Radioactivity remained relatively stable through August 1969 at 66-ft BGS. Radioactivity levels started to slowly decrease in September 1969 (230K cpm at 65-ft BGS) to 3K cpm by May 1987 at 67-ft BGS (see Appendix E1).

In December 1995, Cs-137 was the only radionuclide detected in drywell 41-10-01 (GJ-HAN-12). Cs-137 was detected from the ground surface to 5-ft, from 65 to 67-ft BGS, and at the bottom of the drywell. The maximum Cs-137 concentration of 7 pCi/g was reported at 66-ft BGS. Document GJ-HAN-12 states, *“The Cs-137 contamination from 65 to 76 ft probably originated from a subsurface source. Borehole 41-07-05 is located about 20 ft northeast of borehole 41-10-01. An interval of high Cs-137 activity was identified in borehole 41-07-05 from a depth of 50 to 60ft; the contamination detected from 65 to 67 ft in borehole 41-10-01 probably represents the outer fringe of the contamination plume resulting from the leakage from tank SX-107.”* Figure 4-18 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 4-18. Tank SX-107 Drywell 41-10-01 (HNF-3136)

Note: Bottom of the tank footing is ~52-ft 9-in BGS

4.5.3 Tank SX-107 Drywell Summary

Tank SX-107 was first suspected of leaking at the beginning of March 1964 due to increased radioactivity detected in one of the laterals. No drywell data were recovered during this time and earliest data available was January 1968 for two drywells and March 1969 for the remainder drywells.

The tank SX-107 drywells 41-07-02, 41-07-03, 41-07-10, and 41-07-12 either do not indicate any radioactivity associated with a tank leak or have low levels of radioactivity reported in historical data. Therefore, these drywells are not included in the leak location analysis for tank SX-107.

Radioactivity in drywell 41-07-05 first appeared before January 1968 from 50 to 59-ft BGS. Radioactivity was reported to have increased in drywell 41-07-07 in August 1968; however, the depths and radioactivity level were not reported. Beginning in March 1969, two peaks were reported in drywell 41-07-07 at 59-ft and 63-ft BGS. In March 1969, radioactivity was also reported in drywell 41-10-01 at a lower depth of 66-ft BGS probably due to migration of the tank SX-107 leak.

The first recoverable drywell data indicating radioactivity were in drywells 41-07-05 and 41-07-07, about four years after the first recoverable lateral radiation readings. On the basis of the highest concentration profile existing in drywell 41-07-07, it is likely that this drywell is closest to the location of the leak (RPP-ENV-39658). These were the only drywells that had reported contamination during this time.

Beginning in November 1976, radioactivity was first reported in drywell 41-07-08 at 57-ft BGS. This could be the result of migration from the leak reported in the southern portion of the tank and/or possibly a new leak site.

4.6 POSSIBLE TANK SX-107 LINER LEAK LOCATION(S)

The lateral radioactivity when first detected could be an indication of the location of a liner leak. However, the liner leak may have penetrated the waterproof membrane at any location or pooled on the waterproof membrane and followed concrete cracks or breaks to a different location including the top of the tank footing.

It is likely that the tank SX-107 leak occurred at or near the bottom of the tank. All of the leak indicators, three laterals and four drywells, were located at or near the bottom of the tank.

4.6.1 Leak Detected in 1964, Site A

Tank SX-107 was first suspected of leaking at the beginning of March 1964 due to increased radioactivity detected in lateral 44-07-01 in the north portion of the tank (see site A in Figure 4-19) under the tank, approximately 15-ft from northwest edge. This radioactivity was found approximately one year after the start of nitrate leaching. Radioactivity continued to slowly increase in this lateral through October 1965. No radioactivity was detected in the other laterals and no drywell data were recovered during this time period.

Figure 4-19. Tank SX-107 Possible Leak Location (1964)
Tank inner ring is steel liner, outer ring is outer edge of tank footing

Tank SX-107 was first suspected of leaking in March 1964 due to radioactivity being detected in lateral 44-07-01

4.6.2 Leak Detected in 1968-1969, Site B

The first recoverable reading in the drywells reported radioactivity in drywell 41-07-05 on January 19, 1968 from 50 to 59-ft BGS. The only drywell data recovered at this time was for drywells 41-07-05 and 41-07-07 and there was no reportable contamination in drywell 41-07-07 during this time. In September 1968, radioactivity was detected in the center lateral 44-07-02 and near the end of lateral 44-07-03 (see site B in Figure 4-20). In March 1969, radioactivity increased in drywell 41-07-07 (two peaks reported at 59-ft and 63-ft BGS). Also during this time, the first recoverable reading for drywell 41-10-01 reported radioactivity at 66-ft BGS.

This second site of radioactivity is at the opposite side of the tank from the first indication of a leak in lateral 44-07-01 (see site A in Figure 4-19) and appears to be a separate leak site. Later lateral data from 1986 indicate radioactivity was detected along the entire length of lateral 44-07-02 in the tank shadow (see Section 4.5.1).

Figure 4-20. Tank SX-107 Possible Leak Location (1968-1969)
Tank inner ring is steel liner, outer ring is outer edge of tank footing

Tank SX-107 was first suspected of leaking in March 1964 due to radioactivity being detected in lateral 44-07-01

4.6.3 Leak Detected in 1976, Site C

Beginning in January 1975 to March 1976 radioactivity was reported in drywell 41-07-08 with a peak of 3K cpm reported between 56 to 60-ft BGS. However, radioactivity increased significantly in November 1976 at 56-ft BGS. This third location, designated as site C in Figure 4-21, may be a separate leak site or there may be horizontal migration from one of the other previous sites (see sites A and B shown in Figure 4-22) to this drywell.

Figure 4-21. Tank SX-107 Possible Leak Location (1976)
Tank inner ring is steel liner, outer ring is outer edge of tank footing

Tank SX-107 was first suspected of leaking in March 1964 due to radioactivity being detected in lateral 44-07-01

4.6.4 Leak Location Summary

Tank SX-107 was first suspected of leaking in March 1964 based on radioactivity detected in lateral 44-07-01 in the north portion of the tank as shown by site A in Figure 4-19. No drywell data were recovered during this time and no radioactivity was detected in the other two laterals.

The first recoverable reading for drywell 41-07-05 in January 1968 reported radioactivity from 50 to 59-ft BGS. Beginning in September 1968, radioactivity was detected in the center lateral 44-07-02 and near the end of lateral 44-07-03 (see site B in Figure 4-20). In March 1969, radioactivity increased in drywell 41-07-07 (two peaks reported at 59-ft and 63-ft BGS). Also during this time, the first recoverable reading for drywell 41-10-01 reported radioactivity at 66-ft BGS. This could possibly be the result of the migration of the leak from 1964 or from a new leak location. Later lateral data from 1986 indicates radioactivity was detected along the entire length of lateral 44-07-02 in the tank shadow (see Section 4.5.1).

Beginning in January 1975 to March 1976 radioactivity was reported in drywell 41-07-08 with a peak of 3K cpm reported between 56 to 60-ft BGS. However, radioactivity increased significantly in November 1976 at 56-ft BGS (see site C in Figure 4-21) indicating a new possible leak location or migration of an earlier leak.

Figure 4-22 shows a composite of the leak location sites. It is likely the leak occurred at or near the bottom of the tank since all of the leak indicators (laterals and drywells) were located at or near the tank bottom. Leak locations in Figure 4-22 are based on peak readings and are a representation of possible initial boundaries of radioactivity.

There is a possibility of a liner bulge in the western half of the tank which has been indicated by ALC #2 and #3 guy rod hanging free (see Section 4.4.3). However, there is no direct evidence and the possible location remains inconclusive.

Figure 4-22. Tank SX-107 Possible Radial Leak Locations
 Tank inner ring is steel liner, outer ring is outer edge of tank footing

4.7 POSSIBLE TANK SX-107 LINER LEAK CAUSE(S)

Tank SX-107 was exposed to five conditions that could contribute to a failed liner. Some or all of the factors can act together to contribute to tank liner failure.

4.7.1 Tank Design

The design of the SX Farm tanks was the first that diverged from the round bottom knuckle design used in the earlier waste tanks; the tank bottom liner intersects the sidewall liner orthogonally. A fillet weld was used to close the seam where the sidewall and the tank bottom liner meet. Several other SSTs with fillet welds failed during service (RPP-RPT-45921). Weld inspections were less rigorous. Additionally, the design discontinued the use of the three-ply asphaltic membrane waterproofing between the liner sidewall and the concrete shell. These features were inferior to others and could possibly increase the likelihood of failure of the tank liner from induced stresses (see Section 4.3.1).

4.7.2 Thermal Conditions

Temperature requirements in HW-59919 issued October 22, 1959 indicated that the self-boiling waste operating temperature should be maintained between 50°F and 220°F. The HW-59919 document recommended a uniform rate of temperature increase of 2°F per day and the maximum sludge temperature should not exceed 300°F.

The maximum sludge temperature of 390°F was reported on two separate occasions in February 1958 (see Section 4.4.2). Tank SX-107 temperatures exceeded the maximum sludge temperature limit on several occasions as discussed in Section 4.4.2.

Assuming a 55°F initial temperature of the tank liner when waste was first received on April 13, 1956, the temperature rose to ~165°F by May 2, 1956 (see Appendix B1). Tank SX-113 temperature recorded February 26, 1958 before receiving waste was 42°F, therefore 55°F may not be the worst case for ambient temperature for tank SX-107 in April 1956. No tank SX-107 temperature records were found before the tank began receiving waste. Over this 19 day period there was a temperature increase of ~110°F, and the average rate of rise was ~5.8°F per day which is above the recommended rate of 2°F per day.

The rate of temperature rise reached ~5.9°F per day from January 15, 1958 to February 5, 1958 when temperatures rose from ~265°F to the maximum temperature of 390°F.

Note that the operating temperature limitations specified in HW-59919 were exceeded both before and after issuing the document. Thermal shock creates stress both from rapid temperature rise as well as waste-induced high temperatures.

4.7.3 Chemistry-Corrosion

Tank SX-107 was first filled with REDOX HLW (April 1956) which was stored in the tank for ~12 years total before the tank was suspected of leaking in March 1964. In January 1960, a small amount of REDOX CW was added on top of the REDOX HLW heel. Besides this small addition, tank SX-107 only stored REDOX HLW.

The REDOX HLW consisting of low concentrations of nitrite and hydroxide would have created an environment conducive to pitting and SCC. Results from supernatant samples obtained in March 1961 from tank SX-107 indicate the waste chemistry would not meet the current DST specification (see Section 4.4.4). Under these conditions, there would be a high propensity for corrosion.

Sodium nitrate leaching of tank SX-107 waste started in December 1962 with the transfer of supernatant out of the tank. The remaining nitrate-rich sludge was leached and the sodium nitrate solution (leachate) was transferred out of tank SX-107 to tank SX-114 in January 1963. Transfer of the supernatant prior to leaching decreased nitrite and hydroxide ions which are SCC inhibitors. Loss of the protective nitrite and hydroxide ions would have created an environment conducive to SCC and/or pitting of the tank liner.

4.7.4 Liner Observations

Report ARH-1100 states that photographs indicate a bulged liner; however, report ARH-1105 indicates that tank bottom soundings did not indicate a bulge. Subsequent reports, ARH-R-43 and RHO-R-39, both claim a bulge was present. A review of photographic evidence seems to indicate a possible liner bulge at least from an observation of detachment of the ALC turnbuckle guy rods (see Section 4.4.5). The evidence of a liner bulge is possible in tank SX-107, but the location of the bulge is uncertain. Liner bulging coupled with other tank conditions could affect tank liner integrity; however, by itself bulging can induce stresses that could result in locations that are more susceptible to corrosion.

4.7.5 Tank Construction Temperature

Winter temperatures as low as -6°F occurred during the period when the SX Farm tank liners were being constructed and leak tested (see Section 4.3.2). The low temperatures experienced during construction were less than the current 18°F allowable temperature where impact loading had the potential for creating micro-fissures. Impact occurrences could have occurred during cold temperatures that may have triggered fissures in the steel liner. Later, when the metal is subjected to high stress, it might be possible for the cracks to propagate through the metal, or possibly subject the weakened areas to increased corrosion.

4.8 TANK SX-107 CONCLUSIONS

Evidence indicates that the tank SX-107 liner leaked at or near the bottom of the tank in either two or three locations. Based on engineering judgment and available information the following conditions listed in the order of importance lead to the tank SX-107 failed liner:

1. Thermal conditions – rate of temperature rise and maximum temperature
2. Tank design – expansion limiting design changes
3. Waste storage chemistry and nitrate leaching – corrosion- SCC and/or pitting
4. Construction conditions – ductile-to-brittle transition temperature
5. Bulging liner – an effect of primarily thermal conditions along with tank design and potentially nitrate leaching

There are several liner leak cause conditions that were examined, but the primary cause is the tank SX-107 thermal conditions experienced during the rapid addition of high temperature waste to a cold tank as well as waste storage temperatures. Also, the unique tank design did not allow for expansion of the bottom liner as the tank heated creating stresses. Storage of REDOX HLW at elevated temperatures and subsequent nitrate leaching created a chemical environment susceptible to nitrate-induced SCC and/or pitting attack on an already stressed metal liner. Tank construction occurred in winter under cold temperature conditions which could have affected the ductile-to-brittle steel transition temperature where metal loses its ability to absorb forces such as induced loads or the impact of falling objects creating micro-fissures or hairline cracks. In addition, a bulged bottom imparts stresses in the liner that could have predisposed it to SCC. Some or all of the factors can act serially or together to contribute to tank liner failure.

APPENDIX A1

TANK SX-107 BOILING WASTE OPERATIONAL HISTORY

Table A1-1. RHO-R-39 Boiling Waste Tank Operating Data Table

Tank No.	First Waste	Tank Pre-Heated	Pre-Heat Start	Liquid Heel Used	First Waste Rec'd From	Tank Failed	Inspected For Bulge	Bulge Present	Did Tank Boil on 1st Loading	Tank Started Boiling	Tank Emptied & Reused*	NaNO ₃ Leached from Sludge
101-SX	19 May 54	No	-	No	Redox	No	No	-	Yes	Nov 54	No	No
102-SX	Sep 54	No	-	No	101-SX, Cascade	No	No	-	No	-	No	No
103-SX	Nov 54	No	-	No	102-SX, Cascade	No	No	-	No	-	No	No
104-SX	2 Feb 55	No	-	No	Redox	No	No	-	Yes	Jun 55	No	No
105-SX	11 May 55	No	-	No	104-SX, Cascade	No	No	-	No	-	Yes	No
106-SX	Jun 54	No	-	No	Tank Farm Condensate	No	No	-	No	-	-	-
107-SX	3 Mar 56	No	-	Yes	Redox	Yes, 1964	Yes	Yes	Yes	Jun 56	Yes	Yes
108-SX	8 Nov 55	No	-	No	Redox	Yes, 1962	Yes	Yes	Yes	Jun 56	Yes	Yes
109-SX	20 Sep 55	No	-	Yes	Redox	Yes, 1965	Yes	No	Yes	Dec 55	Yes	No
110-SX	Nov 60	Yes	Apr 60	No	Redox	-	No	-	No	Between 1/61-6/61	Yes	No
111-SX	9 Jun 56	No	-	No	Redox	-	No	-	Yes	Nov 56	Yes	No
112-SX	13 Feb 56	No	-	No	Redox	Yes, 1969	Yes	Yes	Yes	Mar 56	Yes	No
113-SX	20 Feb 58	No	-	No	Redox	Yes, 1958	Yes	Yes	Yes	Apr 58	No	No
114-SX	Nov 56	No	-	No	Redox	-	No	-	Yes	Jun 57	Yes	Yes
115-SX	4 Nov 59	Yes	Sep 58	Yes	Redox	Yes, 1965	No	-	Yes	Nov 59	No	Yes
101-A	20 Jan 56	No	-	6" H ₂ O	Purex	No	Yes	No	Yes	Jul 57	Yes	No
102-A	20 Mar 56	No	-	6" H ₂ O	Purex	No	No	-	Yes	Jul 58	Yes	No
103-A	15 May 56	No	-	6" H ₂ O	Purex	No	No	-	Yes	Jul 56	Yes	No
104-A	30 Jun 59	No	-	6" H ₂ O	Purex	No	Yes	No	Yes	Aug 59	Yes	No
105-A	31 Jan 63	Yes	Jan 63	Yes	Purex	Yes, 1963	Yes	Yes	No***	Mar 63	No	No
106-A	31 Dec 60**	Yes	23 Feb 61	Yes	Purex	No	No	-	Yes	Aug 61	Yes	No
101-AX	1 Jun 65**	Yes	23 Nov 66	Yes	TK-103-A and TK-112-B	No	No	-	No***	Dec 66	Yes	No
102-AX	30 Sep 66**	Yes	2 Mar 69	Yes	TK-101-AX and TK-103-A	No	No	-	No***	Apr 69	No	No
103-AX	10 Feb 65	Yes	Nov 64	Yes	Purex	No	No	-	Yes	Apr 65	No	No
104-AX	9 Sep 66	Yes	Jun 66	Yes	Purex	No	No	-	Yes	Oct 66	No	No

* Emptied indicates supernatant was pumped out but sludge remained.

** Tanks used for temporary waste storage prior to the receipt of LWW or HLW.

*** Did not boil until LWW was routed to the tank.

Note: SX-111 was found to have been NaNO₃ Leached

Table A1-2. ARH-R-43 Waste Tank Leak Experience Table

TABLE 3. Underground Waste Storage Tank Leak Experience

Tank	Built	First Used	Type of Waste Stored	Service	Leak First Suspected	Reason for Suspicion	Leak Confirmed by	Bulge Found	Estimated Volume of Leak, gal	Associated Cs-137, kCi
104-U	1943-44	1947	Bismuth phosphate waste Uranium recovery waste	Nonboiling	1956	Bulged liner	Refill with water (1961)	Yes	55,000*	0.09
113-SX	1953-54	1958	Redox waste	Boiling	1958	Bulged liner	Refill with salt solution (1962)	Yes	15,000**	8
106-TV	1951-52	1953	TBP waste	Nonboiling	1959	Liquid level measurements	Soil radiation readings (1959)		20,000	2
101-U	1943-44	1946	Bismuth phosphate waste Uranium recovery waste Redox waste	Nonboiling	1959	Liquid level measurements	Liquid level measurements		30,000	23
105-TV	1951-52	1953	TBP waste	Nonboiling	1960	Liquid level measurements	Liquid level measurements		35,000	4
108-SX	1953-54	1955	Redox waste	Boiling	1962	Soil radiation readings	Liquid level measurements	Yes	3,400	17
105-A	1954-55	1963	Purex waste	Boiling	1963	Soil radiation readings	Soil radiation readings	Yes	Small	
107-SX	1953-54	1956	Redox waste	Boiling	1964	Soil radiation readings	Soil radiation readings	Yes	Small	
109-SX	1953-54	1955	Redox waste	Boiling	1965	Soil radiation readings	No further evidence	No	Small	
115-SX	1953-54	1958	Redox waste	Boiling	1965	Liquid level measurements	Soil radiation readings		50,000***	40
112-SX	1953-54	1956	Redox waste	Boiling	1969	Liquid level measurements	Soil radiation readings	Yes	30,000	45

* Contained water at time of leak.
 ** Contained NaNO_3 solution at time of leak, also some residual supernatant solution.
 *** Contained NaNO_3 solution at time of leak.

Note: See tank farm segments for information on individual specific tanks

APPENDIX B1

TANK SX-107 TEMPERATURES JANUARY 1956 - DECEMBER 1956

Figure B1-1. Tank SX-107 Sludge Temperature April to June 1956

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure B1-2. Tank SX-107 Sludge Temperature July to December 1956

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

APPENDIX C1

TANK SX-107 TEMPERATURE AUGUST 1956 TO JANUARY 1968

Figure C1-1. RHO-CD-1172 Tank SX-107 Temperature August 1956 to December 1956

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C1-2. RHO-CD-1172 Tank SX-107 Temperature January 1957 to July 1958

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C1-3. RHO-CD-1172 Tank SX-107 Temperature August 1958 to February 1960

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C1-4. RHO-CD-1172 Tank SX-107 Temperature March 1960 to September 1961

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C1-5. RHO-CD-1172 Tank SX-107 Temperature October 1961 to April 1963

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C1-6. RHO-CD-1172 Tank SX-107 Temperature May 1963 to November 1964

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C1-7. RHO-CD-1172 Tank SX-107 Temperature December 1964 to June 1966

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C1-8. RHO-CD-1172 Tank SX-107 Temperature July 1966 to January 1968

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

APPENDIX D1

TANK SX-107 LATERAL ACTIVITY

**Table D1-1. Tank SX-107 Lateral Radioactivity (counts per minute) (December 1962 through June 1987)
(RPP-ENV-39658, Rev. 0, and RPP-RPT-29191) (1 of 2 sheets)**

Date	Reference	241-SX-107		
		44-07-01	44-07-02	44-07-03
12/62	A	No activity detected		
7/63	B	“Continued checking of the laterals under the SX storage tanks. No change was detected.” ³		
8/63	C	“Continued checking of the laterals under the SX storage tanks. No change was detected.” ³		
9/63	D	“Continued checking of the laterals under the SX storage tanks. No change was detected.” ³		
10/63	E	“Continued checking of laterals, no change in readings noted.” ³		
11/63	F	“Continued checking of laterals, no change in readings noted.” ³		
12/63	G	“Continued checking of laterals, no significant change in readings noted.” ³		
1/64	H	“Continued with no significant changes noted.” ³		
2/64	I	“No changes noted except for a 550 c/m reading detected in the South lateral under the 114-SX Tank. Daily checking revealed no change at the end of the month.”		
3/9/64	HW-81620	2.5 K: ~15 ft ²	N/A ⁴	N/A ⁴
3/10/64	J page 41	5.5 K: ~15 ft ²	No activity	No activity
3/21/64	J page 45	10 K: ~15 ft ²	N/A ⁴	N/A ⁴
3/31/64	HW-81620	26 K: ~15 ft ²	N/A ⁴	N/A ⁴
5/1/64	J page 92	80 K: ~15 ft ²	No activity	No activity
5/28/64	J page 92	138 K: ~15 ft ²	No activity	No activity
8/31/64	J page 153	1,600 K	No activity	No activity
9/30/64	J page 176	No change	N/A ⁴	N/A ⁴
3/31/65	K page 65	“No significant change in lateral activity or drywells around tank.” ³		
4/29/65	K page 87	“No change.” ³		
5/26/65	K page 99	“No significant change in laterals or drywell readings.” ³		
6/23/65	K page 111	“No significant change in laterals or drywell readings noted.” ³		
7/14/65	K page 120	“No significant change in laterals or drywell readings.” ³		
8/4/65	K page 129	“No significant change in laterals or drywell readings.” ³		
10/13/65	K page 159	1,700 K at 14.4 ft ² 8 K at 36.4 ft ²	N/A ⁴	N/A ⁴
10/20/65	K page 162	1,700 K at 14.4 ft ² 8 K at 36.4 ft ²	N/A ⁴	N/A ⁴
10/27/65	K page 165	“No significant change in laterals or drywell readings.” ³		
11/24/65	K page 177	“No significant change in laterals or drywell readings.” ³		

**Table D1-1. Tank SX-107 Lateral Radioactivity (counts per minute) (December 1962 through June 1987)
(RPP-ENV-39658, Rev. 0, and RPP-RPT-29191) (2 of 2 sheets)**

Date	Reference	241-SX-107		
		44-07-01	44-07-02	44-07-03
12/22/65	K page 189	“No significant change in laterals or drywell readings.” ³		
1/31/66	L page 10	1,700 K	N/A ⁴	N/A ⁴
2/28/66	M page 11	1,710 K	N/A ⁴	N/A ⁴
3/31/66	N page 13	1,700 K	N/A ⁴	N/A ⁴
4/30/66	O page 13	1,700 K	N/A ⁴	N/A ⁴
5/31/66	P page 11	1,650 K	N/A ⁴	N/A ⁴
6/30/66	Q page 11	1,620 K	N/A ⁴	N/A ⁴
9/9/68 9/23/68	R pages D-2, G-4	N/A ⁴	2 M-3 M	Increased activity
1/2/73	S page 41-07-08	420 K	780 K	975 K
12/31/73	S page 41-07-08	190 K	1,245 K	570 K
9/4/74	S page 41-07-08	132 K	780 K	300 K
7/28/80	S page 41-07-08	N/A ⁴	N/A ⁴	257 K/ 180 K
6/15/81	S page 41-07-08	102 K	624 K	253 K/NA
7/26/82	S page 41-07-08	90 K	580 K/42 K	246 K/192 K
6/14/83	S page 41-07-09	83 K	614 K/45 K	249 K/NA
6/5/84	S page 41-07-08	78 K/115 K	629 K/48 K	249 K/216 K
6/17/85	S page 41-07-08	57 K/124 K	499 K/45 K Stable	241 K/204 K
6/23/87	S page 41-07-08	46 K/141 K Stable	651 K/45 K Stable	255 K/213 K Stable

Notes:

1. West from edge of tank
2. Under west side of tank
3. Ambiguous statement but commonly used to mean that the previous reading has not changed
4. N/A: Data not available

Reference A is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation December 1962*, Rough Draft (Harmon 1963a)

Reference B is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation July 1963*, Rough Draft (Harmon 1963h)

Reference C is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation August 1963*, Rough Draft (Harmon 1963i)

Reference D is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation September 1963*, Rough Draft (Harmon 1963j)

Reference E is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation October 1963*, Rough Draft (Harmon 1963k)

Reference F is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation November 1963*, Rough Draft (Harmon 1963l)

Reference G is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation December 1963*, Rough Draft (Harmon 1963m)

Reference H is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation January 1964*, Rough Draft (Harmon 1964a)

Reference I is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation February 1964*, Rough Draft (Harmon 1964b)

Reference J is HW-80202, *REDOX Weekly Process Reports January through December, 1964*
Reference K is RL-SEP-297, *REDOX Weekly Process Reports January through December, 1965*
Reference L is HAN-93855-1, 1966, *200 Area Monthly Report for January 1966*
Reference M is HAN-93855-2, 1966, *200 Area Monthly Report for February 1966*
Reference N is HAN-93855-3, 1966, *200 Area Monthly Report for March 1966*
Reference O is HAN-93855-4-DEL, 1966, *200 Area Monthly Report for April 1966*
Reference P is HAN-93855-5, 1966, *200 Area Monthly Report for May 1966*
Reference Q is HAN-93855-6-DEL, 1966, *200 Area Monthly Report for June 1966*
Reference R is ARH-308-DEL, 1968, *200 Areas Operation Monthly Report September 1968*
Reference S is SD-WM-TI-356, 1988, *Waste Storage Tank Status and Leak Detection Criteria*

APPENDIX E1

TANK SX-107 GROSS GAMMA DRYWELL DATA

Table E1-1. Tank SX-107 Drywell Radioactivity (GMP K counts per minute) (March 1969 to June 1987)
(Drywell Data Sheets Retrieved on March 8, 2011 and SD-WM-TI-356) (1 of 3 sheets)¹

41-07-02		41-07-03		41-07-05			41-07-07			41-07-08			41-07-10		41-07-12		41-10-01 ⁴		
Drilled 2/19/1962		Drilled 2/20/62		Drilled 2/28/62			Drilled 2/28/62			Drilled 2/22/62			Drilled 2/23/62		Drilled 2/16/62		Drilled 2/22/62		
Date	Peak (K cpm)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)
N/A ³		N/A ³		1/24/68	Present ⁵	50-59	1/24/68	< 50 ⁵	N/A ³	N/A ³			N/A ³		N/A ³		N/A ³		
3/19/69	< 50	3/19/69	< 50	3/27/69	790	56	3/27/69	170	59	3/19/69	< 50	N/A ³	3/19/69	< 50	3/19/69	< 50	3/26/69	315	66
4/3/69	< 50	4/3/69	< 50	4/1/69	860	56		122	63	4/3/69	< 50	N/A ³	4/3/69	< 50	4/3/69	< 50	4/8/69	380	66
5/8/69	< 50	5/8/69	< 50	5/6/69	785	56	5/6/69	175	59	5/8/69	< 50	N/A ³	5/8/69	< 50	5/8/69	< 50	5/5/69	260	66
				6/11/69	815	56		150	63										
7/17/69	< 50	7/17/69	< 50	7/9/69	680	55	6/11/69	180	63	7/17/69	< 50	N/A ³	7/17/69	< 50	7/17/69	< 50	6/12/69	250	66
8/19/69	< 50	8/19/69	< 50	8/8/69	< 1000	54.6		145	63	8/19/69	< 50	N/A ³	8/20/69	< 50	8/19/69	< 50			
9/22/69	< 50	9/22/69	< 50	9/1/69	905	56	7/9/69	178	57	9/22/69	< 50	N/A ³	9/22/69	< 50	9/22/69	< 50	7/8/69	308	65
10/16/69	< 50	10/16/69	< 50	10/2/69	900	56		130	59	10/16/69	< 50	N/A ³	10/16/69	< 50	10/16/69	< 50			
11/20/69	< 50	11/20/69	< 50	11/5/69	900	56	8/8/69	285	59	11/20/69	< 50	N/A ³	11/20/69	< 50	11/20/69	< 50	8/7/69	310	67
12/18/69	< 50	12/18/69	< 50	12/1/69	850	56		238	63	12/18/69	< 50	N/A ³	12/18/69	< 50	12/18/69	< 50			
N/A ³		N/A ³		N/A ³			9/1/69	160	63	N/A ³			N/A ³		N/A ³		9/5/69	230	65
								115	63										
N/A ³		N/A ³		N/A ³			10/2/69	220	60	N/A ³			N/A ³		N/A ³		10/2/69	255	66
								158	63										
N/A ³		N/A ³		N/A ³			11/5/69	258	63	N/A ³			N/A ³		N/A ³		11/5/69	228	66
								153	63										
N/A ³		N/A ³		N/A ³			12/1/69	323	63	N/A ³			N/A ³		N/A ³		12/3/69	230	66
								145	63										
1/21/70	< 50	1/21/70	< 50	1/6/70	850	56	1/6/70	395	59	1/21/70	< 50	N/A ³	1/22/70	< 50	1/21/70	< 50	1/6/70	218	66
								140	63										
2/19/70	< 50	2/19/70	< 50	2/3/70	890	56	2/3/70	515	59	2/19/70	< 50	N/A ³	2/19/70	< 50	2/19/70	< 50	2/2/70	203	66
3/19/70	< 50	3/19/70	< 50	3/4/70	895	56	3/4/70	610	59	3/19/70	< 50	N/A ³	3/23/70	< 50	3/19/70	< 50	3/4/70	188	66

**Table E1-1. Tank SX-107 Drywell Radioactivity (GMP K counts per minute) (March 1969 to June 1987)
(Drywell Data Sheets Retrieved on March 8, 2011 and SD-WM-TI-356) (2 of 3 sheets)¹**

41-07-02		41-07-03		41-07-05			41-07-07			41-07-08			41-07-10		41-07-12		41-10-01 ⁴		
Date	Peak (K cpm)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)
4/20/70	< 50	4/20/70	< 50	4/8/70	900	56	4/8/70	701	58	4/20/70	< 50	N/A ³	4/20/70	< 50	4/20/70	< 50	4/8/70	170	66
5/18/70	< 50	5/18/70	< 50	5/1/70	890	56	5/1/70	760	59	5/19/70	< 50	N/A ³	5/19/70	< 50	5/18/70	< 50	5/3/70	163	66
6/26/70	< 50	6/26/70	< 50	6/17/70	950	56	6/3/70	975	59	6/26/70	< 50	N/A ³	6/26/70	< 50	6/26/70	< 50	6/4/70	165	66
7/27/70	< 50	7/27/70	< 50	7/1/70	900	56	7/1/70	940	59	7/27/70	< 50	N/A ³	7/27/70	< 50	7/27/70	< 50	7/1/70	148	66
8/21/70	< 50	8/21/70	< 50	8/3/70	705	55	8/24/70	680	59	8/21/70	< 50	N/A ³	8/21/70	< 50	8/21/70	< 50	8/4/70	133	66
9/28/70	< 50	9/28/70	< 50	9/11/70	370	55	N/A ³			9/28/70	< 50	N/A ³	9/28/70	< 50	9/28/70	< 50	9/3/70	125	66
10/20/70	< 50	10/20/70	< 50	10/1/70	388	55	N/A ³			10/20/70	< 50	N/A ³	10/20/70	< 50	10/20/70	< 50	10/1/70	110	66
11/9/70	< 50	11/9/70	< 50	11/3/70	820	55	N/A ³			N/A ³			N/A ³		11/9/70	< 50	11/4/70	98	66
12/29/70	< 50	12/29/70	< 50	12/10/70	480	55	N/A ³			12/29/70	< 50	N/A ³	12/29/70	< 50	12/29/70	< 50	12/10/70	98	66
1/18/71	< 50	1/18/71	< 50	1/5/71	450	55	N/A ³			1/18/71	< 50	N/A ³	1/18/71	< 50	1/18/71	< 50	1/6/71	95	66
N/A ³		N/A ³		2/3/71	930	55	N/A ³			N/A ³			N/A ³		N/A ³		2/5/71	95	66
3/29/71	< 50	3/29/71	< 50	3/1/71	940	55	N/A ³			3/29/71	< 50	N/A ³	3/29/71	< 50	3/29/71	< 50	3/4/71	78	66
N/A ³		N/A ³		4/12/71	950	55	N/A ³			N/A ³			N/A ³		N/A ³		4/13/71	71	66
5/3/71	< 50	5/3/71	< 50	5/24/71	950	55	N/A ³			5/3/71	< 50	N/A ³	5/3/71	< 50	5/3/71	< 50	5/5/71	60	66
N/A ³		N/A ³		6/3/71	950	55	N/A ³			N/A ³			N/A ³		N/A ³		6/3/71	65	66
7/15/71	< 50	7/15/71	< 50	7/9/71	940	55	N/A ³			7/15/71	< 50	N/A ³	7/15/71	< 50	7/15/71	< 50	7/9/71	69	66
8/17/71	< 50	8/17/71	< 50	8/2/71	955	55	N/A ³			8/17/71	< 50	N/A ³	8/17/71	< 50	8/17/71	< 50	8/2/71	62	66
9/23/71	< 50	9/23/71	< 50	9/10/71	810	55	N/A ³			9/23/71	< 50	N/A ³	9/23/71	< 50	9/23/71	< 50	9/8/71	61	66
10/21/71	< 50	10/21/71	< 50	10/6/71	810	55	N/A ³			10/21/71	< 50	N/A ³	10/21/71	< 50	10/21/71	< 50	10/4/71	56	66
11/10/71	< 50	11/10/71	< 50	11/1/71	620	55	N/A ³			11/10/71	< 50	N/A	11/10/71	< 50	11/10/71	< 50	11/2/71	55	66
12/15/71	< 50	12/15/71	< 50	12/13/71	430	55	12/8/71	530	59	12/15/71	< 50	N/A ³	12/15/71	< 50	12/15/71	< 50	12/2/71	50	66
2/9/72	< 50	2/9/72	< 50	8/22/72	455	55	7/8/72	470	59	2/9/72	< 50	N/A ³	2/9/72	< 50	2/9/72	< 50	1/4/72	50	66
N/A ³		N/A ³		6/11/73	580	57	6/11/73	825	59	N/A ³			N/A ³		N/A ³		2/7/72	47	66
9/13/73	< 12	9/13/73	< 12	9/12/73	720	50	9/10/73	900	59	9/13/73	< 15	N/A ³	9/13/73	< 12	9/13/73	< 15	9/13/73	18	64

**Table E1-1. Tank SX-107 Drywell Radioactivity (GMP K counts per minute) (March 1969 to June 1987)
(Drywell Data Sheets Retrieved on March 8, 2011 and SD-WM-TI-356) (3 of 3 sheets)¹**

41-07-02		41-07-03		41-07-05			41-07-07			41-07-08			41-07-10		41-07-12		41-10-01 ⁴		
Date	Peak (K cpm)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)
7/24/74	< 12	7/24/74	< 12	1/24/74	540	56	2/21/74	730	59	4/11/74	< 15	N/A ³	4/10/74	< 15	4/10/74	< 15	4/10/74	23	67
N/A ³		8/8/74	< 3	4/17/74	700	57	N/A ³			8/1/74	< 3	N/A ³	8/1/74	< 3 ²	8/1/74	< 3 ²	7/10/74	19	67
1/22/75	< 3 ²	1/29/75	< 3	2/13/75	666 ²	56	1/29/75	1221	61	1/22/75	3	57	1/29/75	< 3	1/29/75	< 3	7/12/74	3 ²	65
7/22/75	< 3	7/22/75	< 3	7/9/75	843	55	7/9/75	1078 ²	60	7/22/75	3	60	7/22/75	< 3	7/22/75	< 3	1/22/75	4	68
4/8/76	< 3	4/7/76	< 3	4/6/76	891	56	3/2/76	1233	62	3/2/76	3	56	4/6/76	< 3	4/6/76	< 3	7/22/75	3	66
N/A ³		N/A ³		N/A ³			10/5/76	1830	60	11/30/76	51	56	N/A ³		N/A ³		4/7/76	4	66
N/A ³		N/A ³		N/A ³			1/4/77	909	57	8/2/77	235	56	8/2/77	< 3	8/16/77	< 3	6/16/76	4	64
8/2/77	< 3	8/2/77	< 3	8/2/77	822	54	8/2/77	1791	58	1/3/78	354	56	N/A ³		N/A ³		8/3/77	3	63
N/A ³		N/A ³		N/A ³			12/6/77	1367	60	7/12/78	571	57	7/4/78	< 3	7/12/78	< 3	7/4/78	4	64
N/A ³		N/A ³		4/4/78	297 ²	54	1/27/78	541 ²	59	1/2/79	701	56	N/A ³		N/A ³		N/A ³		
7/4/78	< 3	7/4/78	< 3	7/4/78	330	53	7/4/78	568	59	7/2/79	903	56	7/17/79	< 3	7/17/79	< 3	7/19/79	3	63
7/17/79	< 3	7/17/79	< 3	7/16/79	299	53	7/16/79	552	59	1/4/80	970	56	N/A ³		N/A ³		N/A ³		
7/15/80	< 3	7/15/80	< 3	7/14/80	244	53	7/14/80	587	59	7/15/80	1301	57	7/15/80	< 3	7/15/80	< 3	7/14/80	3	63
6/30/81	< 3	6/6/81	< 3	6/15/81	298	54	6/15/81	555	60	6/17/81	1629	58	6/17/81	< 3	6/22/81	< 3	6/16/81	3	63
7/28/82	< 3	7/29/82	< 3	7/26/82	329	55	7/26/82	645	61	7/29/82	1619	57	7/29/82	< 3	7/21/82	< 3	7/27/82	4	65
6/23/83	< 3	6/23/83	< 3	6/14/83	267	56	6/14/83	637	62	6/23/83	2078	58	6/23/83	< 3	7/11/83	< 3	6/27/83	3	65
6/12/84	< 3	6/12/84	< 3	6/11/84	274	56	6/11/84	638	62	6/12/84	2311	58	6/12/84	< 3	7/5/84	< 3	5/29/84	4	65
6/11/85	< 3	6/11/85	< 3	6/11/85	260	57	6/11/85	645	63	6/11/85	2311	59	6/11/85	< 3	6/4/85	< 3	4/30/85	3	66
6/9/86	< 3	6/9/86	< 3	6/11/86	307	57	6/11/86	651	64	6/9/86	1891	59	6/9/86	< 3	6/18/86	< 3	6/24/86	3	67
6/24/87	< 3	6/24/87	< 3	6/25/87	305	57	6/25/87	635	64	6/24/87	1616	60	6/24/87	< 3	7/23/87	< 3	5/27/87	3	67

Note: ¹If Depths were not available, the column was omitted from the table

²New Monitoring Equipment

³N/A: Data not available

⁴Readings were recorded using the SP from March 1969 to February 1972. GMP used for the remainder of the data.

⁵Referenced from Drywell Strip Charts- Scintillation Probe used

APPENDIX F1

REDOX WEEKLY TANK FARM READINGS

Table F1-1. REDOX Weekly Tank Farm Readings October 31, 1962 to February 14, 1963

REDOX TANK FARM READINGS																																		
(Recorded once weekly, on Thurs.)																																		
TANK	10-31-62	11-8-62	11-15-62	11-22-62	11-29-62	12-6-62	12-13-62	12-20-62	12-27-62	1-3-63	1-10-63	1-17-63	1-24-63	1-31-63	2-7-63	2-14-63																		
NUMBER	Ft. In	Temp	Ft. In	Temp	Ft. In	Temp	Ft. In	Temp	Ft. In	Temp	Ft. In	Temp	Ft. In	Temp	Ft. In	Temp																		
101-SX																																		
102-SX																																		
103-SX																																		
104-SX																																		
105-SX																																		
106-SX																																		
107-S	16' 7 1/2"	-							17' 4 1/2"	-	17' 6 1/4"	-	1'			18' 7 1/2"	-	19' 1/4"	-															
108-S																																		
109-S																																		
110-S																																		
111-S																																		
112-S																																		
101-SX	13' 6 1/2"	206							13' 10 1/2"	206	13' 10 1/2"	206					13' 10 1/2"	207	13' 10 1/2"	207	13' 10 1/2"	207	13' 10 1/2"	207	13' 10 1/2"	206	13' 10 1/2"	207	13' 10 1/2"	208				
102-SX	26' 10 1/2"	135	29' 5"	136					Pumping	14' 10' 8"	139						23' 4 1/2"	176	23' 4"	171	23' 3 1/2"	165	23' 3 1/2"	166	23' 3 1/2"	164	23' 3 1/2"	162	22' 2 1/2"	161	22' 2 1/2"	157	25' 2 1/2"	156
103-SX	22' 8"	171							22' 5 1/2"	171	22' 7 1/2"	170					22' 7"	170	22' 7"	147	22' 6 1/2"	170	22' 6 1/2"	169	22' 6 1/2"	169	22' 6 1/2"	170	22' 6 1/2"	167	22' 6 1/2"	167		
104-SX	22' 6 1/2"	210							22' 5"	209	22' 5 1/2"	209					22' 5"	207	22' 4 1/2"	210	22' 4 1/2"	210	22' 4 1/2"	209	22' 4 1/2"	209	22' 4 1/2"	208	22' 4 1/2"	210	22' 4 1/2"	210		
105-SX	10' 9 1/2"	115							10' 9 1/2"	114	10' 9 1/2"	118					10' 9 1/2"	115	10' 9 1/2"	113	10' 9 1/2"	120	10' 9 1/2"	121	10' 9 1/2"	121	10' 9 1/2"	120	10' 9 1/2"	121	10' 9 1/2"	115	6' 8 1/2"	117
106-SX	5' 6 1/2"	173	3' 6"	171					5' 11 1/2"	176	5' 8 1/2"	176	6' 6"	174	1' 3 1/2"	177	2' 4 1/2"	176	3' 4 1/2"	173	4' 2"	173	5' 4"	174	5' 7 1/2"	173	5' 4 1/2"	177	5' 11 1/2"	176	6' 1"	177		
107-SX	20' 4 1/2"	243	20' 4 1/2"	240	20' 7"	242			21' 2"	242	21' 3 1/2"	245	11' 9 1/2"	246	19' 9 1/2"	243	5' 3 1/2"	253	10' 5 1/2"	200	10' 5 1/2"	186	9' 1 1/2"	176	4' 6"	190	6' 3 1/2"	187	7' 7 1/2"	217	8' 6 1/2"	218		
108-SX	20' 6 1/2"	205	20' 10"	207	21' 4 1/2"	225			21' 5 1/2"	263	21' 3"	261	21' 8 1/2"	261	21' 8"	262	21' 4 1/2"	261	22' 4"	259	23' 1"	257	24' 1 1/2"	256	21' 7 1/2"	257	25' 2 1/2"	258	24' 6 1/2"	256	25' 1 1/2"	253		
109-SX	19' 1 1/2"	292	19' 9"	289	19' 10"	289			20' 1 1/2"	286	20' 3 1/2"	284	20' 6 1/2"	285	20' 8 1/2"	284	20' 10"	283	21' 0"	282	21' 2"	281	21' 5 1/2"	285	21' 8 1/2"	287	21' 1 1/2"	286	22' 2 1/2"	287	22' 5"	287		
110-SX	22' 1 1/2"	214	21' 11 1/2"	215	21' 10"	226			21' 7 1/2"	254	22' 2"	241	21' 10 1/2"	241	21' 9 1/2"	247	22' 3 1/2"	250	22' 2 1/2"	238	22' 1 1/2"	239	22' 0"	251	21' 10 1/2"	260	21' 8"	271	22' 2"	267	22' 1"	262		
111-SX	20' 7 1/2"	242	20' 7 1/2"	242	21' 7"	242			20' 6 1/2"	242	20' 6 1/2"	242	20' 5 1/2"	243	20' 5 1/2"	242	20' 5 1/2"	243	20' 4 1/2"	244	20' 4 1/2"	244	20' 4"	244	20' 3 1/2"	244	20' 3 1/2"	244	20' 3 1/2"	245	20' 2 1/2"	246		
112-SX	22' 2 1/2"	272	22' 0"	273	21' 9"	279			21' 11 1/2"	294	22' 1 1/2"	297	22' 3"	289	22' 4 1/2"	282	22' 4 1/2"	283	22' 3 1/2"	276	22' 2"	274	22' 0"	275	21' 10 1/2"	280	21' 8"	294	21' 8"	300	22' 1 1/2"	296		
113-SX	3' 6"	116	6' 5 1/2"	117	0' 9 1/2"	111			0' 9 1/2"	106	0' 9 1/2"	103	0' 9 1/2"	108			0' 9 1/2"	100	0' 9"	98			0' 9"	98			0' 8 1/2"	98	21' 3 1/2"	15' 2 1/2"				
114-SX	12' 10 1/2"	155	9' 6 1/2"	153	15' 1"	142			15' 1"	145	15' 1 1/2"	146	15' 1"	147	15' 1 1/2"	147	15' 1 1/2"	149	14' 11 1/2"	150	14' 11 1/2"	150	14' 11 1/2"	150	14' 11 1/2"	150	21' 6 1/2"	150	21' 4 1/2"	150	20' 11 1/2"	232	21' 1 1/2"	151
115-SX	20' 11 1/2"	223	20' 10 1/2"	224	20' 10"	225			20' 8 1/2"	231	21' 5"	226	21' 4"	224	21' 3 1/2"	223	21' 3"	223	21' 2"	223	21' 1 1/2"	222	21' 1"	223	21' 1"	223	21' 1"	226	21' 1"	225		20' 11"	232	
10-29-62	106-SX to 102-SX 26, 173 gals.																12-16-62 - 12-19-62 - Completed pumping 106-SX Gird to 107-SX - 19,228 gals.																	
10-30-62	106-SX to 102-SX 1378 gals.																12-20-62 Pumped raw water to 110-SX, 20,663 gals.																	
" " "	114-SX to 113-SX 33060 gals.																12-29-62 H2O to 107-SX & 241-SX C.T. material. Total received in 107-SX was 37,100 gals.																	
10-31-62	114-SX to 113-SX 50968 gals.																12-22-62 Completed pumping 107-SX dissolved sludge to 114-SX - 219,023 gallons Sulf.																	
" " "	106-SX to 109-SX 68888 gals.																1-23-63 Received a total of 70,944 gallons of condensate in 107-SX from 106-SX.																	
11-1-62	114-SX to 113-SX 51,656 gals.																1-29-63 Salt waste routed to 107-SX, 108-SX, 109-SX, 110-SX, 111-SX, 112-SX, 113-SX, 114-SX, 115-SX, 116-SX, 117-SX, 118-SX, 119-SX, 120-SX, 121-SX, 122-SX, 123-SX, 124-SX, 125-SX, 126-SX, 127-SX, 128-SX, 129-SX, 130-SX, 131-SX, 132-SX, 133-SX, 134-SX, 135-SX, 136-SX, 137-SX, 138-SX, 139-SX, 140-SX, 141-SX, 142-SX, 143-SX, 144-SX, 145-SX, 146-SX, 147-SX, 148-SX, 149-SX, 150-SX, 151-SX, 152-SX, 153-SX, 154-SX, 155-SX, 156-SX, 157-SX, 158-SX, 159-SX, 160-SX, 161-SX, 162-SX, 163-SX, 164-SX, 165-SX, 166-SX, 167-SX, 168-SX, 169-SX, 170-SX, 171-SX, 172-SX, 173-SX, 174-SX, 175-SX, 176-SX, 177-SX, 178-SX, 179-SX, 180-SX, 181-SX, 182-SX, 183-SX, 184-SX, 185-SX, 186-SX, 187-SX, 188-SX, 189-SX, 190-SX, 191-SX, 192-SX, 193-SX, 194-SX, 195-SX, 196-SX, 197-SX, 198-SX, 199-SX, 200-SX, 201-SX, 202-SX, 203-SX, 204-SX, 205-SX, 206-SX, 207-SX, 208-SX, 209-SX, 210-SX, 211-SX, 212-SX, 213-SX, 214-SX, 215-SX, 216-SX, 217-SX, 218-SX, 219-SX, 220-SX, 221-SX, 222-SX, 223-SX, 224-SX, 225-SX, 226-SX, 227-SX, 228-SX, 229-SX, 230-SX, 231-SX, 232-SX, 233-SX, 234-SX, 235-SX, 236-SX, 237-SX, 238-SX, 239-SX, 240-SX, 241-SX, 242-SX, 243-SX, 244-SX, 245-SX, 246-SX, 247-SX, 248-SX, 249-SX, 250-SX, 251-SX, 252-SX, 253-SX, 254-SX, 255-SX, 256-SX, 257-SX, 258-SX, 259-SX, 260-SX, 261-SX, 262-SX, 263-SX, 264-SX, 265-SX, 266-SX, 267-SX, 268-SX, 269-SX, 270-SX, 271-SX, 272-SX, 273-SX, 274-SX, 275-SX, 276-SX, 277-SX, 278-SX, 279-SX, 280-SX, 281-SX, 282-SX, 283-SX, 284-SX, 285-SX, 286-SX, 287-SX, 288-SX, 289-SX, 290-SX, 291-SX, 292-SX, 293-SX, 294-SX, 295-SX, 296-SX, 297-SX, 298-SX, 299-SX, 300-SX, 301-SX, 302-SX, 303-SX, 304-SX, 305-SX, 306-SX, 307-SX, 308-SX, 309-SX, 310-SX, 311-SX, 312-SX, 313-SX, 314-SX, 315-SX, 316-SX, 317-SX, 318-SX, 319-SX, 32																	

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5.1 TANK SX-108 BACKGROUND HISTORY

This section provides information on the historical waste loss event associated with SST 241-SX-108 (SX-108). Tank SX-108 has three laterals installed in December 1962 about 10-ft under the tank (see Figure 5-1). There are seven drywells located around tank SX-108 installed in 1962: 41-08-02, 41-08-03, 41-08-04, 41-08-06, 41-08-07, 41-09-03 and 41-08-11.

The bottom of the tank footing is ~53-ft BGS with ~6-ft 6-in soil cover over the dome (WHC-SD-WM-TI-665). Inside tank SX-108 there are four ALCs 18-in above the tank bottom and equally spaced on a 40-ft diameter circle as shown in Figure 5-1 (H-2-39951). Two ALCs are designated low ALCs (8-ft 6-in tall) and two are high ALCs (13-ft 6-in tall) (H-2-9950).

Figure 5-1. Tank SX-108 Associated Drywells and Laterals
Tank inner ring is steel liner, outer ring is outer edge of tank footing

5.2 TANK SX-108 OPERATIONS SUMMARY

Construction of tank SX-108 was completed in 1954 and put into service November 8, 1955 when REDOX HLW was transferred into the tank. Normally tanks receiving boiling waste were preheated prior to use to minimize transfer stresses. However, tanks in SX Farm were not fitted with steam coils and tank SX-108 was not preheated prior to use. In January 1956, tank SX-108 started boiling and by December 31, 1956, 532 kgal of aged REDOX HLW supernatant were added to the tank with 32 kgal of water (HWN-1991-DEL, *CPD-Waste and Experience*). REDOX HLW additions continued, waste losses occurred due to evaporation and boil off, and condensate was added from tank SX-106 through 1959 (WHC-SD-WM-TI-614, *Waste Status and Transaction Record Summary for the Southwest Quadrant of the Hanford 200 Area*). Water evaporated from tank SX-108, was condensed and collected in tank SX-106. By December 31, 1958, the tank was filled with 785 kgal of REDOX HLW (HW-58201, *Chemical Processing Department Waste Status Summary October 1, 1958 – October 31, 1958*, page 8).

Small REDOX HLW additions, evaporation and boil off continued until May 1962 when 640 kgal of supernatant was pumped out of tank SX-108 to tank SX-103 (HW-83906-E-RD, *Chemical Processing Department 200 West Area Tank Farm Inventory and Waste Reports July 1961 Through 1966*, page 13). The sludge in tank SX-108 was nitrate leached from May to August 1962 with condensate from tank SX-106, resulting in the reduction of the sludge height from 30-in to 14-in (HW-74522 C, *Chemical Research and Development Operation Monthly Report – July 1962*, page C-6). The leachate, known as sodium nitrate waste, was transferred in August 1962 to tank SX-114 and then to the 202-S REDOX Plant for use in the process.

Approximately one week after sludge leachate was transferred out of tank SX-108, dilute non-boiling REDOX HLW supernatant was transferred from tank SX-105 into tank SX-108 in August 1962 through January 1964 for concentration. The REDOX HLW in tank SX-108 self-concentrated and water was evaporated. Condensate was periodically transferred from tank SX-106 to tank SX-108 from January through November 1965 to maintain waste temperature and density within operating limits. Large volumes of unaccounted for water were added to the tank January through December of 1964.

The first indication of a tank SX-108 leak occurred on December 11, 1962 when low levels of radioactivity were detected in laterals 44-08-01 and 44-08-02. However, the tank was kept in service because further monitoring detected no radiation increases. It was thought that the leak had self-sealed and the tank was refilled in 1963 with REDOX HLW (WHC-MR-0300).

In August 1964, radioactivity was reported to be increasing in two of the laterals (HW-83876, *Chemical Processing Department Monthly Report for August, 1964*, page C-2) and continued to increase through November 1964. By mid-1965, increased levels of radioactivity were reported for all three laterals and tank SX-108 was identified as a confirmed leaker in 1964. In November 1965, tank SX-108 was isolated from the tank farm condensate system and fitted with its own condenser (RL-SEP-874-DEL, *Chemical Processing Department Monthly Report for November 1965*, page C-3).

Five test wells were added and soil samples obtained in mid-1965 to further characterize the leak and approximately 388 kgal of supernatant was transferred from tank SX-108 to tank SX-103 in

January 1967 (ISO-806, *Chemical Processing Division Waste Status Summary January 1, 1967 Through March 31, 1967*, page 8). In March 1967, persistent activity in the laterals led to the conclusion the tank leak was still active and the tank was removed from service. The tank was taken out of service in March 1967.

In September 1967, the bottom liner was determined to be bulged upward as reported in ARH-R-43. A month later the bulged liner was reported to be about 2.5-ft in the northwest quadrant of the tank (ARH-59-DEL, *Monthly Report 200 Areas Operation September 1967*) which indicated either a gradual increase in the bulging of the liner or possibly multiple bulging events (RPP-ENV-39658).

Tank SX-108 was administratively stabilized in August 1979 and is estimated to contain 74 kgal of sludge and no drainable interstitial liquid or supernatant (HNF-EP-0182, Rev. 303).

The operational history of tank SX-108 leak related details including temperature and liquid level is charted in Figure 5-2.

Figure 5-2. Operational Leak History of Tank SX-108

5.3 TANK DESIGN/CONSTRUCTION

5.3.1 Tank Design

The SX Farm tanks had multiple design features that could contribute to stresses or possible leak paths when the tank was being operated including:

- Orthogonal intersection between the steel bottom and the sidewall
- Fillet weld used between the bottom and sidewall intersection
- Less rigorous weld inspection testing
- Partial asphaltic membrane waterproofing
- Keyed construction joints in the sidewall

These features are common to all SX Farm tanks and additional details are discussed in Section 3.1.1.

5.3.2 Tank Construction Conditions

The outside temperature between January 16, 1954 and January 30, 1954 ranged from an average high of 24°F to an average low of 9°F. A picture of the SX Farm under construction (see Figure 3-4) taken January 20, 1954 (high 11°F low -6°F), shows several of the tanks full of water either undergoing leak testing or for concrete wall pouring. During this cold period snow covered ice is seen in the water filled tanks.

As described in Section 3.1.2, cold weather affects the ductile-to-brittle steel transition temperature, with 18°F being the assumed unrestricted low temperature construction limitation for the carbon steel liner, which could result in a fracture upon impact. Low temperatures experienced during construction at or less than the 18°F allowable temperature could cause impact loading (e.g. a dropped tool or piece of equipment from scaffolding) and result in the potential for creating micro-fissures weakening the steel liner.

5.4 TANK SX-108 IN-TANK DATA

5.4.1 Liquid Level

The tank SX-108 liquid level was apparently not reviewed for a decrease when radioactivity was first detected in laterals 44-08-01 and 44-08-02 in December 1962. Large volumes of unaccounted for water added to tank SX-108 in 1964 when the lateral radioactivity began to increase precluded the liquid level measurement from being a direct measure of any vertical location of a leak.

A re-analysis of tank SX-108 using the Historical Leak Model indicated the leak may have started as early as May of 1959 (HNF-3233, *Re-Analysis of SX-farm Leak Histories with the Historical Leak Model Rev 1 (HLMr1)*). In addition, the liquid level measurement under self-boiling conditions (evaporation) coupled with ALC operation results in data uncertainties that render the results unusable for determining liquid level losses associated with a tank leak. The

lateral and drywell data also indicate that the tank SX-108 leak was at or below the bottom of the tank.

The liquid level plot in Figure 5-3 indicates the transfer activity into and out of tank SX-108. The liquid levels are end of quarter levels so this figure may not reflect all transfers into and out of the tank that occurred during the operational history of the tank. See Figure 5-2 for historical monthly liquid level readings.

Figure 5-3. Tank SX-108 End of Quarter Surface Level

WHC-SD-WM-ER-352, Rev 0, June 30, 1994, Historical Tank Content Estimate for the Southwest Quadrant of the Hanford 200 West Area

5.4.2 Temperature

Tank SX-108 first received REDOX HLW on November 8, 1955 (HWN-1991-DEL) and reached an equivalent boiling temperature of 240°F in January 1956 (HW-18700-DEL, *REDOX Technical Manual*). The tank had not been preheated and the temperature rose after receiving the waste to ~110°F by November 17, 1955 from a conservative assumed ambient ground temperature of 55°F, and then increased gradually to 240°F by January 8, 1956 (see Appendix B2).

Temperature plots reproduced from RHO-CD-1172 (see Appendix C2) show the maximum temperature of the waste stored in tank SX-108 exceeded 300°F in February and May 1958 and reached a maximum of ~320°F in September 1958. The waste temperature dropped to 240°F in January 1959, then increased to $280 \pm 20^\circ\text{F}$ until May 1962 when temperatures dropped to ~150°F due to supernatant transfers to tanks SX-103 and SX-114.

Tank SX-108 was first suspected of leaking based on radioactivity detected in laterals 44-08-01 and 44-08-02 in December 1962. The waste temperature increased from August 1962 until November 1963 when it peaked at ~290°F. The temperatures then steadied and reached above 300°F in September and October 1964 and again in March and June 1965. Temperatures remained relatively stable through September 1966.

Temperatures began to decline and were reported at ~200°F by January 1967. In January and February 1968 the temperature dropped below 180°F and continued to gradually decrease due to radioactive decay. These relatively high tank waste temperatures are typical with the operating practices for tanks that contained boiling REDOX HLW.

Tank SX-108 was used as part of the testing in document HW-50216 to determine the frequency and severity of bumping in the tanks filled with REDOX HLW. Tank SX-108 was filled to a liquid level of 17-ft between November 8 and December 15, 1955. Of the series of pressure surges (bumping) during January and February 1957, one was believed to have originated in tank SX-108 on January 26, 1955 (HW-50216) with a maximum pressure of 0.6 psig. Once the ALCs were placed into service, this eliminated bumping and the formation of a temperature gradient in the supernatant (HW-50216, page 4).

5.4.3 Liner Observations

Probing of tank SX-108 indicated that the bottom liner bulged upward about two and one-half feet in the northwest portion of the tank. The location of the deformation was reported in ARH-59, *Monthly Report 200 Area Operations September Monthly Report*, to correspond approximately with the site where contamination was detected earlier. This probably referred to drywell 41-08-11 but was not documented.

Photographs taken in October 1967 were reported to confirm the bulge in the bottom liner based on the distortion of the air lift circulators and dip tubes (ARH-60-DEL, *200 Area Operations October Monthly Report*). A review of available photographs (see Section 5.4.5) supports the documentation and provides a means of estimating the extent of the bulge area.

Two subsequent documents RHO-R-39 and ARH-R-43, Rev. 2, both contain tables that list tank SX-108 with a bulged liner (see Appendix A2).

5.4.4 Chemistry-Corrosion

Waste Chemistry

Tank SX-108 began receiving REDOX HLW (R) in November 1955 and stored only this waste type throughout operation (see Table 5-1). The typical concentration for nitrite, nitrate, and hydroxide for this waste type is shown in Table 5-2. Nitrite and hydroxide are known as nitrate-

induced SCC inhibitors. One key characteristic for inhibiting SCC is to maintain a high nitrite concentration to nitrate concentration ratio (see Section 3.2.4).

Table 5-1. Tank SX-108 Waste Storage Chronology

Date	Waste Type	Length of Storage
November 1955 to March 1967	REDOX HLW	~ 11 years 4 months

Table 5-2. Waste Chemistries for Waste Types Stored in Tank SX-108

Waste Type	[NO ₃ ⁻] ¹	[NO ₂ ⁻] ¹	[OH ⁻] ¹	Meets Current DST Specification ²
R ³	4.83	0.74		No ⁴

1. Reference WHC-EP-0449, 1991, *The Sort on Radioactive Waste Type Model: A Method to Sort Single-Shell Tanks into Characteristic Groups*.
2. Reference OSD-T-151-00007, Rev. 12, (2013), *Operating Specifications for the Double-Shell Storage Tanks*.
3. Reference WHC-EP-0772, 1994, *Characterization of the Corrosion Behavior of the Carbon Steel Liner in Hanford Site Single-Shell Tanks*.
4. Does not meet the current DST specification since the hydroxide and nitrite concentrations are not greater than or equal to 1.2M.

Tank SX-108 stored only REDOX HLW throughout operation for a total of over 11 years. REDOX HLW does not meet the current DST specification for waste chemistry due to low concentrations of the nitrate-induced SCC inhibitors, nitrite and hydroxide. Thus, these conditions of the REDOX HLW would likely create an environment conducive to SCC and/or pitting (see Section 3.2.4).

Supernatant sample results from March 1961 are shown in Table 5-3 which were obtained before the tank underwent sodium nitrate sludge leaching. These results indicate the supernatant would not meet the current DST specification since nitrate concentrations must be below or equal to 5.5 M (OSD-T-151-00007, Rev. 12). Under these conditions, the tank would be vulnerable to SCC and/or pitting.

Table 5-3. Tank SX-108 Supernatant Sample Results March 1961

Temperature	[OH ⁻] M	[NO ₂ ⁻] M	[NO ₃ ⁻] M
280.4°F	1.32	0.61	8.35

Referenced from HW-64993, *Chemical Processing Department Monthly Report April, 1961*, page G-5

Nitrate Leaching

As discussed in Section 3.2.4, tank SX-108 was listed as one of the tanks that underwent sodium nitrate sludge leaching. Most of the supernatant from tank SX-108 (~640 kgal) was pumped to tank SX-103 in May 1962 and condensate from tank SX-106 (~270 kgal) was added to tank SX-108 in May/June 1962 to start sodium nitrate leaching as shown in Table 5-4. Leachate remained in tank SX-108 for approximately three months with temperatures ranging from 180°F to 260°F. Between July 31 and August 3, 1962, ~198 kgal of nitrate leachate waste was transferred out of the tank to tank SX-114 (see Table F2-1). About one to two weeks later dilute non-boiling REDOX HLW as well as REDOX HLW were transferred to tank SX-108

(HW-83906-E-RD, see Table F2-1). The first indication of a tank SX-108 leak occurred on December 11, 1962 when radioactivity was detected in laterals 44-08-01 and 44-08-02, less than seven months after initially starting the sodium nitrate leaching process.

Table 5-4. Tank SX-108 Nitrate Leaching Chronology

Date	Transfers/Comments	Duration	Reference
May 1962	Transferred 640 kgal supernatant from tank SX-108 to tank SX-103 leaving a 62 kgal heel	N/A	HW-83906-E pgs 10 and 13
May/June 1962	Transferred ~270 kgal condensate to tank SX-108 from tank SX-106	N/A	HW-83906-E pg 13
July 31 to August 3, 1962	Transferred ~198 kgal nitrate leachate waste from tank SX-108 to tank SX-114	Leached for 3 months	HW-83906-E pg 22
August/ September 1962	Transferred ~326 kgal of dilute REDOX HLW from tank SX-105 and ~142 kgal REDOX HLW to tank SX-108	Nitrate leachate heel stored 1-2 weeks	HW-83906-E pg 22
December 11, 1962	Earliest indication of a tank SX-108 leak	7 months from start of leaching	Current analysis

Sodium nitrate leaching reduces nitrite and hydroxide concentrations which would increase the propensity for corrosion especially at the relatively high temperatures experienced in tank SX-108.

5.4.5 Photographs

Photographs of tank SX-108 were taken in October 1967 after probing indicated a 2.5-ft bottom liner bulge. The photographs were reported to show distortion of ALCs and dip tubes; however, these photos could not be recovered. Earliest photographs recovered, taken February 13, 1968, for tank SX-108 were reviewed and could not be analyzed due to the photographs being foggy. Photographs taken May 7, 1968 show bent piping and one of the ALCs with what appears to be at least one missing turnbuckle guy rod. Earliest clear photographs taken March 25, 1968 also indicated the same ALC problem as the later May 7, 1968 photographs.

The bent piping are thermocouple probes bundled together that are bolted to their respective risers with the lower three of eight routed through guides attached to a support pipe welded to the bottom tank liner. In addition, the piping to ALC #2 does not have the normal parallel alignment (see Figure 5-4). These were obvious areas of concern as another photo at the same time was taken from a different angle that does show ALC #2 in the northwest quadrant of the tank missing a turnbuckle guy rod as well as one turnbuckle guy rod hanging free (see Figure 5-5). Another indicator of a bulging tank is the visible solids surrounding this ALC indicating a potential bulging bottom. Liquid surrounds the other three ALCs which is a normal pattern.

Later photographs of tank SX-108 (see Figure 5-6) taken on July 26, 1977 shows what appears to be the waste raised in the same location as Figure 5-4 as well as ALC #2 missing a turnbuckle guy rod. These 1977 photographs show the raised waste in approximately the same location as that indicated in the 1968 photographs.

**Figure 5-4. Tank SX-108 Combined Photographs 0681608-13 and -24
May 7, 1968**

**Figure 5-5. Tank SX-108 ALC #2 Photograph 0681608-27
May 7, 1968**

**Figure 5-6. Tank SX-108 Combined Photographs 776539-1 and 776539-12
July 26, 1977**

The locations of all ALCs in tank SX-108 are shown in Figure 5-7 with ALC #2 located in the tank possibly showing evidence of a liner bulge. This was the only ALC that had visible detached turnbuckle guy rods during this time.

Figure 5-7. Tank SX-108 Air Lift Circulator Locations

5.5 TANK SX-108 EX-TANK DATA

5.5.1 Laterals

The first indication of a tank SX-108 occurred on December 11, 1962 when radioactivity was first detected in laterals 44-08-01 and 44-08-02 which was recorded in an internal letter issued in January 3, 1963 (Internal Letter from H.W. Stivers/F.S. Stong to L.L. Zahn/W.P. Ingalls, "Radiation Readings in Horizontal Lateral SX-108") (see Appendix D2). Lateral 44-08-01 reported a peak at 2.5K cpm at a location of approximately 5-ft west from the edge of the tank and lateral 44-08-02 reported a peak at 16.8K cpm at an unidentified location.

The tank was kept in service because further monitoring detected little radiation increase (WHC-MR-0300, *Tank 241-SX-108 Leak Assessment*). In July 1964, radioactivity increased in lateral 44-08-01 to 22K cpm at 5-ft west from the edge of the tank. In August 1964, "a steady increase in radiation was detected in two of the horizontal laterals beneath the SX-108 storage

tank (Max. 150K cpm at month end)” (HW-83876, *Chemical Processing Department Monthly Report for August, 1964*, page C-2). The radioactivity in lateral 44-08-01 increased to 260K cpm during September 1964 (HW-84354, *Chemical Processing Department Monthly Report September 1964*, page C-2) and 720K cpm in November 1964 (RL-SEP-112, *Chemical Processing Department for November 1964*). Radioactivity continued to increase with additional peaks at 6.8-ft and 10.8-ft in January 1965 at >1,000K cpm. Radioactivity also increased in lateral 44-08-02 but levels were lower compared to lateral 44-08-01. In November 1964 an additional peak was recorded in lateral 44-08-02 at 9.3-ft west of the edge of the tank (1K cpm) and a peak at 6.4-ft under the west side of the tank (180K cpm); radioactivity increased at these two locations by the next month. Radioactivity levels continued to increase gradually in both laterals from March through December 1965. Supernatant was eventually transferred from tank SX-108 in January 1967 to tank SX-103 (ISO-806, page 8). See Appendix D2 for lateral data from December 1962 through April 1989.

Lateral 44-08-03, which showed no activity until March 1966, recorded a reading of 945K cpm at ~9-ft from the northwest edge of the tank (BNWL-CC-701, *Characterization of Subsurface Contamination in the SX Tank Farm*). This was reported as indicating that the plume had spread and moved toward the south (RPP-ENV-39658). In 1966, efforts were completed to characterize the subsurface contamination near tank SX-108 and are documented in BNWL-CC-701. This document estimated the extent of the tank leak which is shown in Figure 5-8 and Figure 5-9.

Figure 5-8. Tank SX-108 Subsurface Cs-137 Concentration at 55-ft BGS 1966 (BNWL-CC-701)

Figure 5-9. Tank SX-108 Subsurface Cs-137 Concentration at 60-ft BGS 1966 (BNWL-CC-701)

Later lateral plots are not available until May 2005 which is reported in RPP-RPT-27605. The 2005 gamma surveys indicate radioactivity was present in two laterals and maximum Cs-137 was reported to be 118,000K and 206,000K pCi/g for laterals 44-08-01 and 44-08-02, respectively. Lateral 44-08-03 was apparently not scanned during this time. See Figure 5-10 and Figure 5-11 for the 2005 lateral scans, which shows the widespread contamination throughout most of the length of the laterals.

Figure 5-10. Summary Gamma Survey for Lateral 44-08-01
May 12, 2005
(RPP-RPT-27605, Rev. 0)

**Figure 5-11. Summary Gamma Survey for Lateral 44-08-02
May 13, 2005
(RPP-RPT-27605, Rev. 0)**

5.5.2 Drywells

There are seven drywells located around tank SX-108 installed in 1962: 41-08-02, 41-08-03, 41-08-04, 41-08-06, 41-08-07, 41-09-03 and 41-08-11. All of the radiation readings in drywells are assumed to be maximum values or peak readings unless otherwise noted and are from the Red-GM probe unless otherwise indicated (see Section 3.3.2). The bottom of the tank footing is ~53-ft BGS. The following subsections report the available drywell information and the drywell summary section provides the analyses of the associated drywells with tank SX-108.

Five additional test wells were drilled in 1965 to measure the extent of the leak and were addressed in BNWL-CC-701; however, data from these test wells were not used in the analysis of the leak location for tank SX-108 as it didn't materially add to the information already available. See Figure 5-8 and Figure 5-9 for location of these test wells.

5.5.2.1 Drywell 41-08-02 (N29°E)

Drywell 41-08-02 was drilled March 16, 1962 with the first recoverable reading on March 1, 1965 which reported a peak of 120K cpm at 52-ft BGS (see Appendix E2). The radiation continued at an elevated level and was recorded as 145K cpm by May 28, 1965 both at 52-ft BGS. No further drywell data were recovered until April 24, 1970 when two peak readings of ~1K cpm at 54-ft BGS and 0.3K cpm at 76-ft BGS was recorded. Low levels of radioactivity continued to be reported to July 1974. A new probe (SSP or shielded scintillation probe) versus the prior GMP used previously was used July 12, 1974 which returned a reading of ~1,347K cpm at 56-ft BGS. The readings continued at this level through June 1986 (see Appendix E2).

In November 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-08-02 (GJ-HAN-10). Cs-137 was measured from the ground surface to total depth of 74.5-ft BGS with the maximum concentration of 3,000 pCi/g detected at 55.5-ft BGS. From 53.5 to 55.5-ft BGS, the detector was saturated. Document GJ-HAN-10 states, *“Because the high concentrations of Cs-137 occur near the tank bottom, and there is no apparent lithology control over the contaminant distribution, it is almost certain that the contamination detected at 55 ft originated from tank SX-108.”* Figure 5-12 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 5-12. Tank SX-108 Drywell 41-08-02 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

5.5.2.2 Drywell 41-08-03 (N82°E)

Drywell 41-08-03 was drilled March 19, 1962 with the first recoverable reading on March 20, 1969 reported as less than 50K cpm. Radioactivity continued to be reported as less than values through June 1986 (see Appendix E2).

In November 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-08-03 (GJ-HAN-10). Cs-137 was detected almost continuously from the ground surface to the total depth of 74.5-ft BGS with concentrations typically less than 1 pCi/g. Document GJ-HAN-10 states, *“Based on the distribution and low concentrations of Cs-137 in this borehole, it is unlikely that any nearby subsurface source exists.”* Therefore, drywell 41-08-03 is not included as part of the leak location for tank SX-108. Figure 5-13 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 5-13. Tank SX-108 Drywell 41-08-03 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

5.5.2.3 Drywell 41-08-04 (S48°E)

Drywell 41-08-04 was drilled March 14, 1962 and the first recoverable log data from December 1962 show elevated readings at about 21.5-ft BGS but no elevated readings below this depth (WHC-MR-0300). An exploratory sludge level detector caisson was installed prior to December 1968 between drywell 41-08-04 and the tank and extended to the concrete footing (see Section 5.6). No drywell data were recovered after December 1962 until March 27, 1969 which reported a peak >1,000K cpm from 39 to 50-ft BGS (see Appendix E2). Readings were likely due to the radioactivity being detected in the drywell from the contents in the tank through the caisson air space. This caisson was backfilled in November 1981 and the drywell readings returned to the pre-caisson original readings with a peak at 21.5-ft BGS level likely associated with a pipeline/encasement leak or other near surface contamination sources. This indicated the effect of backfill shielding was similar to the original soil, and the drywell was reading the tank contents up to the point of backfilling the caisson as shown in Figure 5-14 (HNF-3136 [note that the y axis reads 1975 to 1994 from the right]).

In November 1995, Cs-137 and possibly Sr-90 were the only man-made radionuclides detected in drywell 41-08-04 (GJ-HAN-10). Cs-137 was detected almost continuously from the surface to the total depth of 76.5-ft BGS, and SGLS indicate the maximum concentrations are approximately 3 and 6 pCi/g at 21.5 and 50-ft BGS, respectively. Possible Sr-90 exists near 21.5-ft BGS but remains inconclusive (GJ-HAN-10). Document GJ-HAN-10 states, *“These data suggest two sources of contamination may exist; one at about 21.5 that is not associated with a tank leak, and another from 38 to 50 ft that could be a result of a subsurface source.”*

Due to historical low levels of radioactivity and the effect of the caisson on the 1968 to 1981 drywell data, drywell 41-08-04 is not included as part of the leak location for tank SX-108. Figure 5-14 shows the depths of radioactivity from 1975 to 1995.

Figure 5-14. Tank SX-108 Drywell 41-08-04 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

5.5.2.4 Drywell 41-08-06 (S0°)

Drywell 41-08-06 was drilled March 12, 1962 with the first recoverable reading on March 20, 1969 reported as less than 50K cpm. Radioactivity continued to be reported as less than values through June 1986 (see Appendix E2).

In November 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-08-06 (GJ-HAN-10). Cs-137 was measure from the ground surface to 7-ft BGS at concentrations less than 1 pCi/g except for near-surface contamination. Since historical records report little radioactivity in this drywell, drywell 41-08-06 is not included as part of the leak location for tank SX-108. Figure 5-15 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 5-15. Tank SX-108 Drywell 41-08-06 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

5.5.2.5 Drywell 41-08-07 (S50°W)

Drywell 41-08-07 was drilled March 16, 1962 with the first recoverable reading reported as having no activity in mid-1965 (WHC-MR-0300 Page 1-5). No drywell data were recovered until March 27, 1969 when there were two peaks reported to be 615K cpm at 66-ft BGS and >1,000K cpm at 70-ft BGS (see Appendix E2). Radioactivity gradually increased and by July 1969 the peak was reported at >1,000K cpm from 63-ft BGS to the bottom of the drywell. Radioactivity continued to be reported through June 1986 (see Appendix E2).

In November 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-08-07 (GJ-HAN-10). Cs-137 was measured continuously from the ground surface to the total depth of 73.5-ft BGS. Concentrations increased with depth in this drywell and measured about 1,000 pCi/g at 62-ft BGS. From 62 to 73.5-ft BGS, the detector was saturated. Document GJ-HAN-10 states, "There is no definitive explanation for the distribution of the Cs-137 contamination that is evident from the surface to about 62 ft. However, the high contamination zone below 62 ft is clearly from a subsurface source." Figure 5-16 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 5-16. Tank SX-108 Drywell 41-08-07 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

5.5.2.6 Drywell 41-08-11 (N27°W)

Drywell 41-08-11 was drilled March, 15 1962 with the first recoverable reading of 5K cpm in August 1964 and remained unchanged at the end of the month as shown in Table 5-5 (HW-83876, page C-2). This was shortly after the 1964 increases in laterals 44-08-01 and 44-08-02. Radiation in the drywell doubled to 10K cpm in November 1964 (RL-SEP-112, page C-3). A continuation to March 1967 of available drywell data is contained in Table 5-5. This was the only drywell of the seven reporting an increase during this time. No other drywell data were recovered until March 9, 1969 which reported a peak of >1,000K cpm at 55 to 56-ft BGS (see Appendix E2). See Appendix E2 for drywell 41-08-11 data from March 1969 to June 1986.

Table 5-5. Tank SX-108 Drywell 41-08-11

Date	Radiation (cpm)	Depth (ft)	Reference
August 1964	5 K	N/A ⁴	HW83876 page C-2
November 1964	10 K	N/A ⁴	RL-SEP-112 page C-3
December 1964	12.5 K	N/A ⁴	WHC-MR-0300 Supplement 1 Ref. 22
March 1965	13 K	N/A ⁴	HAN-91198 page 16
April 1965	68 K	N/A ⁴	HAN-91499 page 14
May 1965	120 K	N/A ⁴	HAN-91791 page 19
June 1965	290 K	N/A ⁴	HAN-92077 page 15
July 1965	350 K	N/A ⁴	HAN-92316 page 14
August 1965	350 K ¹	59	HAN-92750 page 15
September 1965	430 K	59	HAN-92750 page 15
October 1965	215 K ²	N/A ⁴	HAN-93300 page 14
December 1965	225 K	N/A ⁴	HAN-93551 page 14
January 1966	380 K	N/A ⁴	HAN-93802 page 14
February 1966	380 K	N/A ⁴	HAN-94040 page 15
March 1966	410 K	N/A ⁴	HAN-94330 page 16
April 1966	520 K	N/A ⁴	HAN-94591 page 14
May 1966	400 K	N/A ⁴	HAN-94842 page 18
June 1966	420 K	N/A ⁴	HAN-95105 page 16
July 1966	450 K	N/A ⁴	HAN-95284 page 14
August 1966	450 K	55	HAN-95491 page 17
September 13, 1966	450 K	55	HAN-95695 page AIII-3
October 1966	450 K	55	HAN-95918 page AIII-3
November 1966	450 K	55	HAN-96143 page AIII-3
December 1966	480 K	55	HAN-96350 page AIII-4
January 1967	900 K ³	55	HAN-96590 page AIII-4
February 1967	1,400 K	55	HAN-96805 page AIII-4
March 1967	150 K	55	HAN-97066 page AIII-4

¹ Assumed to be 350 K as no changes in activity detected as stated in HAN-92525

² Modified GM tube used, same level as the previous month

³ "Deviations of radiation readings for tanks 108-SX, 109-SX, and test well 29 from last month occurred when a new probe was installed, after which no changes have been noted." Reference HAN-96590

⁴ N/A: Data not available

In November 1995, Cs-137 and possibly Sr-90 were the only man-made radionuclides detected in drywell 41-08-11 (GJ-HAN-10). Cs-137 was measured continuously from the ground surface

to the total depth of 75-ft BGS with a concentration of 50 pCi/g measured at 48.5-ft BGS. From 48.5 to 62.5-ft BGS, the detector was saturated. Document GJ-HAN-10 states, *“The high contamination zone from 48.5 to 65 ft is clearly from a subsurface source. The gross gamma log data indicates the maximum activity was reached at a depth corresponding approximately with the bottom of the tank. Contamination at this depth suggests the borehole is close to the contamination source and that the contamination spread laterally as a result of the tank excavation surface.”* Figure 5-17 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 5-17. Tank SX-108 Drywell 41-08-11 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS. Depth shifting is a method to align the zero point due to inconsistent data collection.

5.5.2.7 Drywell 41-09-03 (N82°W of Tank SX-108)

Drywell 41-09-03 was drilled March 19, 1962 with the first recoverable reading found on January 2, 1968 which reported that there was radioactivity present at 62-ft BGS (see Appendix E2). It appears the peak reported at 62-ft BGS was with a GM probe, but radioactivity levels remain unclear. No data were recovered until March 27, 1969 when radioactivity was reported at 890K cpm at 64-ft BGS (see Appendix E2). Radiation levels increased to >1,000K cpm by August 1969, and then gradually decreased to 505K cpm at 63-ft BGS on January 4, 1972 (SD-WM-TI-356 Vol. 2 Sec. 1 of 2). The readings rose to 1,260K cpm by August 1977 and continued at that level ranging from 60-ft BGS to 70-ft BGS with most readings at ~64-ft BGS (see Appendix E2).

In November 1995, Cs-137 and possibly Sr-90 were the only man-made radionuclides detected in drywell 41-09-03 (GJ-HAN-10). Cs-137 was measured continuously from the ground surface to the total depth of 73.5-ft BGS and the detector became saturated from 58.5 to 72-ft BGS. It is possible that in this zone where the detector was saturated, Sr-90 could be present. Document GJ-HAN-10 states, *"The slightly elevated Cs-137 concentrations from about 20 to 40 ft could have originated from a leaking cascade line. However, the contamination increase from 58.5 ft to TD is clearly from a subsurface source."* Document WHC-MR-0300 (page 4-11) states that activity detected in drywell 41-09-03 is associated with the tank SX-108 leak. Figure 5-18 shows the depths of radioactivity from 1975 to 1995 (HNF-3136)

Figure 5-18. Tank SX-109 Drywell 41-09-03 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

5.5.3 Tank SX-108 Drywell Summary

Tank SX-108 was first suspected of leaking on December 11, 1962 due to radioactivity detected in laterals 44-08-01 and 44-08-02. The only drywell data recovered during this time was for drywell 41-08-04; however, this was at a much higher BGS level compared to the BGS level of the laterals. Most of the drywell data was not available until 1964-1965 and 1968-1969.

Tank SX-108 drywells 41-08-03 and 41-08-06 do not indicate any radioactivity associated with a tank leak. Drywell 41-08-04 reports radioactivity at the 21.5-ft BGS level which is probably associated with a pipeline/encasement leak or other near surface contamination source. The caisson installed between drywell 41-08-04 and the tank wall showed an indication of radioactivity from a sample of crust on the tank footing as well as cracking in the footing (see Section 5.6). Therefore, drywells 41-08-03, 41-08-04, and 41-08-06 are not included as part of the leak location for tank SX-108.

All of the other four drywells reported radiation at or near the tank footing. In addition, the first recoverable drywell radiation reading (from drywells 41-08-02, 41-08-07, 41-08-11, and 41-09-03) was in drywell 41-08-11 in August 1964, about 20 months after the first recoverable lateral reported radiation readings. This was the only drywell of the seven reporting an increase at that time.

Drywells 41-08-02 and 41-08-11 both show radioactivity near the tank footing; however, drywell 41-08-11 appears to have lagged slightly behind drywell 41-08-02 after the initial indication based only on the absolute values and timing of the radiation levels of March through May 1965. The first recoverable readings for drywell 41-08-11 in August and November 1964 noted that it was the only drywell reporting an increase during this period.

Drywells 41-09-03 and 41-08-07 both report radioactivity at a consistently lower level (>60-ft BGS) than drywells 41-08-02 and 41-08-11. In addition, what evidence there is available suggests that both drywells 41-09-03 and 41-08-07 began detecting radiation after drywells 41-08-02 and 41-08-11.

5.6 TANK SX-108 FOOTING AND SIDEWALL CONDITION

An exploratory sludge level detector caisson 10-ft in diameter (H-2-33907) was installed prior to December 1968 partially between drywell 41-08-04 and the tank and ultimately extending to the bottom of the tank concrete footing (see Figure 5-1). Radiation readings were detected under the footing at 500 mR/hr and at the bottom of the caisson at 150 mR/hr with the bottom of one core sample at 5,000 cpm (ARH-R-43, Rev. 2, page A-7). A sample of crust on top of the tank footing at 500 cpm showed Cs-137 contamination and nitrate with an elevated pH of 9.6 versus normal soil pH of 7-8 indicating the possibility of a tank leak in the vicinity of the caisson (ARH-R-43, Rev. 2, page A-7). There is a possibility that the radioactivity originally found at 21.5-ft could have followed the tank side wall to the bottom of the tank. There is, however, no mention of contamination found when installing the drywell.

The extended caisson was used to check on the condition of the footing and tank sidewall with photographs and concrete core samples. The photograph in Figure 5-19 shows cracks in the core sample of the footing across the top and down the side. Figure 5-20 shows a sidewall crack and

one of two core drill holes. Figure 5-21 shows a crack down the tank SX-108 footing. These and other photographs were used in a structural analysis that in part addressed the SX Farm tanks (ARH-R-45, *Interim Summary Report: Stress and Strength Analysis for Waste Tank Structures at Hanford, Washington*). The document indicates that radial fractures can be expected in the SX Farm tanks with the boiling temperatures encountered and that the higher the temperature the larger the crack and the greater fracture propagation.

**Figure 5-19. Core of Tank SX-108 Footing Photograph 0684618-6
December 10, 1968**

**Figure 5-20. Tank SX-108 Sidewall Crack Photograph 0684613-4
December 10-1968**

**Figure 5-21. Tank SX-108 Footing Crack Photograph 0684773-1
December 19, 1968**

5.7 TANK SX-108 ATMOSPHERIC CONDENSER

The nine early air-cooled condensers which extended above the waste tanks in the SX Farm tanks developed leaks around the base gaskets. Sealing was accomplished by pouring additional concrete around the condenser bases in sufficient quantity to cover the flanged areas as several of the gaskets failed and waste leaked down the outside of the tanks. The tank SX-108 air-cooled condenser is above the same location as laterals 44-08-01 and 44-08-02. There was a question as to the possibility of the radioactivity from a leaking gasket reaching down below the tank and contributing to the lateral radiation.

An investigation was initiated and on March 30, 1965, the soil science group took a soil sample(s) from the SX-108 air-cooled condenser base 16-ft BGS and drilled 30-ft BGS. None of the soil samples were radioactive (RL-SEP-297, Page 65, *REDOX Weekly Process Reports January through December, 1965*). Therefore, the air-cooled condenser is not considered to be associated with the tank SX-108 leak.

Drywell or lateral radioactivity was not detected in the condenser area of any of the other leaking SX Farm tanks.

5.8 POSSIBLE TANK SX-108 LINER LEAK LOCATION(S)

The lateral radioactivity when first detected could be an indication of the location of liner leak. However the liner leak may have penetrated the waterproof membrane at any location or pooled on the waterproof membrane and followed concrete cracks or breaks to a different location including the top of the tank footing.

It is likely that the tank SX-108 leak occurred at or near the tank bottom because all of the leak indicators, three laterals and four drywells, were located at or near the bottom of the tank.

5.8.1 Leak Detected in 1962, Site A

Tank SX-108 was first suspected of leaking due to radioactivity being detected in laterals 44-08-01 and 44-08-02 on December 11, 1962 at or near the tank footing in the northwest quadrant of the tank (see site A in Figure 5-22). This is based on initial lateral 44-08-01 radiation data estimated to have been detected ~5-ft west of the edge of the tank and lateral 44-08-02 radiation estimated to have been detected 6.3-ft toward the center of the tank from the northwest edge. This leak apparently self-sealed at least to the extent that the radiation leveled out for a number of months until July 1964.

Figure 5-22. Tank SX-108 Possible Leak Location (1962)
Tank inner ring is steel liner, outer ring is outer edge of tank footing

Tank SX-108 was first suspected of leaking in December 1962 based on radioactivity detected in laterals 44-08-01 and 44-08-02.

5.8.2 Leak Detected in 1964, Site B

Radioactivity in lateral 44-08-01 began increasing in July 1964, followed by lateral 44-08-02; with the first recoverable data for drywell 41-08-11 reported radioactivity in August 1964 (see Figure 5-23). From the location of these increases it appears the 1962 leak location (see site A in Figure 5-22) began re-leaking and was spreading. All three locations continued to increase in radiation. In March 1965, the first recoverable readings for drywell 41-08-02 reported peak radioactivity at ~52-ft BGS. This could be migration from the leak site detected in the northwest quadrant of the tank as shown by site B, or this could be a separate leak site since radioactivity was detected at a higher BGS level. However, the source of the drywell 41-08-02 radioactivity remains inconclusive. All of the drywell activity occurred at or near the tank footing.

Figure 5-23. Tank SX-108 Possible Leak Location (1964)
Tank inner ring is steel liner, outer ring is outer edge of tank footing

Tank SX-108 was first suspected of leaking in December 1962 based on radioactivity detected in laterals 44-08-01 and 44-08-02.

5.8.3 Leak Detected in 1966-1969, Site C

Lateral 44-08-03 began to dramatically increase from no reported radioactivity in February 1966 to 945K cpm at 9-ft from the northwest edge, of the tank one month later in March 1966. The first recoverable data for drywells 41-09-03 and 41-08-07 were reported in January 1968 and March 1969, respectively, at a level between 64 and 70-ft BGS (see site C in Figure 5-24). This radioactivity was possibly the result of the continuing leak in the northwest quadrant or a new leak in the southwest quadrant. Support for the latter was put forth in document WHC-MR-0300 as the result of the very strong radiation peak in lateral 44-08-03.

Figure 5-24. Tank SX-108 Possible Leak Location (1966-1969)
Tank inner ring is steel liner, outer ring is outer edge of tank footing

Tank SX-108 was first suspected of leaking in December 1962 based on radioactivity detected in laterals 44-08-01 and 44-08-02.

5.8.4 Leak Detected in 1968, Site D

One other location that may be an indicator of an additional leak is where radioactivity was found in a crust material at 500 cpm on the top of the footing in the Sludge Level Detector Caisson before December 1968 with a radiation reading of 500 mR/hr under the cracked footing (see site D in Figure 5-25). Another possible explanation is that radioactivity from the leak in the northwest and/or southwest corner pooled on top of the waterproof membrane. This could have leaked through the water stop between the footing and the sidewall or through footing cracks and formed a crust on top of the tank footing and contamination under the footing. This liquid could have oozed out through the water stop and onto the tank base at any location around the tank.

Figure 5-25. Tank SX-108 Possible Leak Location (1968)
Tank inner ring is steel liner, outer ring is outer edge of tank footing

Tank SX-108 was first suspected of leaking in December 1962 based on radioactivity detected in laterals 44-08-01 and 44-08-02.

5.8.5 Leak Location Summary

Tank SX-108 was first suspected of leaking in December 1962 based on radioactivity being detected in two of the laterals, and believed to have started in the northwest portion of the tank as shown by site A in Figure 5-22. The tank was kept in service as the leak apparently self-sealed.

Tank SX-108 was declared a confirmed leaker in 1964 because it appeared the 1962 leak location (site A) began re-leaking and was spreading as shown in site B (see Figure 5-23). The first recoverable data for drywell 41-08-02 reported radioactivity in March 1965 which could be related to the earlier leak and/or a separate leak site due to peak radioactivity being detected at a higher BGS level compared to drywell 41-08-11, which is located closer to the 1962 leak site.

From 1966 to 1969, radioactivity was first detected in lateral 44-08-03 (and later reported in drywells 41-09-03 and 41-08-07) in the southwest quadrant of the tank possibly from a new leak location or as the result of migration from the earlier leak detected in 1962 (see site C in Figure 5-24).

One other location that may be an indicator of an additional leak is where the radioactivity was reported in December 1968 in the crust material on the top of the tank footing in the Sludge Level Detector Caisson, located in the southeast quadrant of the tank (see site D in Figure 5-25).

The tank SX-108 leak likely occurred at or near the tank bottom because all of the leak indicators, three laterals and four drywells, were located at or near the bottom of the tank.

Leak locations in Figure 5-26 are based on peak readings and are a representation of possible initial boundaries of radioactivity.

Tank SX-108 was reported to have bulged ~2.5-ft and the location of the liner bulge is believed to be located in the northwest quadrant of the tank as shown in Figure 5-27. Photographs from 1968 indicate detached turnbuckle guy rods from ALC #2 and a raised waste surface near this ALC (see Section 5.4.5).

Figure 5-26. Tank SX-108 Possible Radial Leak Locations
 Tank inner ring is steel liner, outer ring is outer edge of tank footing

5.8.6 Estimated Location of Bulge

Photographic evidence for a possible tank liner bulge was found, some of which seems to fit the description of the original reports in ARH-59 and ARH-60. The location is superimposed in Figure 5-27 in relationship to the tank leak locations.

Figure 5-27. Tank SX-108 Possible Radial Leak Locations with Estimated Bulge

5.9 POSSIBLE TANK SX-108 LINER LEAK CAUSE(S)

Tank SX-108 was exposed to five conditions that could contribute to a failed liner. Some or all of the factors can act together to contribute to tank liner failure.

5.9.1 Tank Design

The design of the SX Farm tanks was the first that diverged from the round bottom knuckle design used in the earlier waste tanks; the tank bottom liner intersects the sidewall liner orthogonally. A fillet weld was used to close the seam where the sidewall and tank bottom liner meet. Several other SSTs with fillet welds failed during service (RPP-RPT-45921). Weld inspections were less rigorous. Additionally, the design discontinued the use of the three-ply asphaltic membrane waterproofing between the liner sidewall and the concrete shell. These features were inferior to others and could possibly increase the likelihood of failure of the tank liner from induced stresses (see Section 5.3.1).

5.9.2 Thermal Conditions

Temperature requirements in HW-59919 issued October 22, 1959 indicated that the self-boiling waste operating temperature should be maintained between 50°F and 220°F. The HW-59919 document recommended a uniform rate of temperature increase of 2°F per day and the maximum sludge temperature should not exceed 300°F.

Assuming a conservative 55°F initial temperature of the tank liner when waste was first received on November 8, 1955 (HWN-1991-DEL), the temperature rose to ~160°F by December 1, 1955 (see Figure B2). Tank SX-113 temperature recorded February 26, 1958 before receiving waste was 42°F, therefore 55°F may not be the worst case for ambient temperature for tank SX-108 in November 1955. No recording of tank SX-108 temperature was found before receiving waste. Over this 23 day period there was a temperature increase of ~105°F, and the average rate of rise was ~4.6°F per day which is above the recommended rate of 2°F per day. There were no other increases in temperatures that exceeded the initial average rate of rise of 4.6°F per day during the operation of tank SX-108.

As discussed in Section 5.4.2, the maximum temperature of 320°F was reported in September 1958 and tank SX-108 temperatures exceeded the maximum sludge temperature limit on several occasions throughout operation.

Note that the operating temperature limitations in HW-59919 were exceeded both before and after issuing the document. Thermal shock creates stress both from rapid temperature rise as well as waste-induced high temperatures. The most severe incidences occurred in the initial waste receiving period and then again when a maximum temperature of 320°F was recorded in September 1958.

5.9.3 Chemistry-Corrosion

Tank SX-108 was first filled with REDOX HLW (November 1955) which was stored in the tank for about seven years before the tank was suspected of leaking in December 1962 (or over 11 years before the supernatant was pumped out of the tank).

Sodium nitrate leaching of tank SX-108 waste started in May 1962 with the transfer of supernatant from the tank. The remaining nitrate-rich sludge was leached and the resulting sodium nitrate solution (leachate) was transferred out of tank SX-108 to tank SX-114 approximately two months later in August 1962. Transfer of the supernatant prior to leaching decreased nitrite and hydroxide ions which are SCC inhibitors. Approximately one week after the leachate transfer to tank SX-114, the tank was filled with dilute REDOX HLW supernatant from tank SX-105, and ~5 months later there was evidence of a leak detected in laterals 44-08-01 and 44-08-02. Loss of the protective nitrite and hydroxide ions would have created an environment conducive to SCC and/or pitting of the tank liner.

The REDOX HLW consisting of low concentrations of nitrite and hydroxide would have created an environment conducive to pitting and SCC. Results from supernatant samples obtained in March 1961 from tank SX-108 indicate the waste chemistry would not meet the current DST specification (see Section 5.4.4). Under these conditions, there would be a high propensity for corrosion.

5.9.4 Liner Observations

The probing for a liner bulge documented in ARH-59 indicating a bulge of two and one-half feet in the northwest portion of the tank coupled with the pictures mentioned in ARH-60 confirm that there was evidence of a bulge in the tank SX-108 bottom liner. A review of the available photographs taken May 7, 1968 supports the evidence of a tank bottom liner bulge. It is not known when the tank bottom liner bulge first occurred.

Liner bulging coupled with other tank conditions could affect tank liner integrity; however, by itself bulging induces stresses that can cause breaching of the tank liner.

5.9.5 Tank Construction Temperature

Winter temperatures as low as -6°F occurred during the period when the SX Farm tank liners were being constructed and leak tested (see Section 5.3.2). The low temperatures experienced during construction were less than the current 18°F allowable temperature where impact loading had the potential for creating micro-fissures. Impact occurrences could have occurred during cold temperatures that may have triggered fissures in the steel liner. Later, when the metal is subjected to high stress, it might be possible for the cracks to propagate through the metal, or possibly subject the weakened areas to increased corrosion.

5.10 TANK SX-108 CONCLUSIONS

Evidence indicates that the tank SX-108 liner leaked at or near the bottom of the tank in either two to four locations. Based on engineering judgment and available information the following conditions listed in the order of importance lead to the tank SX-108 failed liner.

1. Thermal conditions – rate of temperature rise and maximum temperature
2. Tank design – expansion limiting design changes
3. Waste storage chemistry and nitrate leaching – SCC and/or pitting
4. Construction conditions – ductile-to-brittle transition temperature
5. Bulging liner – an effect of primarily thermal conditions along with tank design

There are several liner leak cause conditions that were examined, but the primary cause is the tank SX-108 thermal conditions experienced during the rapid addition of high temperature waste to a cold tank as well as waste storage temperatures. Also, the unique tank design did not allow for expansion of the bottom liner as the tank heated creating stresses. Storage of REDOX HLW at elevated temperatures and subsequent nitrate leaching created a chemical environment susceptible to nitrate-induced SCC and/or pitting attack on an already stressed metal liner. Tank construction occurred in winter under cold temperature conditions which could have affected the ductile-to-brittle steel transition temperature where metal loses its ability to absorb forces such as induced loads or the impact of falling objects creating micro-fissures or hairline cracks. In addition, a bulged bottom imparts stresses in the liner that could have predisposed it to SCC. Some or all of the factors can act serially or together to contribute to tank liner failure.

APPENDIX A2

TANK SX-108 BOILING WASTE OPERATIONAL HISTORY

Table A2-1. RHO-R-39 Boiling Waste Tank Operating Data Table

Tank No.	First Waste	Tank Pre-Heated	Pre-Heat Start	Liquid Heel Used	First Waste Rec'd From	Tank Failed	Inspected For Bulge	Bulge Present	Did Tank Boil on 1st Loading	Tank Started Boiling	Tank Emptied & Reused*	NaNO ₃ Leached from Sludge
101-SX	19 May 54	No	-	No	Redox	No	No	-	Yes	Nov 54	No	No
102-SX	Sep 54	No	-	No	101-SX, Cascade	No	No	-	No	-	No	No
103-SX	Nov 54	No	-	No	102-SX, Cascade	No	No	-	No	-	No	No
104-SX	2 Feb 55	No	-	No	Redox	No	No	-	Yes	Jun 55	No	No
105-SX	11 May 55	No	-	No	104-SX, Cascade	No	No	-	No	-	Yes	No
106-SX	Jun 54	No	-	No	Tank Farm Condensate	No	No	-	No	-	-	-
107-SX	3 Mar 56	No	-	Yes	Redox	Yes, 1964	Yes	Yes	Yes	Jun 56	Yes	Yes
108-SX	8 Nov 55	No	-	No	Redox	Yes, 1962	Yes	Yes	Yes	Jun 56	Yes	Yes
109-SX	20 Sep 55	No	-	Yes	Redox	Yes, 1965	Yes	No	Yes	Dec 55	Yes	No
110-SX	Nov 60	Yes	Apr 60	No	Redox	-	No	-	No	Between 1/61-6/61	Yes	No
111-SX	9 Jun 56	No	-	No	Redox	-	No	-	Yes	Nov 56	Yes	No
112-SX	13 Feb 56	No	-	No	Redox	Yes, 1969	Yes	Yes	Yes	Mar 56	Yes	No
113-SX	20 Feb 58	No	-	No	Redox	Yes, 1958	Yes	Yes	Yes	Apr 58	No	No
114-SX	Nov 56	No	-	No	Redox	-	No	-	Yes	Jun 57	Yes	Yes
115-SX	4 Nov 59	Yes	Sep 58	Yes	Redox	Yes, 1965	No	-	Yes	Nov 59	No	Yes
101-A	20 Jan 56	No	-	6" H ₂ O	Purex	No	Yes	No	Yes	Jul 57	Yes	No
102-A	20 Mar 56	No	-	6" H ₂ O	Purex	No	No	-	Yes	Jul 58	Yes	No
103-A	15 May 56	No	-	6" H ₂ O	Purex	No	No	-	Yes	Jul 56	Yes	No
104-A	30 Jun 59	No	-	6" H ₂ O	Purex	No	Yes	No	Yes	Aug 59	Yes	No
105-A	31 Jan 63	Yes	Jan 63	Yes	Purex	Yes, 1963	Yes	Yes	No***	Mar 63	No	No
106-A	31 Dec 60**	Yes	23 Feb 61	Yes	Purex	No	No	-	Yes	Aug 61	Yes	No
101-AX	1 Jun 65**	Yes	23 Nov 66	Yes	TK-103-A and TK-112-B	No	No	-	No***	Dec 66	Yes	No
102-AX	30 Sep 66**	Yes	2 Mar 69	Yes	TK-101-AX and TK-103-A	No	No	-	No***	Apr 69	No	No
103-AX	10 Feb 65	Yes	Nov 64	Yes	Purex	No	No	-	Yes	Apr 65	No	No
104-AX	9 Sep 66	Yes	Jun 66	Yes	Purex	No	No	-	Yes	Oct 66	No	No

* Emptied indicates supernatant was pumped out but sludge remained.

** Tanks used for temporary waste storage prior to the receipt of LWW or HLW.

*** Did not boil until LWW was routed to the tank.

Note: SX-111 was found to have been NaNO₃ Leached

Table A2-2. ARH-R-43 Waste Tank Leak Experience Table

TABLE 3. Underground Waste Storage Tank Leak Experience

Tank	Built	First Used	Type of Waste Stored	Service	Leak First Suspected	Reason for Suspicion	Leak Confirmed by	Bulge Found	Estimated Volume of Leak, gal	Associated Cs-137, kCi
104-U	1943-44	1947	Bismuth phosphate waste Uranium recovery waste	Nonboiling	1956	Bulged liner	Refill with water (1961)	Yes	55,000*	0.09
113-SX	1953-54	1958	Redox waste	Boiling	1958	Bulged liner	Refill with salt solution (1962)	Yes	15,000**	8
106-TV	1951-52	1953	TBP waste	Nonboiling	1959	Liquid level measurements	Soil radiation readings (1959)		20,000	2
101-U	1943-44	1946	Bismuth phosphate waste Uranium recovery waste Redox waste	Nonboiling	1959	Liquid level measurements	Liquid level measurements		30,000	23
105-TV	1951-52	1953	TBP waste	Nonboiling	1960	Liquid level measurements	Liquid level measurements		35,000	4
108-SX	1953-54	1955	Redox waste	Boiling	1962	Soil radiation readings	Liquid level measurements	Yes	3,400	17
105-A	1954-55	1963	Purex waste	Boiling	1963	Soil radiation readings	Soil radiation readings	Yes	Small	
107-SX	1953-54	1956	Redox waste	Boiling	1964	Soil radiation readings	Soil radiation readings	Yes	Small	
109-SX	1953-54	1955	Redox waste	Boiling	1965	Soil radiation readings	No further evidence	No	Small	
115-SX	1953-54	1958	Redox waste	Boiling	1965	Liquid level measurements	Soil radiation readings		50,000***	40
112-SX	1953-54	1956	Redox waste	Boiling	1969	Liquid level measurements	Soil radiation readings	Yes	30,000	45

* Contained water at time of leak.
 ** Contained NaNO_3 solution at time of leak, also some residual supernatant solution.
 *** Contained NaNO_3 solution at time of leak.

Note: See tank farm segments for information on individual specific tanks

APPENDIX B2

TANK SX-108 TEMPERATURES JANUARY 1954 TO JUNE 1957

Figure B2-1. Tank SX-108 Temperature November to December 1955

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure B2-2. Tank SX-108 Temperature January to June 1956

Figure B2-3. Tank SX-108 Temperature July to December 1956

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure B2-4. Tank SX-108 Temperature January to June 1957

APPENDIX C2

TANK SX-108 TEMPERATURE JANUARY 1957 TO JANUARY 1968

Figure C2-1. RHO-CD-1172 Tank SX-108 Temperature January 1957 through July 1958

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C2-2. RHO-CD-1172 Tank SX-108 Temperature August 1958 through February 1960

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C2-3. RHO-CD-1172 Tank SX-108 Temperature March 1960 through September 1961

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C2-4. RHO-CD-1172 Tank SX-108 Temperature October 1961 through May 1963

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C2-5. RHO-CD-1172 Tank SX-108 Temperature May 1963 through November 1964

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C2-6. RHO-CD-1172 Tank SX-108 Temperature December 1964 through June 1966

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C2-7. RHO-CD-1172 Tank SX-108 Temperature July 1966 through January 1968

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

APPENDIX D2

TANK SX-108 LATERAL ACTIVITY

Table D2-1. Tank SX-108 Lateral Radioactivity (counts per minute) (December 1962 through April 1989)
(Excerpts from RPP-ENV-39658 Rev 0 and RPP-RPT-29191) (1 of 3 sheets)

Date	Reference	241-SX-108		
		44-08-01	44-08-02	44-08-03
12/11/62	A	2.5 K: ~5-ft ¹	16.8 K	N/A ⁵
12/20/62	A	6 K	16.8 K	N/A ⁵
1/63	B	No change in readings ⁶		
2/63	C	“Continued probing revealed no increase in radiation readings”		
3/63	D	“Took radiation reading under the 108-SX Tank with no increase noted”		
5/63	RPP-ENV-39658	8.4 K	28.2 K	N/A ⁵
6/63	E	“Laterals under the 108-SX, 109-SX, 111-SX, 112-SX and 115-SX were monitored; no readings were obtained except under the 108-SX”		
7/63	F	“Continued checking of the laterals under the SX storage tanks. No change was detected.” ⁶		
8/63	G	“Continued checking of the laterals under the SX storage tanks. No change was detected.” ⁶		
9/63	H	“Continued checking of the laterals under the SX storage tanks. No change was detected.” ⁶		
10/63	I	“Continued checking of laterals, no change in readings noted.” ⁶		
11/63	J	“Continued checking of laterals, no change in readings noted.” ⁶		
12/63	K	“Continued checking of laterals, no significant change in readings noted.” ⁶		
1/64	L	“Continued with no significant changes noted.” ⁶		
2/64	M	“No changes noted except for a 550 c/m reading detected in the South lateral under the 114-SX Tank. Daily checking revealed no change at the end of the month.” ⁶		
7/1/64	N page 140	22 K: ~5-ft ¹	N/A ⁵	N/A ⁵
7/30/64	N page 140	52 K: ~5-ft ¹	N/A ⁵	N/A ⁵
8/31/64	N page 153	158 K	27 K	N/A ⁵
9/30/64	N page 176	260 K	52 K	N/A ⁵
11/1/64	N page 185	340 K	114 K	No indications of vapor header leak
11/30/64	N page 205	670 K	1 K at 9.3-ft ¹ 180 K at 6.4-ft ²	N/A ⁵
11/64	RL-SEP-112	720 K ³	N/A ⁵	N/A ⁵
12/64	WHC-MR-0300 Supplement 1	Increase slightly at 5.2-ft ¹ >1,000 K at 6.8 and 10.8-ft ²	52 K at 9.3-ft ¹ 300 K at 6.4-ft ²	N/A ⁵
1/16/65	O page 16	Increase slightly at 5.2-ft ¹ >1,000 K at 6.8 and 10.8-ft ²	52 K at 9.3-ft ¹ 300 K at 6.4-ft ²	N/A ⁵
3/20/65	O page 54	“Contamination readings are static, no new report.”		

Table D2-1. Tank SX-108 Lateral Radioactivity (counts per minute) (December 1962 through April 1989)
(Excerpts from RPP-ENV-39658 Rev 0 and RPP-RPT-29191) (2 of 3 sheets)

Date	Reference	241-SX-108		
		44-08-01	44-08-02	44-08-03
3/31/65	O page 65	“Activity in both “hot” laterals increased... On 3/30/65, soil science group took a soil sample from 108-SX air cooled condenser base 16’ below grade and drilled 30’. None of the soil samples were radioactive.”		
4/29/65	O page 87	“Activity in both hot laterals continued to increase.”		
5/26/65	O page 99	“Peak readings in each lateral increased slightly.”		
6/23/65	O page 111	“Lateral readings are continuing to show an activity spread near the laterals. Peak readings are continuing to increase.”		
7/14/65	O page 120	“Peak readings in the laterals under this tank have continued to show slight increase.”		
8/4/65	O page 129	“Peak readings in the laterals under this tank appear to be leveling out.”		
9/1/65	O page 141	N/A ⁵	132 K at 5.3-ft ¹	N/A ⁵
9/29/65	O page 153	N/A ⁵	150 K at 5.3-ft ¹	N/A ⁵
10/6/65	O page 156	1,080 K at 8.8-ft ²	385 K at 4.7-ft ²	N/A ⁵
10/13/65	O page 159	1,035 K at 8.8-ft ²	390 K at 4.7-ft ²	N/A ⁵
10/20/65	O page 162	1,095 K at 8.8-ft ²	390 K at 4.7-ft ²	N/A ⁵
10/27/65	O page 165	“Lateral readings are continuing to show slight increase.”		
11/24/65	O page 177	“Lateral readings under this tank appear to have leveled off this month but leveling may be due to lower reading No. 2 caisson probe replacements.”		
12/22/65	O page 189	“No significant change under this tank. No loss of material has been detected.” ⁶		
12/65	HAN-93551	500 K	485 K	N/A ⁵
1/31/66	HAN-93802	600 K	250 K	N/A ⁵
2/28/66	HAN-94040	960 K	600 K	N/A ⁵
3/31/66	HAN-94330	930 K	705 K	945 K at 9-ft ⁴
4/30/66	HAN-94591	1,200 K	960 K	960 K
5/31/66	HAN-94842	1,050 K	1,020 K	970 K
6/30/66	P page 11	885 K	930 K	1,020 K
1970	RPP-ENV-39658	690 K	990 K	1,080 K
1971	RPP-ENV-39658	840 K	1,200 K	1,440 K
1972	RPP-ENV-39658	465 K	630 K	735 K
1/73	RPP-ENV-39658	540 K	615 K	660 K
8/73	RPP-ENV-39658	600 K	857 K	964 K
4/74	RPP-ENV-39658	750 K	1,200 K	1,260 K

Table D2-1. Tank SX-108 Lateral Radioactivity (counts per minute) (December 1962 through April 1989)
(Excerpts from RPP-ENV-39658 Rev 0 and RPP-RPT-29191) (3 of 3 sheets)

Date	Reference	241-SX-108		
		44-08-01	44-08-02	44-08-03
9/74	RPP-ENV-39658	480 K	930 K	945 K
2/75	RPP-ENV-39658	945 K	1,080 K	1,125 K
7/75	RPP-ENV-39658	360 K	432 K	435 K
10/75	RPP-ENV-39658	402 K	450 K	450 K
3/76	RPP-ENV-39658	369 K	438 K	465 K
2/77	RPP-ENV-39658	960 K	1,020 K	1,020 K
10/77	RPP-ENV-39658	1,000 K	780 K	1,050 K
7/78	RPP-ENV-39658	960 K	1,053 K	1,020 K
7/79	RPP-ENV-39658	996 K	1,062 K	1,026 K
7/80	RPP-ENV-39658	864 K	1,020 K	1,005 K
6/81	RPP-ENV-39658	960 K	1,086 K	1,086 K
7/82	RPP-ENV-39658	938 K	1,122 K	1,119 K
6/83	RPP-ENV-39658	980 K	1,239 K	1,290 K
6/84	RPP-ENV-39658	1,000 K	1,299 K	1,380 K
6/85	RPP-ENV-39658	1,000 K	1,326 K	1,424 K
6/86	RPP-ENV-39658	1,000 K	1,395 K	1,446 K
7/87	RPP-ENV-39658	1,212 K	1,515 K	1,614 K
4/89	RPP-ENV-39658	995 K	1,176 K	1,200 K

Notes:

1. West from edge of tank
2. Under west side of tank
3. The maximum radioactivity for both laterals, possibly occurring in Lateral 44-08-02
4. Under west side of tank. Referenced from BNWL-CC-701
5. N/A: Data not available
6. Ambiguous statement but commonly used to mean that the previous reading has not changed

Reference A is internal letter H.W. Stivers/F. S. Strong to L.L. Zahn/W.P. Ingalls

Reference B is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation January 1963*, Rough Draft (Harmon 1963b)

Reference C is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation February 1963*, Rough Draft (Harmon 1963c)

Reference D is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation March 1963*, Rough Draft (Harmon 1963d)

Reference E is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation June 1963*, Rough Draft (Harmon 1963g)

Reference F is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation July 1963*, Rough Draft (Harmon 1963h)

Reference G is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation August 1963*, Rough Draft (Harmon 1963i)

Reference H is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation September 1963*, Rough Draft (Harmon 1963j)

RPP-RPT-54910, Rev. 0

Reference I is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation October 1963*, Rough Draft (Harmon 1963k)
Reference J is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation November 1963*, Rough Draft (Harmon 1963l)
Reference K is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation December 1963*, Rough Draft (Harmon 1963m)
Reference L is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation January 1964*, Rough Draft (Harmon 1964a)
Reference M is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation February 1964*, Rough Draft (Harmon 1964b)
Reference N is HW-80202, *REDOX Weekly Process Reports January through December, 1964*
Reference O is RL-SEP-297, *REDOX Weekly Process Reports January through December, 1965*
Reference P is HAN-93855-6-DEL, 1966, *200 Area Monthly Report for June 1966*

APPENDIX E2

TANK SX-108 GROSS GAMMA DRYWELL DATA

Table E2-1. Tank SX-108 Drywell Radioactivity (K counts per minute) (March 1969 to June 1986)
(Drywell Data Sheets Retrieved on March 8, 2011 and SD-WM-TI-356) (1 of 6 sheets)¹

41-08-02 ⁷			41-08-03 ⁵		41-08-04 ⁴			41-08-06 ⁵		41-08-07 ⁵			41-08-11 ⁵			41-09-03 ⁵			
Drilled 3/16/1962			Drilled 3/19/1962		Drilled 3/14/1962			Drilled 3/12/1962		Drilled 3/16/1962			Drilled 3/15/1962			Drilled 3/19/1962			
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	
3/1/65	120 ⁶	52	N/A ³		12/62 Elevated Readings ~21.5-ft BGS ⁶			N/A ³		Mid 1965 – No Activity ⁶			For earlier data see Table 5-5			N/A ³			
3/31/65	90 ⁶	52	N/A ³					N/A ³								N/A ³			
5/28/65	145 ⁶	52	N/A ³					N/A ³								1/2/68	Present ⁸	62	
N/A ³			3/20/69	< 50	3/26/69	> 1000	39-50	3/20/69	< 50	3/27/69	615	66	3/27/69	>1000	55-56	3/27/69	890	64	
N/A ³			4/3/69	< 50	4/8/69	> 1000	39-50	4/3/69	< 50	4/2/69	605	66	4/1/69	>1000	55-56	4/1/69	980	64	
N/A ³			5/8/69	< 50	5/5/69	755	39-50	5/8/69	< 50	5/7/69	630	66	5/6/69	>1000	55-56	5/6/69	1000	N/A ³	
N/A ³			N/A ³		6/12/69	685	47	N/A ³		6/11/69	600	66	6/11/69	>1000	N/A ³	6/11/69	980	64	
N/A ³			7/21/69	< 50	7/8/69	690	45	7/17/69	< 50	7/16/69	>1000	63 to Bottom	7/9/69	>1000	53-55	7/9/69	970	62	
N/A ³			8/21/69	< 50	8/7/69	700	47	8/21/69	< 50	8/8/69	>1000	66-64	8/8/69	>1000	54-57	8/8/69	>1000	63-66	
N/A ³			9/22/69	< 50	9/23/69	700	45	9/22/69	< 50	9/1/69	>1000	68-74	9/1/69	510	56	9/1/69	575	63	
N/A ³			10/17/69	< 50	10/17/69	775	N/A ³	N/A ³		10/2/69	695	67	10/2/69	>1000	57	10/2/69	975	N/A ³	
N/A ³			11/20/69	< 50	11/21/69	895	45-49	11/20/69	< 50	11/6/69	695	67	11/6/69	>1000	57	11/6/69	>1000	65	
N/A ³			12/22/69	< 50	12/23/69	850	45-49	12/22/69	< 50	12/1/69	675	67	12/1/69	>1000	57	12/1/69	940	64	
N/A ³			1/22/69	< 50	1/22/70	855	N/A ³	1/22/69	< 50	1/12/70	670	67	1/6/70	>1000	56	1/6/70	935	64	
N/A ³			2/24/70	< 50	2/24/70	890	N/A ³	2/24/70	< 50	2/4/70	715	67	2/3/70	>1000	56	2/3/70	975	64	
N/A ³			3/24/70	< 50	3/24/70	880	N/A ³	3/24/70	< 50	3/12/70	705	67	3/4/70	>1000	56	3/4/70	>1000	N/A ³	
4/24/70	1	54	4/21/70	< 50	4/21/70	880	N/A ³	N/A ³		4/9/70	710	66	4/8/70	>1000	56	4/9/70	985	64	
	0.3	76																	

Table E2-1. Tank SX-108 Drywell Radioactivity (K counts per minute) (March 1969 to June 1986)
(Drywell Data Sheets Retrieved on March 8, 2011 and SD-WM-TI-356) (2 of 6 sheets)¹

41-08-02 ⁷			41-08-03 ⁵		41-08-04 ⁴			41-08-06 ⁵		41-08-07 ⁵			41-08-11 ⁵			41-09-03 ⁵		
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)
5/1/70	1	54	5/19/70	< 50	N/A ³			5/19/70	< 50	5/1/70	700	66	5/1/70	>1000	56	5/1/70	>1000	64
	0.2	76									>1000	70-74						
6/4/70	2	54	6/29/70	< 50	6/29/70	885	42	6/29/70	< 50	6/4/70	855	66	6/3/70	>1000	56	6/4/70	>1000	64
	0.2	76									>1000	70-74						
7/10/70	7	54	7/27/70	< 50	7/15/70	915	44	7/27/70	< 50	7/22/70	>1000	65-74	7/22/70	>1000	53-58	7/22/70	>1000	64
	0.1	76				15	76											
8/3/70	4	54	8/24/70	< 50	8/4/70	905	44	8/24/70	< 50	8/3/70	770	74	8/3/70	730	55	8/3/70	690	64
	0.2	76				10	76											
N/A ³			9/28/70	< 50	9/3/70	925	44	9/28/70	< 50	9/25/70	520	65-74	9/11/70	420	54	9/11/70	368	63
						10	76											
N/A ³			10/20/70	< 50	10/1/70	890	44	10/20/70	< 50	10/5/70	540	74	10/5/70	450	54	10/1/70	415	63
						11	76							0.4	76			
N/A ³			N/A ³		N/A ³			N/A ³		11/3/70	945	65-74	11/12/70	620	55	11/3/70	950	63
														0.4	76			
N/A ³			12/29/70	< 50	12/30/70	840	46	12/29/70	< 50	12/11/70	425	66	12/10/70	600	55	12/10/70	550	64
						15	76				685	74		10	76			
N/A ³			1/18/71	< 50	1/6/71	830	46	1/18/71	< 50	1/5/71	430	66	1/5/71	570	55	1/5/71	540	64
						15	76				200	74		15	76			
N/A ³			N/A ³		2/5/71	855	45	N/A ³		2/3/71	945	66-74	2/3/71	940	55	2/3/71	945	64
						10	76											
N/A ³			3/29/71	< 50	3/4/71	660	45	3/29/71	< 50	3/1/71	945	66-74	3/1/71	940	55	3/1/71	940	64
						15	76							5	76			
N/A ³			N/A ³		4/13/71	635	46	N/A ³		4/12/71	950	66-74	4/26/71	945	55	4/12/71	945	64
						15	76							10	76			

Table E2-1. Tank SX-108 Drywell Radioactivity (K counts per minute) (March 1969 to June 1986)
(Drywell Data Sheets Retrieved on March 8, 2011 and SD-WM-TI-356) (3 of 6 sheets)¹

41-08-02 ⁷			41-08-03 ⁵		41-08-04 ⁴			41-08-06 ⁵		41-08-07 ⁵			41-08-11 ⁵			41-09-03 ⁵				
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)		
N/A ³			5/3/71	< 50	5/24/71	590	46	5/3/71	< 50	5/24/71	950	66-74	5/24/71	950	55	5/24/71	950	64		
						15	76							10	76					
N/A ³			N/A ³		6/3/71	600	46	N/A ³		6/3/71	950	66-74	6/3/71	945	55	6/3/71	945	64		
						10	76							15	76					
N/A ³			7/29/71	< 50	N/A ³			7/29/71	< 50	N/A ³			7/9/71	945	55-58	7/9/71	945	64		
														5	76					
N/A ³			8/18/71	< 50	8/2/71	670	46	8/18/71	< 50	8/2/71	950	66-74	8/2/71	955	55	8/2/71	955	64		
						20	76							15	76					
N/A ³			9/24/71	< 50	9/8/71	665	46	9/24/71	< 50	9/10/71	950	66-74	9/10/71	825	55	9/10/71	875	64		
						9	76							20	76					
N/A ³			10/22/71	< 50	10/4/71	650	46	10/22/71	< 50	10/6/71	945	66-74	10/6/71	850	55	10/6/71	870	64		
						10	76							10	76					
N/A ³			11/15/71	< 50	11/7/71	610	N/A ³	11/15/71	< 50	11/1/71	920	66-74	11/1/71	825	55	11/1/71	745	64		
														10	76					
12/27/71	1	54	12/15/71	< 50	12/2/71	635	46	N/A ³		12/3/71	610	66-74	12/3/71	530	55	12/3/71	545	64		
						15	76							10	76					
N/A ³			N/A ³		1/4/72	640	46	N/A ³		1/4/72	645	66-74	1/4/72	540	55	1/4/72	505	63		
						15	77							15	76					
N/A ³			2/14/71	< 50	2/3/72	650	46	N/A ³		2/3/72	650	66-74	2/3/72	530	55	N/A ³				
						9	77							20	76					
N/A ³			N/A ³		3/13/72	640	46	N/A ³		3/1/72	630	66-74	3/1/72	520	55	N/A ³				
						20	77							20	76					
N/A ³			N/A ³		4/24/72	605	N/A ³	N/A ³		N/A ³			4/11/72	880	55	N/A ³				
														15	76					

Table E2-1. Tank SX-108 Drywell Radioactivity (K counts per minute) (March 1969 to June 1986)
(Drywell Data Sheets Retrieved on March 8, 2011 and SD-WM-TI-356) (4 of 6 sheets)¹

41-08-02 ⁷			41-08-03 ⁵		41-08-04 ⁴			41-08-06 ⁵		41-08-07 ⁵			41-08-11 ⁵			41-09-03 ⁵		
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)
N/A ³			N/A ³		5/4/72	605	46	N/A ³		5/5/72	655	66	5/5/72	900	55	N/A ³		
						10	77				955	71-74		20	76			
N/A ³			N/A ³		6/1/72	640	46	N/A ³		6/1/72	645	66	6/1/72	860	55	N/A ³		
						10	77				945	71-74		10	76			
7/28/72	1	54	N/A ³		7/3/72	630	46	N/A ³		7/3/72	335	66	7/3/72	460	55	N/A ³		
						5	77				710	74		15	76			
N/A ³			N/A ³		8/15/72	610	46	N/A ³		8/1/72	315	66	8/1/72	430	55	N/A ³		
						5	77				540	74		10	76			
N/A ³			N/A ³		9/7/72	575	46	N/A ³		9/13/72	585	66	9/12/72	1000	55	N/A ³		
						35	77				840	72		10	76			
N/A ³			N/A ³		10/17/72	615	43	N/A ³		10/3/72	680	66	10/17/72	830	55	N/A ³		
						20	76				700	72		40	74			
N/A ³			N/A ³		11/27/72	625	43	N/A ³		11/7/72	515	66	11/7/72	545	55	N/A ³		
						5	76				730	72		35	74			
N/A ³			N/A ³		12/11/72	410	43	N/A ³		12/19/72	780	N/A ³	12/19/72	610	55	N/A ³		
						10	76							25	74			
N/A ³			N/A ³		1/8/73	460	43	N/A ³		1/3/73	720	66	1/25/73	770	N/A ³	1/30/73	755	64
						20	76				840	72						
N/A ³			N/A ³		2/12/73	435	43	N/A ³		2/6/73	695	66	2/13/73	735	55	N/A ³		
						3	76				840	72		20	75			
3/26/73	3	50	N/A ³		3/12/73	615	43	N/A ³		3/5/73	700	N/A ³	3/13/73	410	55	N/A ³		
						5	76							10	75			
N/A ³			N/A ³		4/2/73	640	43	N/A ³		4/3/73	780	66	4/3/73	755	55	N/A ³		
						10	76				900	72						

Table E2-1. Tank SX-108 Drywell Radioactivity (K counts per minute) (March 1969 to June 1986)
(Drywell Data Sheets Retrieved on March 8, 2011 and SD-WM-TI-356) (5 of 6 sheets)¹

41-08-02 ⁷			41-08-03 ⁵		41-08-04 ⁴			41-08-06 ⁵		41-08-07 ⁵			41-08-11 ⁵			41-09-03 ⁵		
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)
N/A ³			N/A ³		5/2/73	690	43	N/A ³		5/7/73	875	64-73	5/7/73	700	56	N/A ³		
N/A ³			N/A ³		6/12/73	565	N/A ³	N/A ³		6/4/73	920	64-72	6/11/73	705	N/A ³	6/18/73	675	64
N/A ³			N/A ³		N/A ³			N/A ³		7/3/73	770	64-71	N/A ³			N/A ³		
N/A ³			N/A ³		N/A ³			N/A ³		8/6/73	740	63-70	N/A ³			N/A ³		
9/13/73	5	50	9/13/73	< 15	9/18/73	915	N/A ³	9/13/73	< 15	9/12/73	1000	N/A ³	9/13/73	800	N/A ³	9/13/73	705	60
4/4/74	4	53	N/A ³		4/25/74	775	N/A ³	N/A ³		N/A ³			4/18/74	760	N/A ³	4/18/74	700	70
4/18/74	3	52	N/A ³		N/A ³			N/A ³		N/A ³			N/A ³			5/31/74	845	66
7/9/74	3	55	7/24/74	< 12	7/24/74	560	N/A ³	7/24/74	< 12	N/A ³			7/31/74	800	N/A ³	N/A ³		
7/12/74	1347	56	N/A ³		N/A ³			N/A ³		N/A ³			N/A ³			N/A ³		
N/A ³			8/8/74	< 3	8/1/74	190	N/A ³	8/1/74	< 3	N/A ³			8/15/74	1029	N/A ³	8/30/74	946	66
N/A ³			N/A ³		N/A ³			N/A ³		9/9/74	720	N/A ³	N/A ³			N/A ³		
N/A ³			N/A ³		N/A ³			N/A ³		9/22/74	1397	N/A ³	N/A ³			N/A ³		
1/22/75	1283	55	1/22/75	< 3	2/5/75	173	N/A ³	1/28/75	< 3	1/29/75	1365	N/A ³	1/29/75	1187	N/A ³	1/29/75	1121	64
7/15/75	1366	54	7/22/75	< 3	7/22/75	192	N/A ³	7/22/75	< 3	7/9/75	1106	N/A ³	7/9/75	1037	N/A ³	7/9/75	975	63
4/7/76	1480	55	4/7/76	< 3	4/7/76	174	N/A ³	4/7/76	< 3	4/6/76	1043	N/A ³	4/6/76	1094	N/A ³	4/6/76	983	64
N/A ³			N/A ³		N/A ³			N/A ³		10/5/76	1763	N/A ³	10/5/76	1378	N/A ³	10/5/76	1201	62
N/A ³			N/A ³		N/A ³			N/A ³		1/4/77	1079	N/A ³	1/4/77	1065	N/A ³	8/2/77	1256	62
8/2/77	906	53	8/3/77	< 3	8/3/77	177	N/A ³	8/3/77	< 3	8/2/77	1648	N/A ³	8/2/77	1333	N/A ³	3/7/78	1090	62
11/21/78	1075	54	7/4/78	< 3	7/4/78	166	N/A ³	7/4/78	< 3	1/27/78	460	N/A ³	1/27/78	432	N/A ³	4/4/78	378	62
N/A ³			N/A ³		N/A ³			N/A ³		7/4/78	490	N/A ³	7/6/78	402	N/A ³	7/4/78	384	62
6/4/79	992	53	7/17/79	< 3	7/17/79	172	N/A ³	7/17/79	< 3	7/16/79	343	N/A ³	7/16/79	456	N/A ³	7/16/79	383	63
7/15/80	1096	53	7/15/80	< 3	7/15/80	162	N/A ³	7/15/80	< 3	7/14/80	498	N/A ³	7/14/80	491	N/A ³	7/14/80	403	61
6/18/81	996	54	6/16/81	< 3	6/17/81	161	N/A ³	6/16/81	< 3	6/15/81	488	N/A ³	6/15/81	446	N/A ³	6/15/81	371	63
7/28/82	1036	54	7/30/82	< 3	7/29/82	4	N/A ³	7/29/82	< 3	7/26/82	381	N/A ³	7/26/82	481	N/A ³	7/26/82	411	64

**Table E2-1. Tank SX-108 Drywell Radioactivity (K counts per minute) (March 1969 to June 1986)
(Drywell Data Sheets Retrieved on March 8, 2011 and SD-WM-TI-356) (6 of 6 sheets)¹**

41-08-02 ⁷			41-08-03 ⁵		41-08-04 ⁴			41-08-06 ⁵		41-08-07 ⁵			41-08-11 ⁵			41-09-03 ⁵		
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)
6/23/83	859	55	6/23/83	< 3	6/23/83	9	N/A ³	6/23/83	< 3	6/15/83	292	N/A ³	6/14/83	438	N/A ³	6/14/83	394	64
6/12/84	852	55	6/12/84	< 3	6/12/84	9	N/A ³	6/12/84	< 3	6/11/84	326	N/A ³	6/11/84	447	N/A ³	7/9/84	382	64
6/11/85	866	56	6/11/85	< 3	6/11/85	7	N/A ³	6/11/85	< 3	6/11/85	294	N/A ³	6/11/85	442	N/A ³	6/11/85	384	65
6/9/86	1049	56	6/9/86	< 3	6/9/86	8	N/A ³	6/9/86	< 3	6/11/86	340	N/A ³	6/11/86	453	N/A ³	6/24/86	357	65

Note: ¹If Depths were not available, the column was omitted from the table

²New Monitoring Equipment

³N/A: Data not available

⁴Readings were recorded using the Scintillation Probe (SP) from March 1969 to September 1973. GMP used for the remainder of the data.

⁵All readings were recorded using the GMP

⁶Reference WHC-MR-0300, Supplement 1 of 5, Ref. 19

⁷Readings were recorded using the GMP from March 1965 to July 9, 1974. SS (Shielded Scintillation) probe used for the remainder of the data.

⁸Referenced from Drywell Strip Charts- GMP used

APPENDIX F2

REDOX WEEKLY TANK FARM READINGS

Table F2-1. REDOX Weekly Tank Farm Readings July 12, 1962 to October 25, 1962

REDOX TANK FARM READINGS

(Recorded Once Weekly on Thurs.)

Tank	7-12-62	7-19-62	7-26-62	8-2-62	8-9-62	8-16-62	8-23-62	8-30-62	9-6-62	9-13-62	9-20-62	9-27-62	10-4-62	10-11-62	10-18-62	10-25-62								
Number	Ft. El.	Temp.	Ft. El.	Temp.	Ft. El.	Temp.	Ft. El.	Temp.	Ft. El.	Temp.	Ft. El.	Temp.	Ft. El.	Temp.	Ft. El.	Temp.								
101-S																								
102-S																								
103-S																								
104-S																								
105-S																								
106-S																								
107-S	26'7"	—	20'7 1/2"	—	20'9 1/2"	—	21' 1/2"	—	21' 1/2"	—	16' 8 1/2"	—	16' 1/2"	—	16' 5"	—								
108-S																								
109-S																								
110-S																								
111-S																								
112-S																								
101-SX	13'10 1/4"	205	13'10 1/2"	205	13' 1/2"	204	13'11"	205	13' 1/4"	205			13' 1/2"	205										
102-SX	26'2 1/2"	131	26'2 1/2"	133	26'2 1/2"	130	26'2 1/2"	130	26'2 1/2"	131	26'2 1/2"	130			26'2 1/2"	132								
103-SX	22'10 1/4"	173	22'10"	173	22'9 1/2"	171	22'9 1/2"	170	22'9 1/2"	170	22'9 1/2"	168			22'9 1/2"	169								
104-SX	20'5"	207	20'5"	209	20'5"	207	20'5"	207	20'5"	208		207			22'6"	208								
105-SX	27'8 1/2"	110	27'8 1/2"	111	27'8 1/2"	107	27'8 1/2"	107	27'8 1/2"	112	25'9 1/4"	109			17'11 1/2"	109								
106-SX	5'4 1/2"	177	6'7 1/2"	175	5'11 1/2"	174	5'11 1/2"	176	6'4 1/2"	174	6'8"	171	6'1 1/2"	171	6'3 1/2"	172								
107-SX	20'1"	241	20'1"	242	20'1"	242	20'1"	241	21'1 1/2"	241	20'1 1/2"	240	20'4 1/2"	240	20'4 1/2"	240								
108-SX	9'11 1/2"	193	9'11"	192	9'10 1/2"	192	7'3 1/2"	192	3'8 1/2"	198	5'7 1/2"	—	13'7 1/2"	157	13'5 1/2"	154								
109-SX	14'4"	276	13'10 1/2"	277	15'0"	279	15'0"	279	15'7"	280	15'8"	277	16'2 1/2"	280	16'6"	282								
110-SX	21'7 1/2"	226	21'5 1/2"	227	21'8 1/2"	230	22' 1/2"	222	22'0"	223	21'10 1/2"	222	21'8"	224	21'7"	225								
111-SX	21'2 1/2"	237	21' 1/2"	237	21' 1/2"	236	21' 1/2"	236	21'0"	236	20'11 1/2"	237	20'11"	237	20'10 1/2"	238								
112-SX	22'5 1/2"	289	22'6 1/2"	284	22'5"	292	22'4 1/2"	284	22'4 1/2"	281	22'2 1/2"	278	22'1 1/2"	281	22'2"	280								
113-SX	—	—	0'1 1/2"	70	4'10 1/2"	157									0'2"	—								
114-SX	9'11"	157	9'10 1/2"	157	9'10 1/2"	151	12'6"	164	16' 1/2"	159	16'0"	159	15'11 1/2"	160	15'11 1/2"	160								
115-SX	20'9 1/2"	226	20'8 1/2"	226	20'8"	220	21'1"	228	20'11 1/2"	224	20'11"	225	21'6 1/2"	225	21'5 1/2"	223								
7-23-62	106-SX	to	109-SX	15,841 gals.													10-2-62	106-SX	to	110-SX	8,265 gal.			
7-24-62	"	"	"	"	19,285 gals.													10-3-62	106-SX	to	110-SX	22,040 gals.		
7-25-62	"	"	"	"	22,729 gals.													10-10-62	114-SX	to	113-SX	50,279 gals.		
7-26-62	106-SX	to	110-SX	17,219 gals.													10-11-62	"	"	"	"	14,809 gals.	Leak check 113-SX.	
7-27-62	"	"	"	"	22,040 gals.													10-22-62	106-SX	to	110-SX	17,219 gals.		
7-30-62	106-SX	to	115-SX	17,219 gals.																				
Pumped a total of 198,360 gals. of dissolved Sulfur soln. from 108-SX to 114-SX between 7-31-62 and 8-3-62.																								

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6.1 TANK SX-109 BACKGROUND HISTORY

This section provides information on the historical waste loss event associated with SST 241-SX-109 (SX-109). Tank SX-109 has three laterals installed in December 1962 about 10-ft under the tank (see Figure 6-1). There are seven drywells located around tank SX-109: 41-09-02, 41-09-03, 41-09-04, 41-09-06, 41-09-07, 41-09-09 and 41-09-11 installed in 1962, and drywell 41-00-08 installed in 1956 located near tank SX-109.

The bottom of the tank footing is 53-ft BGS with ~6-ft 6-in soil cover over the dome (WHC-SD-WM-TI-665, *Soil Load above Hanford Waste Storage Tanks*). Inside tank SX-109 there are four ALCs 18-in above the tank bottom and equally spaced on a 40-ft diameter circle as shown in Figure 6-1 (H-2-39951). Two ALCs are designated low ALCs (8-ft 6-in tall) and two are high ALCs (13-ft 6-in tall) (H-2-9950).

Figure 6-1. Tank SX-109 Associated Drywells and Laterals
Tank inner ring is steel liner, outer ring is outer edge of tank footing

6.2 TANK SX-109 OPERATIONS SUMMARY

Construction of tank SX-109 was completed in 1953 to 1954 and first received 187 kgal of REDOX HLW beginning on September 20, 1955 (HW-39216, *Separations Section Waste – Status Summary for September 1955*, page 8; HWN-1991-DEL). The tank was not preheated but a liquid heel was provided (RHO-R-39, *Boiling Waste Tank Farm Operational History*). Document WHC-SD-WM-TI-614, *Waste Status and Transaction Record Summary for the Southwest Quadrant of the Hanford 200 Area*, lists 26 kgal of water were used as the liquid heel.

Tank SX-109 continued to receive REDOX HLW until November 8, 1955 (HW-40208, *Separations Section Waste – Status Summary for November 1955*, page 8). Self-concentration started December 12, 1955 (HWN-1991-DEL). REDOX HLW was again routed to tank SX-109 from January 1956 (HW-41038, *Separations Section Waste – Status Summary for January 1956*, page 8) through February 1956 (HW-41812, *Separations Section Waste – Status Summary for February 1956*, page 8), resulting in a total of 977 kgal of waste in this tank. No waste was reported to be added to or removed from tank SX-109 from March 1956 until 1960.

Self-evaporation of the waste stored in tank SX-109 continued through 1957, as reported in the waste transfer records and supported by the ~220°F to ~260°F temperature readings shown in Appendix B3 and Appendix C3. No appreciable self-concentration of waste in tank SX-109 was reported for 1958 (3 kgal evaporated) or 1959 (5 kgal evaporated), which is supported by the waste temperature decreasing from ~210°F to ~170°F during this time (see Appendix A3).

Approximately 284 kgal of REDOX HLW supernatant were transferred from tank SX-109 to tank SX-115 from July through September 1960, leaving 334 kgal of supernatant and 333 kgal of sludge in tank SX-109 (HW-66557, *Chemical Processing Department Waste Status Summary, July 1, 1960 – July 31, 1960*, page 8; HW-67696, *Chemical Processing Department Waste Status Summary, September 1, 1960 – September 30, 1960*, page 8; HW-83906-D-RD, *Chemical Processing Department 200 West Area Tank Farm Inventory and Waste Reports January 1959 Through June 1961*, pages 147, 155 and 163). From July through December 1961, tank SX-109 received ~58 kgal of REDOX HLW and ~386 kgal of supernatant were transferred out of the tank to tank SX-110 (HW-72625, *Chemical Processing Department – Waste Status Summary, July – December 1961*, page 8; HW-83906-E-RD, *Chemical Processing Dept 200 W Area Tank Farm Inventory & Waste Reports 07/1961 Thru 1965*, pages 4 and 5). These transfers were conducted to evaporate the tank SX-109 supernatant using the radiolytic decay heat generated by the REDOX HLW stored in tanks SX-115 and SX-110, thus recovering valuable tank space for additional storage of waste from the REDOX Plant. The sludge was not nitrate leached in tank SX-109.

Approximately 507 kgal of REDOX HLW and 89 kgal of dilute waste from tank SX-102 were added to tank SX-109 from January through June 1962 (HW-74647, *Chemical Processing Department – Waste Status Summary, Planning and Scheduling Production Operation, January – June 1962*, page 8; HW-83906-E-RD, pages 13 and 14). The temperature of the waste in tank SX-109 rapidly increased from ~140°F in November 1961 to ~270°F in June 1962, which caused the evaporation of ~447 kgal from January through June 1962.

Tank SX-109 continued to receive REDOX HLW from July through December 1962, receiving 147 kgal of REDOX HLW and 234 kgal of dilute REDOX HLW from tank SX-105. After receipt of these additional wastes and water, the waste temperature in tank SX-109 increased to ~280°F. In order to control the waste temperature in this tank, 120 kgal of water and 87.5 kgal of condensate from SX-106 were also added from July through December 1962 (HW-76223, *Chemical Processing Department – Waste Status Summary, Planning and Scheduling Production Operation, July – December 1962*, page 8; HW-83906-E-RD, pages 22, 23 and 24).

Water continued to be added to tank SX-109 to control the waste temperature through evaporative cooling. A total of 390 kgal of water and 55.8 kgal of tank SX-106 condensate were added to tank SX-109 from January 1963 through May 1965 (HW-83906-E-RD, pages 31, 32, 33, 40, 41, 42, 49, 50, 56a, 56b, 56c, 62a, 62b and 62c). Tank SX-109 also received ~128 kgal of miscellaneous wastes from the 325 Building during this period. The water additions to tank SX-109 were successful in maintaining the waste temperature at ~280°F throughout 1963 and 1964.

In January 1965, radiation was detected in two laterals and the tank was suspected of leaking (ARH-CD-261, *Thermal Conductivity of SX Tank Farm Soils*). The tank was removed from service and declared a confirmed leaker in February 1965 (WHC-MR-0132, *A History of the 200 Area Tank Farms*). Liquid was not immediately removed from the tank, because there was a shortage of storage space for high level waste, and the leak was thought to have self-sealed. In April 1965 radiation was detected in the third lateral (Internal Letter, M.K. Bayless to M.L. Short, “Tank Farm and Waste Handling Report April 1, 1965 Thru April 30, 1965”). The tank waste was allowed to slowly evaporate and the waste temperature slowly declined from ~280°F to ~230°F from June 1965 through June 1968 (see Appendix B3).

In the first quarter of 1968, tank SX-109 was designated as a “possible leaker” (ARH-534, *Chemical Processing Division Waste Status Summary 01/01/1968 Thru 03/31/1968*, page 9). Part of the supernatant was transferred out of the tank in the third quarter of 1969 and the fourth quarter of 1971 (WHC-MR-0301). Radiation significantly increased in September 1972 in four drywells; the tank was pumped to minimum heel in 1973, and allowed to air dry. Tank SX-109 was administratively interim stabilized in May 1981 and is estimated to contain 74 kgal of sludge and no supernatant (HNF-EP-0182, Rev. 301).

The operational history of tank SX-109 leak related details including temperature and liquid level is charted in Figure 6-2.

Figure 6-2. Operational Leak History of Tank SX-109

6.3 TANK DESIGN/CONSTRUCTION

6.3.1 Tank Design

The SX Farm tanks had multiple design features that could contribute to stresses or possible leak paths when the tank was being operated including:

- Orthogonal intersection between the steel bottom and the sidewall
- Fillet weld used between the bottom and sidewall intersection
- Less rigorous weld inspection testing
- Partial asphaltic membrane waterproofing
- Keyed construction joints in the sidewall

These features are common to all SX Farm tanks and additional details are discussed in Section 3.1.1.

6.3.2 Tank Construction Conditions

The outside temperature between January 16, 1954 and January 30, 1954 ranged from an average high of 24°F to an average low of 9°F. A picture of the SX Farm under construction (see Figure 3-4) taken January 20, 1954 (high 11°F low -6°F), shows several of the tanks full of water either undergoing leak testing or for concrete wall pouring. During this cold period snow covered ice is seen in the water filled tanks.

As described in Section 3.1.2, cold weather affects the ductile-to-brittle steel transition temperature, with 18°F being the assumed unrestricted low temperature construction limitation for the carbon steel liner, which could result in a fracture upon impact. Low temperatures experienced during construction at or less than the 18°F allowable temperature could cause impact loading (e.g. a dropped tool or piece of equipment from scaffolding) and result in the potential for creating micro-fissures weakening the steel liner.

6.4 TANK SX-109 IN-TANK DATA

6.4.1 Liquid Level

There was no detected drop in tank SX-109 liquid level when lateral 44-09-03 first indicated a leak in January 1965. The agitation of the waste within the boiling tank, the recycle of cool condensate, and evaporation made it very difficult to detect small leaks with liquid level measurements (ARH-R-43, Rev. 2, *Management of Radioactive Wastes Stored in Underground Tanks at Hanford*). The tank SX-109 liquid level was apparently not reviewed for a decrease as no mention was found in any of the monthly reports, individual letters, or previous leak assessment reports examined for this report. The lateral and drywell data also indicate that the tank SX-109 leak was at or below the bottom of the tank. In addition, the liquid level measurement under self-boiling conditions (evaporation) coupled with ALC operation results in data uncertainties that render the results unusable for determining liquid level losses associated with a tank leak (see Section 3.2.1).

The liquid level plot in Figure 6-3 indicates the transfer activity into and out of tank SX-109. The liquid levels are end of quarter levels so this figure may not reflect all transfers into and out of the tank that occurred during the operational history of the tank. See Figure 6-2 for historical monthly liquid level readings.

Figure 6-3. Tank SX-109 End of Quarter Surface Level

WHC-SD-WM-ER-352, Rev 0, June 30, 1994, Historical Tank Content Estimate for the Southwest Quadrant of the Hanford 200 West Area

6.4.2 Temperature

Tank SX-109 first received REDOX HLW on September 20, 1955 (HWN-1991-DEL) and reached an equivalent boiling temperature of 240°F in November 1955 (HW-18700-DEL, *REDOX Technical Manual*). The tank was initially filled with 26 kgal of water which was used as a liquid heel and the waste temperature rose to ~117°F by September 29, 1955 from a conservative assumed ambient ground temperature of 55°F, and increased to 240°F by November 21, 1955 (see Appendix B3). However, it was reported in document WHC-MR-0301 that the tank started boiling on December 12, 1955.

Temperature plots reproduced from RHO-CD-1172 (see Appendix C3) show the maximum temperature of the waste stored in tank SX-109 did not exceed 300°F during operation, but reached a maximum of ~293°F in September 1962. After initially receiving waste, the waste temperature leveled off between 220°F to 260°F due to self-evaporation through 1957. Between 1958 and 1959, temperatures decreased from ~210°F to ~170°F and very little self-evaporation were occurring.

In January 1962, REDOX HLW was added again to tank SX-109 causing waste temperatures to rapidly increase from ~140°F in November 1961 to ~270°F in June 1962. Waste temperatures were maintained at ~280°F throughout 1963 and 1964 due to the addition of water and condensate while receiving REDOX HLW.

Tank SX-109 was first suspected of leaking due to radioactivity detected in lateral 44-09-03 in January 1965. Waste temperatures slowly declined after May 1965 to ~230°F at the end of June 1968 and have continued to gradually decrease due to radioactive decay. These relatively high tank waste temperatures are typical with the operating practices for tanks that contained boiling REDOX HLW.

Tank SX-109 was used as part of the testing in document HW-50216 to determine the amount of agitation required for the safe storage in the tanks filled with REDOX HLW. Tank SX-109 was filled to the liquid level of 21-ft between September 19 and November 10, 1955. Of the series of pressure surges (bumping) during January and February 1957, none were reported in tank SX-109 and no temperature gradient was built up despite the ALCs never being operated to May 1957 (HW-50216, page 3).

6.4.3 Liner Observations

Photographs taken in July 1969 were reported to confirm the existence of a previously identified bulge in the bottom liner based on the presence of bent and tilted instrument piping and ALCs (ARH-1106-DEL, page G1-3, *200 Areas Operation Monthly Report July 1969*). Documentation of a previously identified tank SX-109 bottom liner bulge was not found. A review of available photographs taken July 14, 1969 supports the documentation and provides a means of estimating the location and extent of the bulged area by the amount of uncovered sludge along the wall (see Section 6.4.5).

Two subsequent documents RHO-R-39 (five months after the July 1969 photographic identification of a liner bulge) and ARH-R-43, Rev. 2, address the tank SX-109 liner bulge. Both reports contain tables that list tank SX-109 having been inspected for a bulge but no bulge was present (see Appendix A3).

6.4.4 Chemistry-Corrosion

Waste Chemistry

Tank SX-109 began receiving REDOX HLW (R) in September 1955 and stored this waste type throughout operation except for a small addition of miscellaneous waste from the 325 Building (see Table 6-1). The 128 kgal of unknown miscellaneous waste from 325 Building was transferred on top of ~500Kgal of REDOX HLW. The typical concentration for nitrite, nitrate,

and hydroxide for REDOX HLW is shown in Table 6-2. Nitrite and hydroxide are known as nitrate-induced SCC inhibitors. One key characteristic for inhibiting SCC is to maintain a high nitrite concentration to nitrate concentration ratio (see Section 3.2.4).

Table 6-1. Tank SX-109 Waste Storage Chronology

Date	Waste Type	Length of Storage
September 1955 to 1969	REDOX HLW	~ 14 years

Table 6-2. Waste Chemistries for Waste Types Stored in Tank SX-109

Waste Type	[NO ₃] ⁻¹	[NO ₂] ⁻¹	[OH] ⁻¹	Meets Current DST Specification ²
R ³	4.83	0.74		No ⁴

1. Reference WHC-EP-0449, 1991, *The Sort on Radioactive Waste Type Model: A Method to Sort Single-Shell Tanks into Characteristic Groups*.
2. Reference OSD-T-151-00007, Rev. 12, (2013), *Operating Specifications for the Double-Shell Storage Tanks*.
3. Reference WHC-EP-0772, 1994, *Characterization of the Corrosion Behavior of the Carbon Steel Liner in Hanford Site Single-Shell Tanks*.
4. Does not meet the current DST specification since the hydroxide and nitrite concentrations are not greater than or equal to 1.2M.

Tank SX-109 mostly stored only REDOX HLW throughout operation for a total of approximately 10 years until the tank was first suspected of leaking (~14 years before the supernatant was pumped out of the tank). REDOX HLW does not meet the current DST specification for waste chemistry due to low concentrations of the nitrate-induced SCC inhibitors, nitrite and hydroxide. Thus, these conditions of the REDOX HLW would likely create an environment conducive to SCC and/or pitting (see Section 3.2.4).

Nitrate Leaching

The review of operating transactions in Section 6.1 indicated there was no sodium nitrate sludge leaching of the waste in tank SX-109. In addition, document RHO-R-39 listed tank SX-109 sludge as not having been sodium nitrate leached.

6.4.5 Photographs

On July 1, 1969, 3-ft of liquid (~99.8 kgal) was pumped from tank SX-109 to tank SX-105, leaving the liquid level at ~13-ft in tank SX-109 (ARH-1023-3-DEL, *Chemical Processing Division Daily Production Reports July, 1969 through September, 1969*, page 1). On July 8, 1969, an additional 3-ft of liquid (~99 kgal) was pumped from tank SX-109 to tank SX-105, leaving the liquid level at ~10-ft in tank SX-109 (ARH-1023-3-DEL, page 9). Photographs indicated that portions of the sludge were uncovered near the edges of the tank at 10-ft.

The following paragraphs were taken from ARH-1106-DEL, page G1-3:

“Investigation of the sludge level in the TK-109-SX has been completed with the aid of photographic techniques. The liquid level was reduced in increments from 16 feet to 10

feet with photographs being taken at the high and low levels and at one intermediate level. Sludge levels were estimated from the temperature profiles which indicated the sludge depth to be between 7 and 8 feet; however, photographs indicated that portions of the sludge were uncovered near the edges of the tank at 10 feet. As a result, 12 inches of liquid were returned to the tank to recover the sludge.”

“The photographs taken at the low liquid levels confirm the existence of a previously identified bulged liner; bent and tilted instrument piping and airlift circulators were readily visible.”

The photographs at the 10-ft level taken on July 14, 1969 were reviewed. One location in the northwest portion of the tank seemed to indicate some of the description in the ARH-1106-DEL as it relates to bent piping and uncovered sludge. The bent piping is thermocouple probes that are bolted to their respective risers and attached to the bottom of the tank. It was not evident from reviewing the photographs that any of the ALCs were bent or had detached turnbuckle guy rods. Only two of the four ALCs were above the surface of the waste and they were completely encrusted with solids. The top of the other two are at the 10-ft waste level.

The photographs were stated to confirm the existence of a previously identified bulged liner. No documented evidence of a previously identified bulged liner was found. A review of the July 14, 1969 photographs turned up only two bent pipes mentioned above. The opposite outward bending of these two pipes from each other might indicate that if a liner bulge existed it could be located between the two.

The composite of several photographs (see Figure 6-4) shows the uncovered sludge near the edge of the tank as well as the bent and tilted thermocouple piping. It is difficult to tell anything about the orientation of the visible encrusted ALCs. There is the possibility of a bulged liner between the two bent thermocouples but the evidence is not conclusive. Earlier photographs for comparison were not available.

**Figure 6-4. Tank SX-109 Combined Photographs 0692992-25 to 27 and 0692992-34 to 36
July 14, 1969**

6.5 TANK SX-109 EX-TANK DATA

6.5.1 Laterals

The first indication of a leak in tank SX-109 was reported in January 1965, when radioactivity was reported to be detected in lateral 44-09-03 at 5K cpm (counts per minute) (WHC-MR-0300). On February 20, 1965, 5K cpm radioactivity was recorded in lateral 44-09-03 at an assumed position of ~18-ft projected from subsequent data from the northeast edge of the tank (RL-SEP-297, *Redox Weekly Process Report 01/1965 Thru 12/1965*, page 36). Radioactivity remained relatively low in lateral 44-09-03 until October 1965 when readings were recorded at 90K cpm at 31.5-ft from the northeast edge of the tank. Radioactivity gradually increased to approximately 500K cpm in 1977 and remained at this level through April 1989 (see Appendix D3).

Radioactivity was first detected in lateral 44-09-02 on March 31, 1965 at 14.1K cpm (assumed position ~21-ft from the northeast edge of the tank from subsequent data). Radioactivity continued to slowly increase in lateral 44-09-02 with a new peak recorded on January 2, 1973 at 130K cpm at 70.5-ft from the northeast edge of the tank. A third peak at 244K cpm was recorded September 28, 1973 at 65.5-ft from the northeast edge of the tank. Radioactivity remained relatively stable through April 1989 (see Appendix D3).

On April 29, 1965, radioactivity was detected for the first time in lateral 44-09-01 at an assumed position of ~21-ft from the northeast edge of the tank with a reading of 0.2K cpm. Radioactivity increased to 57K cpm by October 1965 at ~21-ft from the northeast edge of the tank. A substantial increase in radioactivity occurred in early 1975 and then readings remained relatively stable through April 1989.

There appears to be two periods when tank SX-109 was actively leaking, one was in 1965 when the tank was first suspected of leaking. The second period appears to be in the mid-1970s when radioactivity began to increase in the laterals after a period of being stable (WHC-MR-0301). The last tank SX-109 lateral survey was in 1989.

6.5.2 Drywells

There are seven drywells located around tank SX-109: 41-09-02, 41-09-03, 41-09-04, 41-09-06, 41-09-07, 41-09-09 and 41-09-11 installed in 1962, and drywell 41-00-08 installed in 1956 located near tank SX-109. All of the radiation readings in drywells are assumed to be maximum values or peak readings unless otherwise noted (see Section 3.3.2). The bottom of the tank footing is ~53-ft BGS. The following subsections report the available drywell information and the drywell summary section provides the analyses of the associated drywells with tank SX-109.

6.5.2.1 Drywell 41-09-02 (N27°E)

Drywell 41-09-02 was drilled March 23, 1962 with the first recoverable reading reported radioactivity in January 1965 as a “small amount” (WHC-MR-0300, *Tank 241-SX-108 Leak Assessment*, Supplement 1 of 5, Ref. 18). The next recoverable reading recorded a peak of 130K cpm on February 28, 1965 at ~57-ft BGS (WHC-MR-0300, Ref. 19-17 and 19-21). No data were recovered from May 1965 until March 24, 1969 when a peak reading of 238K cpm at 59-ft BGS was recorded. Radiation levels gradually decreased and on September 13, 1973 a peak reading of 19K cpm at 57-ft BGS was recorded. The 57-ft BGS readings diminished until they reached less than detectable values by April 6, 1976 probably from a short lived radioisotope. The readings continued as less than values through May 1987 (see Appendix E3).

In December 1995, Cs-137 and Eu-154 were the only man-made radionuclides detected in drywell 41-09-02 (GJ-HAN-11). Cs-137 was detected continuously from the ground surface to the total depth of 73.5-ft BGS with the maximum concentration of 3 pCi/g reported at 5.5-ft BGS. A slight rise in concentration was observed from about 40 to 73.5-ft BGS with a maximum concentration of 1.3 pCi/g reported at 58-ft BGS. Eu-154 was detected at three depth locations in the interval from 5.5 to 6.5-ft BGS with a maximum concentration of 0.8 pCi/g. Document GJ-HAN-11 states that earlier 1965 readings were due to contamination detected on the drywell probe; however, it appears additional data were recovered since document GJ-HAN-11 was issued and radioactivity continued to be present in drywell 41-09-02 after the initial 1965 reading (see Appendix E3). Figure 6-5 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 6-5. Tank SX-109 Drywell 41-09-02 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

6.5.2.2 Drywell 41-09-03 (N82°E)

Drywell 41-09-03 was drilled March 19, 1962 with the first recoverable reading on March 27, 1969 at 890K cpm at 64-ft BGS (see Appendix E3). Radiation levels increased to >1,000K cpm by August 1969, and then gradually decreased to 505K cpm at 63-ft BGS on January 4, 1972 (SD-WM-TI-356). The readings rose to 1,260K cpm by August 1977 and continued at that level ranging from 60-ft BGS to 70-ft BGS with most readings at ~64-ft BGS. It is possible there was a change in the probes which could account for these anomalies since the probe used was not specified. The radioactivity continued to be detected and is shown in Figure 6-6 through 1994 (HNF-3136).

Radioactivity found in this drywell was determined to have been attributed to the leak in tank SX-108 due to radioactivity being detected at this lower depth (see Section 5.5.2.7 for details). Therefore, drywell 41-09-03 is not included as part of the leak location for tank SX-109.

Figure 6-6. Tank SX-109 Drywell 41-09-03 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

6.5.2.3 Drywell 41-09-04 (S49°E)

Drywell 41-09-04 was drilled March 21, 1962, and the first recoverable reading reported a small amount of radioactivity in January 1965 (WHC-MR-0300 Supplement 1 of 5, Ref. 18). The next recoverable reading reported a peak of 885K cpm on February 28, 1965 at ~57-ft BGS (see Appendix E3). The early reading may be attributed to contamination on the probe (GJ-HAN-11); however, the readings from February 1965 were recorded at specific depths and were considered in the leak location analysis. No other readings were recovered until March 1969 when two peaks were reported at 2K cpm at 58-ft BGS and 66K cpm at 73-ft BGS (see Appendix E3). Radiation levels gradually increased and on February 2, 1972 peak readings of 192K cpm at 74-ft BGS were recorded (SD-WM-TI-356). The readings rose to 740K cpm at 79-ft BGS by August 1977 and continued at that level ranging from 78 to 81-ft BGS.

In December 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-09-04 (GJ-HAN-11). Relatively high concentrations of Cs-137 were measured continuously from the ground surface to the total depth of 57-ft BGS. Ground surface Cs-137 concentrations were reported at 3,300 pCi/g, 10 pCi/g from 10 to 20-ft BGS, 100 pCi/g from 20 to 40-ft BGS, and greater than 40 pCi/g from 40 to 57-ft BGS. Logging of drywell 41-09-04 was stopped after 1982, because contamination inside the casing was adhering to equipment.

Document GJ-HAN-11 states, *“Because past gross-gamma logging tools have become contaminated, it is apparent that Cs-137 contamination is inside the borehole casing, although the amount and concentration of the contamination cannot be quantified. Because of the high concentrations (about 40 to 100 pCi/g) of Cs-137 throughout much of the borehole, it is likely contamination also exists outside the borehole in the vadose zone. The interval from about 20 to 30 ft may be indicative of a near-surface spillage source; however, the zone of contamination beginning at 57 ft resulted from a subsurface source such as a leaking tank. It has been postulated in some historical records that the source of contamination was in the vicinity of tank SX-108. However, because of the multiple peaks and vertical extent of contamination in this borehole, a source closer to tank SX-109 cannot be discounted.”*

Document WHC-MR-0301 states that radioactivity detected in drywell 41-09-04 is assumed to be influenced by the tank SX-108 leak. However, since radioactivity wasn't detected on the western side of tank SX-108 until 1966, it appears the earlier radioactivity reported in drywell 41-09-04 is associated with the tank SX-109 leak versus a leak from tank SX-108.

Figure 6-7 shows the depths of radioactivity from 1975 to 1995 (HNF-3136). Note, Figure 6-7 x-axis reads later years to earlier years which are the opposite of the other figures.

Figure 6-7. Tank SX-109 Drywell 41-09-04 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS. Depth shifting is a method to align the zero point due to inconsistent data collection.

6.5.2.4 Drywell 41-09-06 (S0°)

Drywell 41-09-06 was drilled March 20, 1962 with the first recoverable readings on March 24, 1969 reported two peaks of 61K cpm at 64-ft BGS and 25K cpm at 69-ft BGS (see Appendix E3). These peaks gradually diminished until September 1969 and no further data were recovered until September 1973. From September 1973 through June 24, 1987, radiation readings were reported as less than values indicating the 64-ft and 69-ft BGS readings diminished until they reached less than detectable values by 1973 probably from more mobile short lived radioisotopes (see Appendix E3).

In December 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-09-06 (GJ-HAN-11). The maximum concentration measured was 1.6 pCi/g at 5.5-ft BGS, excluding measurements at the ground surface. Document GJ-HAN-11 states, “A *subsurface contamination source does not exist in the vicinity of this borehole. Minor contamination is observed at about 5.5 ft in depth.*” Figure 6-8 shows the depths of radioactivity from 1975 to 1995 (HNF-3136). Surface contamination appeared to not be a concern as radiation readings were reported as less than values (see Table E3 in Appendix E3). Since historical records report little radioactivity in this drywell, drywell 41-09-06 is not included as part of the leak location for tank SX-109.

Figure 6-8. Tank SX-109 Drywell 41-09-06 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

6.5.2.5 Drywell 41-09-07 (S53°W)

Drywell 41-09-07 was drilled March 22, 1962 with the first recoverable reading found on January 8, 1968 which reported radioactivity was present at an unspecified BGS depth (see Appendix E3). It appears a peak was reported in the lower portion of the drywell with the GM probe, but radioactivity levels are unclear. No additional data were recovered until April 24, 1970 when radioactivity was reported at 10K cpm at 66-ft BGS (see Appendix E3). Radiation levels gradually increased to 24K cpm by December 19, 1972 at 66-ft BGS and to 42K cpm by March 7, 1978 (SD-WM-TI-356). Radiation levels remained relatively stable through June 1987.

In December 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-09-07 (GJ-HAN-11). A slight indication of a surface source from about 24 to 36-ft BGS was likely attributed from the cascade line. A significant zone of contamination occurs at about 63-ft BGS, where high dead times occurred and logging was terminated. GJ-HAN-11 states, *"The Cs-137 distribution may be the result of contamination inside the casing, as is the case in boreholes 41-09-02 and 41-09-04, where contamination inside the casing was measured from casing swabs. The significant contamination increase at 63 ft results from a subsurface source."* Figure 6-9 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 6-9. Tank SX-109 Drywell 41-09-07 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

6.5.2.6 Drywell 41-09-09 (N75°W)

Drywell 41-09-09 was drilled March 22, 1962 with the first recoverable reading found on January 2, 1968 reported radioactivity was present (see Appendix E3). It appears two peaks were reported at this time with a scintillation probe, but radioactivity levels are unclear. No data were recovered until March 24, 1969 which reported two peaks at 205K cpm at 64-ft BGS and 225K cpm at 72-ft BGS. Radiation levels in both peaks gradually declined to 77K cpm at 64-ft BGS and 23K cpm at 71-ft BGS on February 7, 1972. The upper peak existed in March 1969 and has remained essentially stable since 1974 (see Appendix E3). The 71-ft BGS readings diminished until they reached less than detectable values by 1974 as shown in Figure 6-10 probably from a short lived radioisotope. However, in 1978, the lower peak was again detected and increased in intensity. These peaks suggest two separate sources of radioactivity at different times.

In December 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-09-09 (GJ-HAN-11). Cs-137 contamination was measured in two separate zones, from 63.5 to 66.5-ft BGS and from 69 to 78-ft BGS. The zone from 69 to 78-ft BGS is at least an order of magnitude higher than the concentration in the upper zone. Document GJ-HAN-11 states, *“These peaks suggest two separate sources of contamination arrived in the sediments surrounding the borehole at different times; a source of contamination may still be contributing to the peak at 72 ft.”* Figure 6-10 shows depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 6-10. Tank SX-109 Drywell 41-09-09 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

6.5.2.7 Drywell 41-09-11 (N24°W)

Drywell 41-09-11 was drilled March 23, 1962 with the first recoverable reading on March 20, 1969 reported as less than 50K cpm. Radioactivity continued to be reported as less than values through May 1987 (see Appendix E3).

In December 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-09-11 intermittently throughout the drywell typically at concentrations less than 1 pCi/g (GJ-HAN-11). Figure 6-11 shows the depths of radioactivity from 1975 to 1995 (HNF-3136). Document GJ-HAN-11 states, *“The frequency of low-level concentrations of Cs-137 appears to increase slightly below 40 ft, indicating a potential subsurface source of contamination. However, the concentrations are much lower than detected in other tank SX-109 boreholes, suggesting a nearby subsurface source does not exist.”* Since historical records report little radioactivity in this drywell, drywell 41-09-11 is therefore not included as part of the leak location for tank SX-109.

Figure 6-11. Tank SX-109 Drywell 41-09-11 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

6.5.2.8 Drywell 41-00-08 (N133°W)

Drywell 41-00-08 was drilled March 14, 1956 and is situated about 38-ft from the southwest side of tank SX-109. The first recoverable readings for drywell 41-00-08 on March 24, 1969 reported two peaks at 95K cpm at 72-ft BGS and 120K cpm at ~92-ft BGS (see Appendix E3). By December 3, 1969, radiation readings gradually decreased to 85K cpm at 79-ft BGS and 73K cpm at 92-ft BGS. However, a new peak developed at 9K cpm at 128-ft BGS which gradually diminished by 1983. The 92-ft peak appears to have diminished also as no recordings at this BGS level were found after October 1970. The peak at roughly the 72-ft BGS level remained relatively stable through July 1987 (see Appendix E3).

In December 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-00-08 in two individual zones, from 65.5 to 69-ft BGS and from 75.5 to 80-ft BGS (GJ-HAN-11). The maximum concentrations for the lower and upper zones were 69 and 122 pCi/g, respectively. Document GJ-HAN-11 states, *“The current data support a conclusion of horizontal transport of contamination from one or more leaks from tank SX-109.”*...*“The data suggest contamination from two separate sources (i.e., tank leaks) arriving at the borehole at different times. Contrary to the conclusion documented in the UOR”*... [Unusual occurrence report]...*“that there was no evidence of a new leak, it cannot be ruled out that a new leak from tank SX-109 occurred in the mid-1980s. Furthermore, it cannot be conclusively determined that the tank is not continuing to leak interstitial liquids to the subsurface.”* Figure 6-12 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 6-12. Tank SX-109 Drywell 41-00-08 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

6.5.3 Tank SX-109 Drywell Summary

Tank SX-109 was first suspected of leaking in January 1965 due to radioactivity being detected in lateral 44-09-03. Only drywell data recovered during this time was for drywells 41-09-02 and 41-09-04 which reported a small amount of radioactivity present at an unspecified depth. No other drywell data were recovered until 1968-1969.

The lack of any significant radioactivity in drywell 41-09-11 precludes consideration for the location of a tank SX-109 leak. In addition, drywell 41-09-03 was considered to have been associated with the leak(s) in tank SX-108 (see Tank SX-108 Segment). Therefore, drywells 41-09-11 and 41-09-03 are not included in the leak location analysis for tank SX-109.

Drywell 41-09-02 may have indicated some short lived radioisotope contamination in 1965 at the 57-ft BGS level but there is some question about the possibility of a contaminated probe. Other drywell 41-09-02 radioactivity is at the surface. Drywells 41-09-02, 41-09-06, 41-09-09, 41-09-11 and 41-00-08 all show some very low level short lived radioactivity below 70-ft BGS, the starting dates are not known.

The radioactivity reported in drywell 41-09-04 in January to May 1965 at ~57-ft BGS was in question due to the possibility of a contaminated probe. However, there does appear to be radioactivity near this vertical level which gradually decayed between 1975 through 1983 (HNF-3136). A peak of radiation is also shown at ~65-ft BGS that gradually decays 1975 through 1983; however, the start of the radioactivity at this BGS level is unknown. The major radioactivity found in drywell 41-09-04 started being recorded February 1972 at 192K cpm between 74-ft and 81-ft BGS. The radioactivity level at 192K cpm appears to be close to the starting date of radioactivity based on the subsequent rate of rise.

Drywell 41-09-04 may also have been part of the early 1965 radioactivity but appears to consist of the short lived radioisotopes that decayed away. However, a peak starts being recorded in February 1972 at 74-ft BGS that may be migration of the early 1965 tank SX-109 radioactivity or further migration of the tank SX-108 leak which showed up in drywell 41-09-03 before January 1972 at the 63-ft BGS level.

There appears to be a possible relationship of the radioactivity dates for drywells 41-09-06, 41-09-07 and 41-09-09 as well as the location of radioactivity towards the southwest portion of lateral 44-09-02. These four locations cluster around 65-ft BGS with dates between January 1968 and June 1973. However, in drywell 41-09-06 radiation levels diminish by September 1973 suggesting earlier levels of radioactivity probably consisted of short lived radioisotopes. There is also a possible migration of this radioactivity to drywell 41-00-08 between 65-ft and 68-ft BGS by 1984. There does not seem to be a relationship of this possible leak location with drywell 41-09-04 as there were no intervening peaks in lateral 44-09-01, unless the migration path was beneath the lateral. The possibility of tank SX-112 leak migration to drywell 41-00-08 was also explored, but the lack of radioactivity in the intervening drywells coupled with the location of lateral radioactivity towards the other side of tank SX-112 did not support this possibility (see Tank SX-112 Segment).

Two of the drywells, 41-00-08 and 41-09-09, mentioned in the previous paragraph also had subsequent peaks at lower vertical levels; 72-ft BGS in March 1969 in both drywells, and 75-ft to 79-ft BGS in 1973 in drywell 41-00-08 and 72-ft BGS in 1972 in drywell 41-09-09. These peaks probably migrated from one or more of the original leak sites. No radioactivity was found at the lower level in drywell 41-09-07 situated between drywells 41-00-08 and 41-09-09.

6.6 POSSIBLE TANK SX-109 LINER LEAK LOCATION(S)

The lateral radioactivity when first detected could be an indication of the location of liner leak. However, the liner leak may have penetrated the waterproof membrane at any location or pooled on the waterproof membrane and followed concrete cracks or breaks to a different location including the top of the tank footing.

It is likely that the tank SX-109 leak occurred at or near the bottom of the tank because all of the leak indicators, three laterals and five drywells, were located at or near the tank bottom.

6.6.1 Leak Detected January 1965, Site A

Tank SX-109 was first suspected of leaking in January 1965 based on radioactivity found to have started in the northeast portion of the tank as shown in Figure 6-13 in lateral 44-09-03, ~18-ft toward the center of the tank from the northeast edge, with some possible migration of the more mobile short lived radioisotopes towards drywell 41-09-02 at ~57-ft BGS. Radioactivity that was detected in drywell 41-09-04 in January 1965 was not included in site A in Figure 6-13 due to reports of contamination on the probe and may not be a part of the initial leak site (see Section 6.5.2.3).

Figure 6-13. Tank SX-109 Possible Leak Location (January 1965)
Tank inner ring is steel liner, outer ring is outer edge of tank footing

Tank SX-109 was first suspected of leaking in January 1965 based on radioactivity being detected in lateral 44-09-03

6.6.2 Leak Detected in March – May 1965, Site B

Radioactivity was first detected in lateral 44-09-02 on March 1965, with a peak at ~21.5-ft toward the center of the tank from northeast edge, and later detected in lateral 44-09-01 in April 1965 at ~21.4-ft toward the center of the tank from northeast edge (see Figure 6-14). High levels of radioactivity were also detected in drywell 41-09-04 at 57-ft BGS. Radioactivity continued to increase in lateral 44-09-03 and drywell 41-09-04 with peak readings at the same horizontal and vertical level stated in the preceding paragraph.

Figure 6-14. Tank SX-109 Possible Leak Location (March-May 1965)

Tank inner ring is steel liner, outer ring is outer edge of tank footing

Tank SX-109 was first suspected of leaking in January 1965 based on radioactivity being detected in lateral 44-09-03

6.6.3 Leak Detected in October 1965 – 1972, Site C

The radioactivity from sites A and B seemed to have spread to the middle of lateral 44-09-03 (~31.5-ft under the tank from northeast edge) by October 1965 (see site C in Figure 6-15). Drywell 41-09-04 may also have been part of the early 1965 radioactivity which appears to consist of shorter lived more mobile radioisotopes that decayed away at ~57-ft BGS and 65-ft BGS (see Section 6.5.2.3). High levels of radioactivity were detected in drywell 41-09-04 later in 1972 at ~74-ft BGS. The later drywell 41-09-04 radioactivity may be migration of the tank SX-109 1965 leak or migration of the tank SX-108 leak.

Figure 6-15. Tank SX-109 Possible Leak Location (October 1965-1972)

Tank inner ring is steel liner, outer ring is outer edge of tank footing

Tank SX-109 was first suspected of leaking in January 1965 based on radioactivity being detected in lateral 44-09-03

6.6.4 Leak Detected in 1968 – 1984, Site D

Tank SX-109 may also have leaked in the southwest portion of the tank as shown by site D in Figure 6-16. Radioactivity was detected before January 1968 in drywells 41-09-06, 41-09-07, and 41-09-09 at 64 to 72-ft BGS. A peak was detected before 1973 in lateral 44-09-02 at ~70-ft from northeast edge. Peak readings in drywell 41-00-08 were detected at a lower depth, 70-79-ft BGS and 90-92-ft during 1969 and later. There is also a possibility that some or all of the original 1965 leak, located at site A (see Figure 6-13), migrated into the southwest portion of the tank.

Possible continuing migration was detected in drywell 41-09-09 at ~72-ft BGS in 1978 and in drywell 41-00-08 at ~65-68-ft BGS in 1984. Nothing was detected at drywell 41-09-06 or from the adjacent tank SX-112 during these later dates.

Figure 6-16. Tank SX-109 Possible Leak Location (1968-1984)
Tank inner ring is steel liner, outer ring is outer edge of tank footing

Tank SX-109 was first suspected of leaking in January 1965 based on radioactivity being detected in lateral 44-09-03

6.6.5 Leak Location Summary

Tank SX-109 leaked before January 1965 based on radioactivity being detected in lateral 44-09-03 with some possible migration detected in drywell 41-09-02, and believed to have started in the northeast portion of the tank as shown by site A in Figure 6-13. The liquid from tank SX-109 was not immediately removed from the tank, because there was a shortage of storage space for high level waste. Further migration of this leak continued a couple months later and was detected in all the laterals as well as drywell 41-09-04 as shown by site B in Figure 6-14. Further migration of this leak continued to 1972 which is shown by site C in Figure 6-15. In 1968, radioactivity was detected in the southwest quadrant of the tank likely from a new leak location or from the earlier leak detected in 1965 (see Figure 6-16).

Figure 6-17 shows a composite of the leak location sites. It is likely the leak occurred at or near the bottom of the tank since the leak indicators (laterals and drywells) were located at or near the tank bottom. Leak locations in Figure 6-17 are based on peak readings and are a representation of possible initial and subsequent boundaries of radioactivity.

Tank SX-109 was reported to have a liner bulge based on the presence of bent and tilted instrument piping and ALCs, and is believed to be located in the northwest quadrant of the tank as shown in Figure 6-18. Photographs from 1969 indicate that portions of the sludge were uncovered near the edges of the tank as well as the presence of bent piping. It was not evident from the photographs whether any of the ALCs had detached turnbuckle guy rods as the ALCs were completely encrusted with solids (see Section 6.4.5).

Figure 6-17. Tank SX-109 Possible Radial Leak Locations
 Tank inner ring is steel liner, outer ring is outer edge of tank footing

6.6.6 Estimated Location of Bulge

Photographic evidence for a possible tank liner bulge was found, some of which seems to fit the description of the original report (ARH-1106-DEL, page G1-3). A composite of the photographs fitting the description was assembled (see Section 6.4.5) and the location is superimposed in Figure 6-18 in relationship to the tank leak locations. This may or may not be the best location that would fit the leak locations; however, the possible bulge location was added for perspective.

Figure 6-18. Tank SX-109 Possible Radial Leak Locations with Estimated Bulge

6.7 POSSIBLE TANK SX-109 LINER LEAK CAUSE(S)

Tank SX-109 was exposed to five conditions that could contribute to a failed liner. Some or all of the factors can act together to contribute to tank liner failure.

6.7.1 Tank Design

The design of the SX Farm tanks was the first that diverged from the round bottom knuckle design used in the earlier waste tanks; the tank bottom liner intersects the sidewall liner orthogonally. A fillet weld was used to close the seam where the sidewall and the tank bottom liner meet. Several other SSTs with fillet welds failed during service (RPP-RPT-45921). Weld inspections were less rigorous. Additionally, the design discontinued the use of the three-ply asphaltic membrane waterproofing between the liner sidewall and the concrete shell. These features were inferior to earlier designs and could possibly increase the likelihood of failure of the tank liner from induced stresses (see Section 6.3.1).

6.7.2 Thermal Conditions

Temperature requirements in HW-59919 issued October 22, 1959 indicated that the self-boiling waste operating temperature should be maintained between 50°F and 220°F. The HW-59919 document recommended a uniform rate of temperature increase of 2°F per day and the maximum sludge temperature should not exceed 300°F.

The maximum temperature of 293°F was reported on September 20, 1962, which was below the maximum sludge temperature of 300°F (see Section 5.4.2). Tank SX-109 temperatures did not exceed the maximum sludge temperature limit.

Assuming a 55°F initial temperature of the tank liner when waste was first received on September 20, 1955 (HWN-1991-DEL), the temperature rose to ~185°F by October 13, 1955 (see Figure B3). Tank SX-113 temperature recorded February 26, 1958 before receiving waste was 42°F, therefore 55°F may not be the worst case for ambient temperature for tank SX-109 in September 1955. No tank SX-109 temperature records were found before the tank began receiving waste. Over this 23 day period there was a temperature increase of ~130°F, and the average rate of rise was ~5.7°F per day which is above the recommended rate of 2°F per day.

There were no other increases in temperatures that exceeded the initial average rate of rise of 5.7°F per day during the operation of tank SX-109. Exceeding the operating temperature requirements would create liner stress when thermally hot high level waste was received and stored in the tank especially without pre-heating. Thermal shock creates stress both from rapid temperature rise as well as high temperatures. The most severe operating temperature rate of rise occurred in the initial waste receiving period, before the HW-59919 document was issued.

6.7.3 Chemistry-Corrosion

Tank SX-109 was first filled with REDOX HLW (September 1955) which was stored in the tank for about ten years before the tank was suspected of leaking in January 1965 (or over 14 years before the supernatant was pumped out of the tank).

The REDOX HLW consisting of low concentrations of nitrite and hydroxide would have created an environment conducive to pitting and SCC (see Section 6.4.4). The small quantity of 325 building waste was unlikely to have substantially have changed the REDOX HLW chemistry. Under these conditions, there would be a high propensity for corrosion.

Nitrate leaching was not performed on the tank SX-109 waste.

6.7.4 Liner observations

A review of photographic evidence seems to indicate a possible liner bulge reported in ARH-1106-DEL at least from an observation of bent piping. However, the table in RHO-R-39, issued five months later, indicated there was an inspection for a bulge in tank SX-109 and that there was no bulge present. The evidence of a liner bulge is possible but not conclusive.

Liner bulging coupled with other tank conditions could affect tank liner integrity; however, by itself bulging induces stresses that can cause breaching of the tank liner.

6.7.5 Tank Construction Temperature

Winter temperatures as low as -6°F occurred during the period when the SX Farm tank liners were being constructed and leak tested (see Section 6.3.2). The low temperatures experienced during construction were less than the current 18°F allowable temperature where impact loading had the potential for creating micro-fissures. Impact occurrences could have occurred during cold temperatures that may have triggered fissures in the steel liner. Later, when the metal is subjected to high stress, it might be possible for the cracks to propagate through the metal, or possibly subject the weakened areas to increased corrosion.

6.8 TANK SX-109 CONCLUSIONS

Evidence indicates that the tank SX-109 liner leaked at or near the bottom of the tank in one location with the possibility of a second location or migration from the first. Based on engineering judgment and available information the following conditions listed in the order of importance lead to the tank SX-109 failed liner:

1. Tank design – expansion limiting design changes
2. Thermal conditions – rate of temperature rise
3. Waste storage chemistry – SCC and/or pitting
4. Construction conditions – ductile-to-brittle transition temperature
5. Bulging liner – an effect of primarily thermal conditions along with tank design

There are several liner leak cause conditions that were examined, but the primary cause of the tank SX-109 leak was tank design. The unique tank design did not allow for expansion of the bottom liner as the tank heated during the addition of high temperature waste which creating stresses in the bottom liner. Storage of REDOX HLW at elevated temperatures created a chemical environment susceptible to nitrate-induced SCC and/or pitting attack on an already stressed metal liner. Tank construction occurred in winter under cold temperature conditions which could have affected the ductile-to-brittle steel transition temperature where metal loses its ability to absorb forces such as induced loads or the impact of falling objects creating micro-fissures or hairline cracks. In addition, a bulged bottom imparts stresses in the liner that could have predisposed it to SCC. Some or all of the factors can act serially or together to contribute to tank liner failure.

APPENDIX A3

TANK SX-109 BOILING WASTE OPERATIONAL HISTORY

Table A3-1. RHO-R-39 Boiling Waste Tank Operating Data Table

Tank No.	First Waste	Tank Pre-Heated	Pre-Heat Start	Liquid Heel Used	First Waste Rec'd From	Tank Failed	Inspected For Bulge	Bulge Present	Did Tank Boil on 1st Loading	Tank Started Boiling	Tank Emptied & Reused*	NaNO ₃ Leached from Sludge
101-SX	19 May 54	No	-	No	Redox	No	No	-	Yes	Nov 54	No	No
102-SX	Sep 54	No	-	No	101-SX, Cascade	No	No	-	No	-	No	No
103-SX	Nov 54	No	-	No	102-SX, Cascade	No	No	-	No	-	No	No
104-SX	2 Feb 55	No	-	No	Redox	No	No	-	Yes	Jun 55	No	No
105-SX	11 May 55	No	-	No	104-SX, Cascade	No	No	-	No	-	Yes	No
106-SX	Jun 54	No	-	No	Tank Farm Condensate	No	No	-	No	-	-	-
107-SX	3 Mar 56	No	-	Yes	Redox	Yes, 1964	Yes	Yes	Yes	Jun 56	Yes	Yes
108-SX	8 Nov 55	No	-	No	Redox	Yes, 1962	Yes	Yes	Yes	Jun 56	Yes	Yes
109-SX	20 Sep 55	No	-	Yes	Redox	Yes, 1965	Yes	No	Yes	Dec 55	Yes	No
110-SX	Nov 60	Yes	Apr 60	No	Redox	-	No	-	No	Between 1/61-6/61	Yes	No
111-SX	9 Jun 56	No	-	No	Redox	-	No	-	Yes	Nov 56	Yes	No
112-SX	13 Feb 56	No	-	No	Redox	Yes, 1969	Yes	Yes	Yes	Mar 56	Yes	No
113-SX	20 Feb 58	No	-	No	Redox	Yes, 1958	Yes	Yes	Yes	Apr 58	No	No
114-SX	Nov 56	No	-	No	Redox	-	No	-	Yes	Jun 57	Yes	Yes
115-SX	4 Nov 59	Yes	Sep 58	Yes	Redox	Yes, 1965	No	-	Yes	Nov 59	No	Yes
101-A	20 Jan 56	No	-	6" H ₂ O	Purex	No	Yes	No	Yes	Jul 57	Yes	No
102-A	20 Mar 56	No	-	6" H ₂ O	Purex	No	No	-	Yes	Jul 58	Yes	No
103-A	15 May 56	No	-	6" H ₂ O	Purex	No	No	-	Yes	Jul 56	Yes	No
104-A	30 Jun 59	No	-	6" H ₂ O	Purex	No	Yes	No	Yes	Aug 59	Yes	No
105-A	31 Jan 63	Yes	Jan 63	Yes	Purex	Yes, 1963	Yes	Yes	No***	Mar 63	No	No
106-A	31 Dec 60**	Yes	23 Feb 61	Yes	Purex	No	No	-	Yes	Aug 61	Yes	No
101-AX	1 Jun 65**	Yes	23 Nov 66	Yes	TK-103-A and TK-112-B	No	No	-	No***	Dec 66	Yes	No
102-AX	30 Sep 66**	Yes	2 Mar 69	Yes	TK-101-AX and TK-103-A	No	No	-	No***	Apr 69	No	No
103-AX	10 Feb 65	Yes	Nov 64	Yes	Purex	No	No	-	Yes	Apr 65	No	No
104-AX	9 Sep 66	Yes	Jun 66	Yes	Purex	No	No	-	Yes	Oct 66	No	No

* Emptied indicates supernatant was pumped out but sludge remained.

** Tanks used for temporary waste storage prior to the receipt of LWW or HLW.

*** Did not boil until LWW was routed to the tank.

Note: SX-111 was found to have been NaNO₃ Leached

Table A3-2. ARH-R-43 Waste Tank Leak Experience Table

TABLE 3. Underground Waste Storage Tank Leak Experience

Tank	Built	First Used	Type of Waste Stored	Service	Leak First Suspected	Reason for Suspicion	Leak Confirmed by	Bulge Found	Estimated Volume of Leak, gal	Associated Cs-137, kCi
104-U	1943-44	1947	Bismuth phosphate waste Uranium recovery waste	Nonboiling	1956	Bulged liner	Refill with water (1961)	Yes	55,000*	0.09
113-SX	1953-54	1958	Redox waste	Boiling	1958	Bulged liner	Refill with salt solution (1962)	Yes	15,000**	8
106-TV	1951-52	1953	TBP waste	Nonboiling	1959	Liquid level measurements	Soil radiation readings (1959)		20,000	2
101-U	1943-44	1946	Bismuth phosphate waste Uranium recovery waste Redox waste	Nonboiling	1959	Liquid level measurements	Liquid level measurements		30,000	23
105-TV	1951-52	1953	TBP waste	Nonboiling	1960	Liquid level measurements	Liquid level measurements		35,000	4
108-SX	1953-54	1955	Redox waste	Boiling	1962	Soil radiation readings	Liquid level measurements	Yes	3,400	17
105-A	1954-55	1963	Purex waste	Boiling	1963	Soil radiation readings	Soil radiation readings	Yes	Small	
107-SX	1953-54	1956	Redox waste	Boiling	1964	Soil radiation readings	Soil radiation readings	Yes	Small	
109-SX	1953-54	1955	Redox waste	Boiling	1965	Soil radiation readings	No further evidence	No	Small	
115-SX	1953-54	1958	Redox waste	Boiling	1965	Liquid level measurements	Soil radiation readings		50,000***	40
112-SX	1953-54	1956	Redox waste	Boiling	1969	Liquid level measurements	Soil radiation readings	Yes	30,000	45

* Contained water at time of leak.
 ** Contained NaNO_3 solution at time of leak, also some residual supernatant solution.
 *** Contained NaNO_3 solution at time of leak.

Note: See tank farm segments for information on individual specific tanks

APPENDIX B3

TANK SX-109 TEMPERATURES JANUARY 1954 TO JUNE 1957

Figure B3-1. Tank SX-109 Temperature October to December 1955

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure B3-2. Tank SX-109 Temperature January to July 1956

Figure B3-3. Tank SX-109 Temperature July to December 1956

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure B3-4. Tank SX-109 Temperature January to June 1957

APPENDIX C3

TANK SX-109 TEMPERATURE JANUARY 1957 TO JANUARY 1968

Figure C3-1. RHO-CD-1172 Tank SX-109 Temperature January 1957 through July 1958

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C3-2. RHO-CD-1172 Tank SX-109 Temperature August 1958 through February 1960

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C3-3. RHO-CD-1172 Tank SX-109 Temperature March 1960 through September 1961

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C3-4. RHO-CD-1172 Tank SX-109 Temperature October 1961 through May 1963

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C3-5. RHO-CD-1172 Tank SX-109 Temperature December 1964 through June 1966

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C3-6. RHO-CD-1172 Tank SX-109 Temperature July 1966 through January 1968

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

APPENDIX D3

TANK SX-109 LATERAL ACTIVITY

Table D3-1. Tank SX-109 Lateral Radioactivity (counts per minute) (December 1962 through April 1989)
(Excerpts from RPP-ENV-39658, Rev. 0, and RPP-RPT-29191) (1 of 3 sheets)

Date	Reference	241-SX-109		
		44-09-01	44-09-02	44-09-03
12/62	A	No activity detected		
6/63	B	“Laterals under the 108-SX, 109-SX, 111-SX, 112-SX and 115-SX were monitored; no readings were obtained except under the 108-SX” No readings were found.		
7/63	C	“Continued checking of the laterals under the SX storage tanks. No change was detected.”		
8/63	D	“Continued checking of the laterals under the SX storage tanks. No change was detected.”		
9/63	E	“Continued checking of the laterals under the SX storage tanks. No change was detected.”		
10/63	F	“Continued checking of laterals, no change in readings noted.”		
11/63	G	“Continued checking of laterals, no change in readings noted.”		
12/63	H	“Continued checking of laterals, no significant change in readings noted.”		
1/64	I	“Continued with no significant changes noted.”		
2/64	J	“No changes noted except for a 550 c/m reading detected in the South lateral under the 114-SX Tank. Daily checking revealed no change at the end of the month.”		
1/30/65	WHC-MR-0300 Supplement 1	N/A ³	N/A ³	5 K
2/6/65	K page 28	“Tank 109-SX has been reported to give evidence of leakage, in addition to the three leak peaks now being monitored as above scale under 108-SX. New instrumentation to better monitor these tanks is being considered, since current measuring instruments are limited to 500 K.”		
2/20/65	K page 36	N/A ³	N/A ³	5 K
3/31/65	K page 65 WHC-MR-0300 Supplement 1	No activity detected	14.1 K	0.03 K at 18.5 ft ¹
4/29/65	K page 87	0.2 K	40 K	2 K at 18.5 ft ¹
9/1/65	K page 141		60 K to 65 K	N/A ³
9/15/65	K page 147		79 K	N/A ³
10/6/65	K page 156	57 K at 21.4 ft ¹	93 K at 21.5 ft ¹	90 K at 31.5 ft ¹
10/13/65	K page 159	58 K at 21.4 ft ¹	99 K at 21.5 ft ¹	90 K at 31.5 ft ¹
10/20/65	K page 162	63 K at 21.4 ft ¹	99 K at 21.5 ft ¹	99 K at 31.5 ft ¹
10/27/65	K page 165	“Lateral readings are continuing to show slight increase.”		
11/24/65	K page 177	Lateral readings under this tank appear to have leveled off this month.		
12/65	HAN-93551 page 14	25 K	40 K	55 K
12/22/65	K page 189	“No significant change in lateral readings during this report period.”		

Table D3-1. Tank SX-109 Lateral Radioactivity (counts per minute) (December 1962 through April 1989)
(Excerpts from RPP-ENV-39658, Rev. 0, and RPP-RPT-29191) (2 of 3 sheets)

Date	Reference	241-SX-109		
		44-09-01	44-09-02	44-09-03
1/31/66	L page 10	19.5 K	29 K	42 K
2/28/66	M page 11	24 K	50 K	130 K
3/31/66	N page 13	55.5 K	160 K	22 K
4/30/66	O page 13	30 K	57 K	not reported
5/31/66	P page 11	38 K	54 K	150 K
6/30/66	Q page 11	40 K	660 K ⁴	180 K
1/2/73	WHC-MR-0301	N/A ³	130 K at 70.5 ft ¹	N/A ³
2/2/73	WHC-MR-0301	16 K at 18.4 ft ¹	14 K	N/A ³
2/7/73	WHC-MR-0301	N/A ³	N/A ³	106.8 K at 30.5 ft ¹
5/21/73	WHC-MR-0301	N/A ³	N/A ³	143 K at 30.5 ft ¹
8/24/73	WHC-MR-0301	N/A ³	N/A ³	113 K at 30.5 ft ¹
9/14/73	WHC-MR-0301	20.8 K at 18.4 ft ¹	N/A ³	N/A ³
9/28/73	WHC-MR-0301	N/A ³	244 K at 65.5 ft ¹	N/A ³
12/31/73	WHC-MR-0301	15 K at 23.4 ft ¹	144 K at 65.5 ft ¹	N/A ³
4/29/74	WHC-MR-0301	17.4 K at 23.4 ft ¹	147 K at 60.5 ft ¹	N/A ³
5/8/74	WHC-MR-0301	N/A ³	N/A ³	105 K at 30.5 ft ¹
9/6/74	WHC-MR-0301	14.7 K at 23.4 ft ¹	127.5 K at 60.5 ft ¹	105 K at 30.5 ft ¹
2/5/75	WHC-MR-0301	71.4 K at 23.4 ft ¹	215 K at 60.5 ft ¹	190 K at 30.5 ft ¹
7/9/75	WHC-MR-0301	66 K at 23.4 ft ¹	210 K at 60.5 ft ¹	210 K at 30.5 ft ¹
10/1/75	WHC-MR-0301	64 K at 23.4 ft ¹	245 K at 60.5 ft ¹	225 K at 30.5 ft ¹
3/3/76	WHC-MR-0301	66 K at 23.4 ft ¹	240 K at 60.5 ft ¹	221 K at 30.5 ft ¹
2/2/77	WHC-MR-0301	130.5 K at 23.4 ft ^{1,2}	570 K at 60.5 ft ^{1,2}	480 K at 34.5 ft ^{1,2}
10/11/77	WHC-MR-0301	128 K at 23.4 ft ¹	564 K at 60.5 ft ¹	465 K at 34.5 ft ¹
7/11/78	WHC-MR-0301	135 K at 23.4 ft ¹	564 K at 60.5 ft ¹	495 K at 34.5 ft ¹
7/16/79	WHC-MR-0301	N/A ³	240 K at 60.5 ft ¹	N/A ³
8/1/79	WHC-MR-0301	129 K at 23.4 ft ¹	N/A ³	N/A ³
8/14/79	WHC-MR-0301	N/A ³	N/A ³	465 K at 34.5 ft ¹
7/14/80	WHC-MR-0301	108 K at 23.4 ft ¹	411 K at 60.5 ft ¹	420 K at 34.5 ft ¹
6/22/81	WHC-MR-0301	159 K at 23.4 ft ¹	455 K at 59.5 ft ¹	510 K at 32.5 ft ¹

Table D3-1. Tank SX-109 Lateral Radioactivity (counts per minute) (December 1962 through April 1989)
(Excerpts from RPP-ENV-39658, Rev. 0, and RPP-RPT-29191) (3 of 3 sheets)

Date	Reference	241-SX-109		
		44-09-01	44-09-02	44-09-03
7/26/82	WHC-MR-0301	165 K at 22.4 ft ¹	N/A ³	499 K at 31.5 ft ¹
6/14/83	WHC-MR-0301	154 K at 21.4 ft ¹	N/A ³	
7/9/84	WHC-MR-0301	137 K at 23.4 ft ¹	445 K at 60.5 ft ¹	430 K at 33.5 ft ¹
6/17/85	WHC-MR-0301	157 K at 21.4 ft ¹	492 K at 57.5 ft ¹ 80 K at 20.5 ft ¹	422 K at 30.5 ft ¹
4/10/86	WHC-MR-0301	N/A ³	480 K at 55.5 ft ¹ 250 K at 19.5 ft ¹	N/A ³
6/6/86	WHC-MR-0301	171 K at 20.4 ft ¹	500 K at 55.5 ft ¹ 280 K at 20.5 ft ¹	460 K at 30.5 ft ¹
1/22/87	WHC-MR-0301	156 K ~23 ft ¹	N/A ³	N/A ³
4/13/87	WHC-MR-0301	N/A ³	N/A ³	400 K ~33 ft ¹
6/19/87	WHC-MR-0301	169 K at 25.4 ft ¹	380 K at 61.5 ft ¹ 368 K at 24.5 ft ¹	440 K at 34.5 ft ¹
1/5/88	WHC-MR-0301	184.5 K at 25.4 ft ¹	531.6 K at 57.5 ft ¹	N/A ³
3/16/88	WHC-MR-0301	180 K ~23 ft ¹	460 K ~17 ft ¹	490 K at 35.5 ft ¹
10/26/88	WHC-MR-0301	168 K ~23 ft ¹	375 K ~17 ft ¹	400 K ~33 ft ¹
4/13/89	WHC-MR-0301	156 K at 25.4 ft ¹	464 K at 62.5 ft ¹ 412 K at 24.5 ft ¹	412 K at 32.5 ft ¹

¹Under northeast side of tank

²New monitoring equipment—red probe

³N/A: Data not available

⁴This reading appears to be an anomaly. Length was not specified at this reading nor a cause due to the change in the probe used, and no other readings were found until January 2, 1973.

Reference A is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation December 1962*, Rough Draft (Harmon 1963a)

Reference B is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation June 1963*, Rough Draft (Harmon 1963g)

Reference C is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation July 1963*, Rough Draft (Harmon 1963h)

Reference D is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation August 1963*, Rough Draft (Harmon 1963i)

Reference E is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation September 1963*, Rough Draft (Harmon 1963j)

Reference F is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation October 1963*, Rough Draft (Harmon 1963k)

Reference G is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation November 1963*, Rough Draft (Harmon 1963l)

Reference H is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation December 1963*, Rough Draft (Harmon 1963m)

Reference I is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation January 1964*, Rough Draft (Harmon 1964a)

Reference J is *Monthly Report Waste Handling and Decontamination Operation REDOX Operation February 1964*, Rough Draft (Harmon 1964b)

Reference K is RL-SEP-297, *REDOX Weekly Process Reports January through December, 1965*

Reference L is HAN-93855-1, 1966, *200 Area Monthly Report for January 1966*
Reference M is HAN-93855-2, 1966, *200 Area Monthly Report for February 1966*
Reference N is HAN-93855-3, 1966, *200 Area Monthly Report for March 1966*
Reference O is HAN-93855-4-DEL, 1966, *200 Area Monthly Report for April 1966*
Reference P is HAN-93855-5, 1966, *200 Area Monthly Report for May 1966*
Reference Q is HAN-93855-6-DEL, 1966, *200 Area Monthly Report for June 1966*

APPENDIX E3

TANK SX-109 GROSS GAMMA DRYWELL DATA

Table E3-1. Tank SX-109 Drywell Radioactivity (K counts per minute) (March 1969 to June 1987)
(Drywell Data Sheets Retrieved on March 8, 2011 and SD-WM-TI-356) (1 of 7 sheets)¹

41-09-02 ⁶			41-09-03 ⁷			41-09-04 ⁷			41-09-06 ⁸			41-09-07 ⁷			41-09-09 ⁹			41-09-11 ¹⁰		41-00-08 ¹¹		
Drilled 3/23/1962			Drilled 3/19/1962			Drilled 3/21/1962			Drilled 3/20/1962			Drilled 3/22/1962			Drilled 3/22/1962			Drilled 3/23/62		Drilled 3/14/1956		
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)
01/65	Sm. Amt ⁴	N/A ³	N/A ³			01/65	Sm. Amt ⁴	N/A ³	N/A ³			N/A ³			N/A ³			N/A ³		N/A ³		
2/28/65	130 ⁵	57	N/A ³			2/28/65	885 ⁵	57	N/A ³			N/A ³			N/A ³			N/A ³		N/A ³		
5/30/65	100 ⁵	57	N/A ³			5/30/65	900 ⁵	57	N/A ³			1/8/68	Present ¹²	N/A ³	1/2/68	Present ¹²	N/A ³	N/A ³		N/A ³		
3/24/69	238	59	3/27/69	890	64	3/27/69	2	58	3/24/69	61	64	N/A ³			3/24/69	205	64	3/20/69	< 50	3/24/69	95	72
							66	73		25	69					225	72				120	92
4/8/69	230	59	4/1/69	980	64	4/2/69	3	58	4/8/69	68	64	N/A ³			4/8/69	210	64	4/3/69	< 50	4/8/69	83	72
										26	69					175	72				128	92
5/5/69	155	59	5/6/69	1000	N/A ³	5/7/69	3	58	5/5/69	47	64	N/A ³			5/5/69	115	64	5/8/69	< 50	5/5/69	65	72
										19	69					110	72				80	92
6/12/69	135	59	6/11/69	980	64	6/11/69	2	58	6/18/69	37	64	N/A ³			6/12/69	140	64	N/A ³		6/12/69	58	72
										14	69					115	72				73	92
7/2/69	113	55	7/9/69	970	62	N/A ³			7/9/69	43	63	N/A ³			7/2/69	140	64	7/21/69	< 50	7/9/69	68	75
										15	67					115	72				81	90
8/7/69	110	62	8/8/69	>1000	63-66	N/A ³			8/22/69	29	64	N/A ³			8/12/69	135	64	8/21/69	< 50	8/5/69	67	70
										13	69					120	73				77	89
9/5/69	140	59	9/1/69	575	63	9/1/69	1.4	58	9/23/69	8	65	N/A ³			9/5/69	138	64	9/22/69	< 50	9/5/69	65	72
																120	72				82	91
10/3/69	115	60	10/2/69	975	N/A ³	10/2/69	3	58	N/A ³			N/A ³			10/3/69	135	64	10/17/69	< 50	10/2/69	61	73
							3	66								105	72				76	92
11/5/69	113	60	11/6/69	>1000	65	11/6/69	3.4	58	N/A ³			N/A ³			11/5/69	130	64	11/20/69	< 50	11/3/69	59	73
							3.2	66								103	72				73	92
12/3/69	120	60	12/1/69	940	64	12/1/69	3.4	58	N/A ³			N/A ³			12/3/69	138	64	12/22/69	< 50	12/3/69	85	79
							4.4	66								105	72				73	92
																					9	128

Table E3-1. Tank SX-109 Drywell Radioactivity (K counts per minute) (March 1969 to June 1987)
(Drywell Data Sheets Retrieved on March 8, 2011 and SD-WM-TI-356) (2 of 7 sheets)¹

41-09-02 ⁶			41-09-03 ⁷			41-09-04 ⁷			41-09-06 ⁸			41-09-07 ⁷			41-09-09 ⁹			41-09-11 ¹⁰		41-00-08 ¹¹		
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)
1/8/70	100	60	1/6/70	935	64	1/6/70	3.6	58	N/A ³	N/A ³	1/8/70	130	64	1/22/70	< 50	1/6/70	88	79		88	79	
							4.4	66				98	72				72	92				
							66	74									8	128				
2/2/70	103	59	2/3/70	975	64	2/4/70	3.4	58	N/A ³	N/A ³	2/2/70	143	64	2/24/70	< 50	2/2/70	96	78		64	91	
							6	66				100	72				8	128				
							70	74														
3/4/70	98	59	3/4/70	>1000	N/A ³	3/5/70	3.6	58	N/A ³	N/A ³	3/4/70	118	64	3/24/70	< 50	3/4/70	> 100	78		63	91	
							5.4	66				83	72				7	128				
							71	74														
4/1/70	> 100	59	4/9/70	985	64	4/9/70	13.8	58	N/A ³	4/24/70	10	66	4/1/70	128	64	4/27/70	< 50	4/8/70	98	78		
							5.2	66						>100	72				62	91		
							81	74											8	128		
5/3/70	99	60	5/1/70	>1000	64	5/1/70	4	58	N/A ³	5/1/70	12	66	5/3/70	120	65	5/19/70	< 50	5/3/70	103	78		
							5.7	66						96	72				62	91		
							77	74											9	128		
6/9/70	90	60	6/4/70	>1000	64	6/4/70	5.2	58	N/A ³	6/4/70	12	66	6/4/70	115	64	6/29/70	< 50	6/9/70	80	76		
							44	74						85	72				50	89		
																			7	125		
7/1/70	78	62	7/22/70	>1000	64	7/22/70	4	58	N/A ³	7/22/70	12	66	7/1/70	95	64	7/27/70	< 50	7/1/70	94	76		
							110	74						90	75				52	89		
8/4/70	75	62	8/3/70	690	64	8/3/70	10	59	N/A ³	8/3/70	23	66	8/11/70	90	64	8/24/70	< 50	8/4/70	98	76		
							17	65						73	72				50	89		
							165	74											10	125		

Table E3-1. Tank SX-109 Drywell Radioactivity (K counts per minute) (March 1969 to June 1987)
(Drywell Data Sheets Retrieved on March 8, 2011 and SD-WM-TI-356) (3 of 7 sheets)¹

41-09-02 ⁶			41-09-03 ⁷			41-09-04 ⁷			41-09-06 ⁸			41-09-07 ⁷			41-09-09 ⁹			41-09-11 ¹⁰		41-00-08 ¹¹		
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)
9/3/70	70	62	9/11/70	368	63	9/11/70	19	66	N/A ³	9/11/70	23	66	9/3/70	100	64	9/30/70	< 50	9/3/70	110	75		
							135	74						76	72				46	89		
																			8	125		
10/1/70	71	62	10/1/70	415	63	10/5/70	8	58	N/A ³	10/5/70	19	66	10/1/70	90	64	10/20/70	< 50	10/1/70	95	76		
							22	66						64	72				9	125		
							50	74														
11/4/70	65	62	11/3/70	950	63	11/3/70	17	66	N/A ³	11/3/70	22	66	11/4/70	88	65	N/A ³		11/4/70	95	76		
							162	74						13	75				9	125		
12/10/70	61	62	12/10/70	550	64	12/11/70	8	66	N/A ³	12/11/70	9	66	12/10/70	100	65	12/29/70	< 50	12/10/70	125	76		
							63	74											8	125		
1/6/71	58	60	1/5/71	540	64	1/5/71	10	66	N/A ³	1/5/71	9	66	1/6/71	105	64	1/18/71	< 50	1/6/71	123	76		
							66	74						56	71				10	125		
2/5/71	55	60	2/3/71	945	64	2/11/71	12	58	N/A ³	2/3/71	27	66	2/5/71	108	64	N/A ³		2/5/71	135	76		
							33	66						50	71				10	125		
							200	74														
3/4/71	43	60	3/1/71	940	64	3/1/71	11	58	N/A ³	3/1/71	32	66	3/4/71	89	64	3/29/71	< 50	3/4/71	90	76		
							33	66						42	71				7	125		
							198	74														
N/A ³			4/12/71	945	64	4/12/71	14	58	N/A ³	4/12/71	28	66	4/13/71	86	64	N/A ³		4/12/71	105	76		
							34	66						38	71				15	125		
							190	74														
N/A ³			5/24/71	950	64	5/24/71	13	58	N/A ³	5/24/71	30	66	5/24/71	73	64	5/3/71	< 50	5/5/71	85	76		
							37	66						33	71				8	125		
							200	74														

**Table E3-1. Tank SX-109 Drywell Radioactivity (K counts per minute) (March 1969 to June 1987)
(Drywell Data Sheets Retrieved on March 8, 2011 and SD-WM-TI-356) (4 of 7 sheets)¹**

41-09-02 ⁶			41-09-03 ⁷			41-09-04 ⁷			41-09-06 ⁸			41-09-07 ⁷			41-09-09 ⁹			41-09-11 ¹⁰		41-00-08 ¹¹		
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)
N/A ³	6/3/71	945	64	6/16/71	14	58	N/A ³	6/3/71	30	66	6/3/71	82	64	N/A ³	6/3/71	115	76					
					38	66						33	71			10	125					
					203	74																
N/A ³	7/9/71	945	64	7/9/71	15	58	N/A ³	7/9/71	33	66	7/9/71	87	65	7/29/71	< 50	7/9/71	120	76				
					41	66						33	71				8	125				
					210	74																
N/A ³	8/2/71	955	64	8/2/71	15	58	N/A ³	8/2/71	24	66	8/2/71	86	64	8/18/71	< 50	8/2/71	118	76				
					41	66						32	71				7	125				
					200	74																
N/A ³	9/10/71	875	64	9/10/71	15	58	N/A ³	9/10/71	30	66	9/8/71	90	64	9/28/71	< 50	9/7/71	110	76				
					41	66						32	71				7	125				
					215	74																
N/A ³	10/6/71	870	64	10/6/71	17	58	N/A ³	10/6/71	30	66	10/4/71	80	64	10/22/71	< 50	10/4/71	95	76				
					37	66						28	71				7	125				
					208	74																
N/A ³	11/1/71	745	64	11/1/71	13	58	N/A ³	11/1/71	28	66	11/2/71	70	64	11/15/71	< 50	11/2/71	115	76				
					44	66						30	71				5	125				
					200	74																
N/A ³	12/3/71	545	64	12/3/71	5	58	N/A ³	12/3/71	14	66	12/2/71	81	64	12/15/71	< 50	12/2/71	118	76				
					19	66						30	71				10	125				
					90	74																
N/A ³	1/4/72	505	63	1/4/72	55	58	N/A ³	1/4/72	12	66	1/4/72	80	64	N/A ³	1/4/72	118	76					
					18	66						26	71				10	125				
					100	74																

**Table E3-1. Tank SX-109 Drywell Radioactivity (K counts per minute) (March 1969 to June 1987)
(Drywell Data Sheets Retrieved on March 8, 2011 and SD-WM-TI-356) (5 of 7 sheets)¹**

41-09-02 ⁶			41-09-03 ⁷			41-09-04 ⁷			41-09-06 ⁸			41-09-07 ⁷			41-09-09 ⁹			41-09-11 ¹⁰		41-00-08 ¹¹		
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)
N/A ³			N/A ³			2/2/72	192	74	N/A ³			2/3/72	13	66	2/7/72	77	64	2/14/72	< 50	2/7/72	105	76
																23	71				10	125
N/A ³			N/A ³			N/A ³			N/A ³			3/1/72	14	66	3/13/72	76	64	N/A ³		3/13/72	90	76
																					5	125
N/A ³			N/A ³			N/A ³			N/A ³			4/11/72	17	66	4/18/72	76	64	N/A ³		4/10/72	95	76
																					5	125
N/A ³			N/A ³			N/A ³			N/A ³			5/5/72	17	66	5/4/72	76	64	N/A ³		5/4/72	103	76
																					7	125
N/A ³			N/A ³			N/A ³			N/A ³			6/1/72	18	66	6/1/72	75	64	N/A ³		6/1/72	118	76
																					5	125
N/A ³			N/A ³			N/A ³			N/A ³			7/3/72	5	66	7/3/72	76	65	N/A ³		7/3/72	103	76
																					8	125
N/A ³			N/A ³			N/A ³			N/A ³			8/1/72	5	66	8/15/72	80	65	N/A ³		8/15/72	115	76
																					3	125
N/A ³			N/A ³			N/A ³			N/A ³			9/20/72	29	66	9/7/72	72	65	N/A ³		9/7/72	95	75
																					9	125
N/A ³			N/A ³			N/A ³			N/A ³			10/2/72	22	66	10/2/72	64	65	N/A ³		10/10/72	90	75
																					5	125
N/A ³			N/A ³			N/A ³			N/A ³			11/6/72	21	66	11/6/72	78	65	N/A ³		11/10/72	105	75
																					8	120
N/A ³			N/A ³			N/A ³			N/A ³			12/19/72	24	66	12/7/72	40	65	N/A ³		12/7/72	81	75
																					6	120
N/A ³			1/30/73	755	64	N/A ³			N/A ³			N/A ³			1/2/73	34	65	N/A ³		1/8/73	78	75
																					2	120

**Table E3-1. Tank SX-109 Drywell Radioactivity (K counts per minute) (March 1969 to June 1987)
(Drywell Data Sheets Retrieved on March 8, 2011 and SD-WM-TI-356) (6 of 7 sheets)¹**

41-09-02 ⁶			41-09-03 ⁷			41-09-04 ⁷			41-09-06 ⁸			41-09-07 ⁷			41-09-09 ⁹			41-09-11 ¹⁰		41-00-08 ¹¹		
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)
N/A ³			N/A ³			2/21/73	420	74	N/A ³			N/A ³			2/5/73	43	65	N/A ³		2/15/73	72	75
																					4	120
N/A ³			N/A ³			N/A ³			N/A ³			N/A ³			3/7/73	61	65	N/A ³		3/7/73	88	75
																					13	120
N/A ³			N/A ³			N/A ³			N/A ³			4/3/73	8	66	4/2/73	52	65	N/A ³		4/2/73	70	75
																					9	120
N/A ³			N/A ³			N/A ³			N/A ³			N/A ³			5/2/73	59	65	N/A ³		5/2/73	95	75
																					10	120
N/A ³			6/18/73	675	64	N/A ³			N/A ³			N/A ³			6/5/73	64	65	N/A ³		6/5/73	54	75
																					8	120
N/A ³			N/A ³			N/A ³			N/A ³			N/A ³			6/12/73	36	65	7/13/73	< 12	7/2/73	115	75
																					10	122
N/A ³			N/A ³			N/A ³			N/A ³			N/A ³			N/A ³			N/A ³		8/8/73	88	73
9/13/73	19	57	9/13/73	705	60	9/13/73	580	82	9/13/73	< 15	N/A ³	9/12/73	46	61	9/16/73	79	61	N/A ³		9/18/73	140	76
4/10/74	16	58	4/18/74	700	70	4/18/74	365	82	4/10/74	< 12	N/A ³	4/18/74	45	66	4/16/74	74	63	4/10/74	< 12	4/16/74	140	76
7/24/74	12	58	5/31/74	845	66	N/A ³			N/A ³			N/A ³			N/A ³			N/A ³		N/A ³		
8/1/74	5 ²	60	8/30/74	946	66	8/15/74	521 ²	81	7/10/74	< 12	N/A ³	8/15/74	25	66	7/12/74	16 ²	66	7/23/74	< 12	7/24/74	80	79
1/23/75	3	59	1/29/75	1121 ²	64	N/A ³			7/17/74	< 3	N/A ³	N/A ³			N/A ³			7/30/74	< 3 ²	7/30/74	34 ²	77
N/A ³			N/A ³			2/6/75	559	81	1/23/75	< 3	N/A ³	2/6/75	27	66	1/23/75	16	63	1/23/75	< 3	1/22/75	33	78
7/22/75	3	62	7/9/75	975	63	7/9/75	552	80	7/22/75	< 3	N/A ³	7/16/75	28	66	7/22/75	16	65	7/22/75	< 3	7/22/75	26	76
4/6/76	< 3	N/A ³	4/6/76	983	64	4/6/76	574	80	4/9/76	< 3	N/A ³	4/6/76	32	67	4/9/76	19	62	4/6/76	< 3	7/7/76	31	77
N/A ³			10/5/76	1201	62	N/A ³			N/A ³			N/A ³			N/A ³			N/A ³		N/A ³		
8/16/77	< 3	N/A ³	8/2/77	1256	62	5/5/77	713	79	N/A ³			N/A ³			N/A ³			N/A ³		N/A ³		
N/A ³			N/A ³			6/7/77	617	80	N/A ³			N/A ³			N/A ³			N/A ³		N/A ³		

Table E3-1. Tank SX-109 Drywell Radioactivity (K counts per minute) (March 1969 to June 1987)
(Drywell Data Sheets Retrieved on March 8, 2011 and SD-WM-TI-356) (7 of 7 sheets)¹

41-09-02 ⁶			41-09-03 ⁷			41-09-04 ⁷			41-09-06 ⁸			41-09-07 ⁷			41-09-09 ⁹			41-09-11 ¹⁰		41-00-08 ¹¹		
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)
N/A ³			N/A ³			8/2/77	740	79	8/3/77	< 3	N/A ³	8/2/77	32	63	8/3/77	12	63	8/3/77	< 3	8/2/77	27	75
N/A ³			3/7/78	1090	62	3/7/78	731	79	N/A ³			3/7/78	42 ²	64	N/A ³			N/A ³		N/A ³		
N/A ³			4/4/78	378 ²	62	4/4/78	255 ²	79	N/A ³			4/4/78	10	64	N/A ³			N/A ³		N/A ³		
7/18/78	< 3	N/A ³	7/4/78	384	62	9/12/78	257	79	7/4/78	< 3	N/A ³	7/4/78	11	64	7/4/78	13	63	7/18/78	< 3	7/3/78	33	79
7/17/79	< 3	N/A ³	7/16/79	383	63	7/16/79	263	80	7/17/79	< 3	N/A ³	8/13/79	17	65	7/2/79	14	63	7/19/79	< 3	7/16/79	25	74
																3	70					
7/15/80	< 3	N/A ³	7/14/80	403	61	7/14/80	281	78	7/15/80	< 3	N/A ³	7/14/80	11	63	7/14/80	16	62	7/14/80	< 3	7/14/80	32	75
																3	70					
6/16/81	< 3	N/A ³	6/15/81	371	63	6/15/81	255	80	6/18/81	< 3	N/A ³	6/15/81	18	65	6/15/81	16	63	6/30/81	< 3	6/15/81	27	77
																8	71					
7/29/82	< 3	N/A ³	7/26/82	411	64	7/26/82	285	80	8/2/82	< 3	N/A ³	7/26/82	16	66	7/27/82	18	62	7/27/82	< 3	7/27/82	31	76
																28	72					
N/A ³			N/A ³			N/A ³			N/A ³			N/A ³			10/19/82	11	64	N/A ³		N/A ³		
																39	72					
6/27/83	< 3	N/A ³	6/14/83	394	64	N/A ³			6/23/83	< 3	N/A ³	6/15/83	19	66	6/23/83	13	65	6/27/83	< 3	6/23/83	22	77
																81	72					
7/9/84	< 3	N/A ³	7/9/84	382	64	N/A ³			7/9/84	< 3	N/A ³	7/9/84	18	66	7/9/84	13	65	7/9/84	< 3	6/12/84	20	77
																197	72					
4/29/85	< 3	N/A ³	6/11/85	384	65	N/A ³			6/11/85	< 3	N/A ³	6/11/85	18	67	6/11/85	12	66	4/30/85	< 3	6/11/85	20	78
																406	73					
6/24/86	< 3	N/A ³	6/24/86	357	65	N/A ³			6/24/86	< 3	N/A ³	6/24/86	21	67	6/24/86	14	65	6/24/86	< 3	6/9/86	27	78
																742	74				6	68
5/27/87	< 3	N/A ³	6/25/87	365	65	N/A ³			6/24/87	< 3	N/A ³	6/25/87	23	67	6/24/87	14	66	5/27/87	< 3	7/9/87	29	78
																1401	74				7	68

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- Note:
- ¹If Depths were not available; the column was omitted from the table
 - ²New Monitoring Equipment
 - ³N/A: Data not available
 - ⁴Sm. Amt: "Small amount" as referenced from WHC-MR-0300, Supplement 1 of 5, Ref. 18
 - ⁵Referenced from WHC-MR-0300, Ref. 19-17 and 19-21
 - ⁶Readings were recorded using the Scintillation Probe (SP) from March 1969 to March 1971. GMP used for the remainder of the data.
 - ⁷All readings were recorded using the GMP
 - ⁸Readings were recorded using the SP in 1969. GMP used for the remainder of the data.
 - ⁹Readings were recorded using the SP from March 1969 to April 1974. GMP used for the remainder of the data.
 - ¹⁰Readings were recorded using the SP from March 1969 to February 1972. GMP used for the remainder of the data.
 - ¹¹Readings were recorded using the SP from March 1969 to September 1973. GMP used for the remainder of the data.
 - ¹²Referenced from Tank SX-109 Drywell Strip Charts

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7.1 TANK SX-111 BACKGROUND HISTORY

This section provides information on the historical waste loss event associated with SST 241-SX-111 (SX-111). Tank SX-111 has three laterals installed in 1963 about 10-ft under the tank (see Figure 7-1). There are seven drywells located around tank SX-111: 41-11-02, 41-11-03, 41-11-05, 41-11-06, 41-11-08, 41-11-09 installed in 1962, and 41-11-10 installed in 1956.

The top of the tank footing is 53-ft BGS with about 6-ft 6-in soil cover over the dome (WHC-SD-WM-TI-665). Inside tank SX-111 there are four ALCs 18-in above the tank bottom and equally spaced on a 40-ft diameter circle as shown in Figure 7-1 (H-2-39951). Two ALCs are designated low ALCs (8-ft 6-in tall) and two are high ALCs (13-ft 6-in tall) (H-2-9950).

Figure 7-1. Tank SX-111 Drywell and Laterals

Tank inner ring is steel liner, outer ring is outer edge of tank footing

7.2 TANK SX-111 OPERATIONS SUMMARY

Tank SX-111 was constructed from 1953 to 1954 and sat unused until June 9, 1956 when the tank initially received 123 kgal of REDOX HLW from the REDOX Facility (HW-43895, *Separations Section Waste Status Summary for June 1956*, page 8; HWN-1991, *Chemical Processing Division - Waste Storage and Experience*, page 51). Normally tanks receiving boiling waste were preheated prior to use to minimize transfer stresses. However, tanks in SX Farm were not fitted with steam coils and tank SX-111 was not preheated prior to use. Waste temperatures rose from a conservative assumed ambient temperature of 55°F on June 9, 1956 to ~158°F by June 27, 1956 (see Figure B4).

Tank SX-111 continued to receive REDOX HLW until November 1956. When the waste volume in tank SX-111 reached 994 kgal, waste began to cascade into tank SX-112 on October 27, 1956 (HW-46382, *Chemical Processing Department Waste – Status Summary October 1, 1956 – October 31, 1956*, page 8). Self-concentration started November 1956 and no waste was added or removed through September 1958 supported by the ~196°F to ~260°F temperature readings (see Appendix B4). A total of 392 kgal of condensate was evaporated from tank SX-111 from November 1956 through September 1958 leaving ~631 kgal of waste in this tank (HW-57711, *Chemical Processing Department Waste Status Summary September 1, 1958 – September 30, 1958*, page 8).

In October 1958, 60 kgal of the concentrated REDOX HLW supernatant was transferred from tank SX-111 to tank U-102 (HW-58201, *Chemical Processing Department Waste Status Summary October 1, 1958 – October 31, 1958*, page 8). An additional 465 kgal of waste were transferred from tank SX-111 into tanks U-102 and U-103 in November 1958 (HW-58579, *Chemical Processing Department Waste Status Summary November 1, 1958 – November 30, 1958*, page 8) and 1 kgal to tank U-103 in December 1958 (HW-58831, *Chemical Processing Department Waste Status Summary December 1, 1958 – December 31, 1958*, page 8). These transfers left an estimated 29 kgal of sludge and 76 kgal of supernatant in tank SX-111.

In January 1959, REDOX HLW was again routed to tank SX-111 (HW-59204, *Chemical Processing Department Waste Status Summary January 1, 1959- January 31, 1959*, page 8) through December 1959 (HW-63559, *Chemical Processing Dept Waste Status Summary for 12/1/1959 through 12/31/1959*, page 8). Approximately 233 kgal of REDOX supernatant were also transferred from tank SX-112 to tank SX-111 from January to March 1960. Waste temperatures reached 211°F in May 1959 with self-boiling of the waste commencing and continuing through March 1964 (HW-60738, *Chemical Processing Department Waste Status Summary May 1, 1959 – May 31, 1959*; HW-83906-E-RD, *Chemical Processing Department 200 West Area Tank Farm Inventory and Waste Reports July 1961 Through 1966*, page 50).

Approximately 21 kgal of condensate were transferred from tank SX-106 into tank SX-111 in April 1960 (HW-65272, *Chemical Processing Department Waste Status Summary April 1 – 30, 1960*, page 8), 45 kgal in May 1960 (HW-65643, *Chemical Processing Department Waste Status Summary May 1 – 31, 1960*, page 8), and 10 kgal, along with 43 kgal of water, in June 1960 (HW-66187, *Chemical Processing Department – Waste Status Summary, June 1, 1960 – June 30, 1960*, page 8). An additional 149 kgal of water were added to tank SX-111 from

July 1960 (HW-66557, *Chemical Processing Department Waste Status Summary, July 1, 1960 – July 31, 1960*, page 8) through January 1961 (HW-83906-D-RD, *Chemical Processing Department 200 West Area Tank Farm Inventory and Waste Reports January 1959 Through June 1961*, page 193). Approximately 91 kgal of condensate were transferred from tank SX-106 into tank SX-111 in January and February 1962 (HW-83906-E-RD, page 14). These additions of condensate and water were conducted to maintain the waste density and temperature within operating limits.

In March 1964, 484 kgal of REDOX HLW supernatant and ~52 kgal of dilution water were transferred from tank SX-111 to tank SX-103 leaving ~108 kgal of waste in tank SX-111 (HW-83906-E-RD, page 50; HW-80202, *REDOX Weekly Process Reports January through December, 1964*, No. 626). In March and April 1964, 203 kgal of condensate were transferred from tank SX-106 to tank SX-111 (HW-83906-E-RD, page 49) to leach sodium nitrate from the REDOX sludge. Sodium nitrate was leached from REDOX sludge for reuse in the 202-S REDOX Plant, and ~202 kgal of REDOX nitrate waste were transferred from tank SX-111 into tank SX-105 on June 25, 1964, leaving an estimated 123 kgal of waste in tank SX-111 (HW-83906-E-RD, page 49; HW-80202, No. 638).

After nitrate leaching, tank SX-111 was not filled for approximately six months until December 23, 1964 when it began its third filling with REDOX HLW and received ~89 kgal by month end (HW-80202, No. 665; HW-83903-E-RD, page 56a and 60). Tank SX-111 rapidly reached boiling conditions on January 2, 1965 (RL-SEP-297, *REDOX Weekly Process Reports January through December, 1965*). From January to October 1965, tank SX-111 received a total of 1,128 kgal of REDOX HLW (HW-83906-E-RD pages 62a, 62b, 62c, 68a, 68b, and 75). Waste temperatures continued to increase reaching 258°F and 292°F in September 1965, prompting air sparging of the tank contents all day September 9, 1965 to aid in cooling (RL-SEP-297, No. 702). Continuous water addition to tank SX-111 was started on September 19, 1965 (RL-SEP-297, No. 703) to further reduce the waste temperature. Water additions to this tank were as follows:

March 1965:	35 kgal condensate (HW-83906-E-RD, page 62b)
September 1965:	~54 kgal (HW-83906-E-RD, page 68b).
Oct – Dec 1965:	~274 kgal (HW-83906-E-RD, pages 75 and 76)
April – June 1966:	123 kgal (HW-83906-E-RD, page 83)
July – Sept 1966:	199 kgal (ISO-538, page 8)
Oct – Dec 1966:	179 kgal (ISO-674, page 8)

Average evaporation rate was ~1-gpm over the time period, which was routed to a crib. Waste temperatures remained elevated and temperatures reached ~320°F by January 1968 (see Appendix C4).

Tank SX-111 received 145 kgal of REDOX HLW supernatant from tank SX-107 in 1968 (ARH-871, *Chemical Processing Division Waste Status Summary July 1, 1968 Through September 30, 1968*, page 9) and 111 kgal from tank SX-112 in 1969 (ARH-1200 A, *Chemical Processing Division Waste Status Summary January 1, 1969 through March 31, 1969*, page 10). These transfers were made as a result of suspected waste leakage from tanks SX-107 and

SX-112. No further waste additions were made to tank SX-111 for the remainder of 1969 until 1971.

In 1971, all REDOX HLW supernatant from tank SX-111 were transferred to tank SX-102 (ARH-2074 C, *Chemical Processing Division Waste Status Summary July 1, 1971 Through September 30, 1971*, page 10; ARH-2074 D, *Chemical Processing Division Waste Status Summary October 1, 1971 Through December 31, 1971*, page 10). This supernatant was then processed in B Plant for separation of cesium, and then referred to as REDOX ion exchange (RIX) waste. In the fourth quarter of 1971, tank SX-111 received 790 kgal of RIX waste from tank SX-105 and 170 kgal of non-boiling REDOX HLW supernatant from tank SX-106. It appears tank SX-111 continued to evaporate waste after 1971 due to declining liquid levels. On May 3, 1974 waste temperatures were ~218°F (RL Occurrence Report 74-38, *Symptoms of leakage from an underground waste tank-111-SX*).

On May 4, 1974, it was determined that tank SX-111 was leaking waste based on a liquid level decline and an increase in radioactivity detected in lateral 44-11-02 beginning April 30, 1974. The RIX and non-boiling REDOX HLW were transferred out of tank SX-111 to tanks S-107 (757 kgal) and SX-105 (2 kgal) (ARH-CD-133B, *Operations Division Waste Status Summary April 1, 1974 through June 30, 1974*, page 8; RL Occurrence Report 74-38).

A saltwell was installed in tank SX-111 on May 20, 1974 and pumping of the interstitial liquid from the saltwell was periodically attempted until January 1979. Tank SX-111 was declared interim stabilized in January 1979 based on January 3, 1979 in-tank photographs which estimated the waste surface to be 99% dry solids and to contain ~50 gal of supernatant. Pictures taken in March 1987 indicate no supernatant present in the tank.

The operational history of tank SX-111 leak related details including temperature and liquid level is charted in Figure 7-2.

Figure 7-2. Operational Leak History of Tank SX-111

7.3 TANK DESIGN/CONSTRUCTION

7.3.1 Tank Design

The SX Farm tanks had multiple design features that could contribute to stresses or possible leak paths when the tank was being operated including:

- Orthogonal intersection between the steel bottom and the sidewall
- Fillet weld used between the bottom and sidewall intersection
- Less rigorous weld inspection testing
- Partial asphaltic membrane waterproofing
- Keyed construction joints in the sidewall

These features are common to all SX Farm tanks and additional details are discussed in Section 3.1.1.

7.3.2 Tank Construction Conditions

The outside temperature between January 16, 1954 and January 30, 1954 ranged from an average high of 24°F to an average low of 9°F. A picture of the SX Farm under construction (see Figure 3-4) taken January 20, 1954 (high 11°F low -6°F), shows several of the tanks full of water either undergoing leak testing or for concrete wall pouring. During this cold period snow covered ice is seen in the water filled tanks.

As described in Section 3.1.2, cold weather affects the ductile-to-brittle steel transition temperature, with 18°F being the assumed unrestricted low temperature construction limitation for the carbon steel liner, which could result in a fracture upon impact. Low temperatures experienced during construction at or less than the 18°F allowable temperature could cause impact loading (e.g. a dropped tool or piece of equipment from scaffolding) and result in the potential for creating micro-fissures weakening the steel liner.

7.4 TANK SX-111 IN-TANK DATA

7.4.1 Liquid Level

The tank SX-111 liquid level declined an average of 73.2 gal/day from March 4 to April 4, 1974 (from 329-in to 327.15-in) which was shown to be due to evaporation (Internal Letter ARHC-051574, "111-SX Tank Leak"). However, the average liquid loss rate for tank SX-111 increased to 176.8 gal per day from April 7 to May 4, 1974 (from 327-in to 325.2-in) (Internal Letter ARHC-051574). The rate of liquid level lost increased by 103.6 gal/day during these 27 days, likely as a result of the tank leak. It is interesting to note that lateral 44-11-02 first indicated radioactivity April 30, 1974 (see Section 7.5.1).

The liquid level plot in Figure 7-3 indicates the transfer activity into and out of tank SX-111. The liquid levels are end of quarter levels so this figure may not reflect all significant transfers into and out of the tank that occurred during the operational history of the tank. See Figure 7-2 for historical monthly liquid level readings.

Figure 7-3. Tank SX-111 End of Quarter Surface Level

WHC-SD-WM-ER-352, Rev 0, June 30, 1994, Historical Tank Content Estimate for the Southwest Quadrant of the Hanford 200 West Area

7.4.2 Temperature

Tank SX-111 was not preheated prior to the initial filling of waste on June 9, 1956 (HWN-1991-DEL). Temperatures quickly rose to ~136°F 11 days later from a conservative assumed ambient ground temperature of 55°F and continued to increase to an equivalent boiling temperature of 240°F in October 1956. The remaining available thermal history for tank SX-111 starts in August 1956 and is shown in Figure 7-2 (see Appendix B4 and Appendix C4).

After initially receiving waste, the waste temperature leveled off at ~260°F due to self-evaporation and slowly decreased to ~196°F in October 1958 (HW-58201 page 8). In May 1959 supernatant temperatures reached ~211°F due to the second loading of REDOX HLW and reached slightly above 300°F in 1960. Self-boiling commenced continuing through March 1964. Supernatant temperatures gradually declined until January 1965 when the third filling of REDOX HLW began in December 1964. Waste temperatures were difficult to control during this time and were near or slightly above 300°F throughout most of the months between 1965 and 1968. Maximum waste temperature reached 320°F January 1968 (see Section 7.7.2) and stayed near this temperature until September 1968. Temperatures gradually declined to about

275°F by December 1968, then slowly increased to above 300°F from February to May 1969, and then slowly declined after that (see Figure 7-2). No temperatures are available after January 1970 until September 1974. Temperatures from September 1974 through September 1977 remained around 200°F. Tank SX-111 waste temperatures ranged from 100°F to 200°F from 1981 to the present (see PCSACS).

7.4.3 Liner Observations

Documents RHO-R-39 and ARH-R-43, Rev. 2, contain tables that do not list a bulge in the tank SX-111 liner (see Appendix A4). The photographs of tank SX-111 indicate it is possible a bulge was present at one time due to the presence of failed ALCs (see Section 7.4.5).

No other liner observations relating to a tank SX-111 leak have been found.

7.4.4 Chemistry-Corrosion

Waste Chemistry

Tank SX-111 began receiving REDOX HLW (R) in June 1956 and mostly stored only this waste type throughout operation except for an addition of RIX waste in 1972 (see Table 7-1). The typical concentrations for nitrite, nitrate, and hydroxide for these waste types are shown in Table 7-2. Nitrite and hydroxide are known as nitrate-induced SCC inhibitors. One key characteristic for inhibiting SCC is to maintain a high nitrite concentration to nitrate concentration ratio (see Section 3.2.4).

Table 7-1. Tank SX-111 Waste Storage Chronology

Date	Waste Type	Length of Storage
June 1956 to March 1964	REDOX HLW	~ 8 years
December 1964 to 1971	REDOX HLW	~ 7 years
1972-1974	RIX	~ 2 years

Table 7-2. Waste Chemistries for Waste Types Stored in Tank SX-107

Waste Type	[NO ₃] ¹	[NO ₂] ¹	[OH] ¹	Meets Current DST Specification ²
RIX ¹	1.97	0.27	0.69	Yes
R ³	4.83	0.74		No ⁴

- Reference WHC-EP-0449, 1991, *The Sort on Radioactive Waste Type Model: A Method to Sort Single-Shell Tanks into Characteristic Groups*.
- Reference OSD-T-151-00007, Rev. 12, (2013), *Operating Specifications for the Double-Shell Storage Tanks*.
- Reference WHC-EP-0772, 1994, *Characterization of the Corrosion Behavior of the Carbon Steel Liner in Hanford Site Single-Shell Tanks*.
- Does not meet the current DST specification since the hydroxide and nitrite concentrations are not greater than or equal to 1.2M.

Tank SX-111 stored mostly REDOX HLW throughout operation for approximately 15 years total. REDOX HLW does not meet the current DST specification for waste chemistry due to low concentrations of the nitrate-induced SCC inhibitors, nitrite and hydroxide. Thus, these

conditions of the REDOX HLW would likely create an environment conducive to SCC and/or pitting (see Section 3.2.4). Tank SX-111 also received ~790 kgal of RIX waste in 1972. Storing RIX waste should not have resulted in pitting or SCC of the tank liner.

Nitrate Leaching

The review of operating transactions in separate documents covering weekly and monthly reports for June 1964 (see Section 7.2) indicated there was sodium nitrate sludge leaching of the waste in tank SX-111. Document RHO-R-39, however, listed tank SX-111 sludge not having been sodium nitrate leached. It seems more likely that the weekly and monthly reports recorded at the time of the sludge leaching were the more accurate sources of information.

In the first quarter of 1964, supernatant was pumped out of tank SX-111. The sodium nitrate leaching process began March 1964 (see Table 7-3) and temperatures ranged from 185°F to 240°F during this period. The sodium nitrate leachate waste was transferred to tank SX-105 in June 1964 leaving a heel of 123 kgal in tank SX-111. REDOX HLW was transferred into tank SX-111 six months later in December 1964. Tank SX-111 was first suspected of leaking approximately ten years later when radioactivity was detected in lateral 44-11-02 between April 19 and May 1, 1974 along with a decreasing liquid level.

Table 7-3. Tank SX-111 Nitrate Leaching Chronology

Date	Transfers/Comments	Duration	Reference
March 1964	Transferred 484 kgal supernatant from tank SX-111 to tank SX-102 leaving a 108 kgal heel	N/A	HW-80202 #626
March/April 1964	Transferred 203 kgal condensate to tank SX-111 from tank SX-106	N/A	HW-83906-E pg 49
June 25, 1964	Transfer nitrate leachate waste from SX-111 to SX-105 leaving a 123 kgal heel	Leached for 3 months	HW-83906-E pg 49
December 23, 1964	Transferred ~89 kgal REDOX HLW to SX-111 from	Nitrate leachate heel stored 6 mo	HW-80202 #665
April 1974	Earliest indication of a tank SX-111 leak	10 years from start of leaching	Current analysis

As discussed in Section 3.2.4, sodium nitrate leaching reduces nitrite and hydroxide concentrations which would increase the propensity for corrosion especially at the relatively high temperatures experienced in tank SX-111.

7.4.5 Photographs

Photographs were taken on May 24, 1974 at the start of saltwell pumping; however, no tank leak observations have been documented pertaining to these or other photographs. Photographs taken May 24, 1974 were reviewed and photographs of an ALC with a turnbuckle guy rod hanging free and an ALC with broken and bent piping are shown in Figure 7-4 and Figure 7-5, respectively. Figure 7-4 shows ALC #1 with a turnbuckle guy rod hanging free in the northeast quadrant of

the tank and Figure 7-5 shows ALC #3 with bent and broken piping in the southwest quadrant of the tank.

The locations of all ALCs in tank SX-111 are shown in Figure 7-6 with the two ALCs (#1 and #3) located in the tank possibly showing evidence of a liner bulge. These are the only ALCs that have visible detached turnbuckle guy rods during this time. This may be evidence of a liner bulge that could have resulted in failure of the turnbuckle guy rod bottom liner attachment. However, detachment of the ½-in diameter turnbuckle guy rod as well as bent piping could also be the result of mixing the waste when the ALCs were operating with the resulting forces on internal equipment.

**Figure 7-4. Tank SX-111 ALC #1 Photograph 743521-20CN
May 24, 1974**

**Figure 7-5. Tank SX-111 ALC #3 Photograph 743521-27CN
May 24, 1974**

Figure 7-6. Tank SX-111 Air Lift Circulator Locations
 Tank inner ring is steel liner, outer ring is outer edge of tank footing

7.5 TANK SX-111 EX-TANK DATA

7.5.1 Laterals

The laterals under tank SX-111 were installed in 1963 and the first recoverable data reported no radioactivity in lateral 44-11-02 (no data was reported for laterals 44-11-01 and 44-11-03) on February 27, 1973 (see Table D4). On April 26, 1974 no radioactivity was reported any of the tank SX-111 laterals.

The first indication of a leak in tank SX-111 was reported at the end of April 1974, when radioactivity was reported in lateral 44-11-02 (RHO-CD-213, *Waste Storage Tank Status and Leak Detection Criteria 200 East area*). On April 30, 1974, radioactivity at 0.1K cpm was detected in lateral 44-11-02 at a calculated position of ~23-ft under tank SX-111 from southeast

edge (RHO-CD-213). This coincided with an increased liquid level decline observed April 7, 1974 to May 4, 1974 as discussed in Section 7.4.1. After initial detection of the leak in April 1974, radioactivity levels gradually increased throughout the rest of 1974 in lateral 44-11-02, and tank SX-111 was declared a confirmed leaker in May 1974. On May 21, 1974 a peak in lateral 44-11-02 was recorded at ~28-ft under the tank from the southeast edge of 1.5K cpm possibly due to migration of the earlier leak which gradually increased to 11.4K cpm by November 18, 1974 at ~28-ft from the southeast edge of the tank. Radioactivity levels remained steady until March 3, 1977 when a sudden increase occurred to 60K cpm at ~30-ft from the southeast edge of the tank in lateral 44-11-02 due to new monitoring equipment. Radioactivity appeared to stabilize after 1977 until June 1987. No radioactivity above normal background levels were detected in laterals 44-11-01 and 44-11-03 from 1973 to 1987. All of the radiation readings (see Appendix D4) in laterals are assumed to be maximum peak readings unless otherwise noted.

Lateral plots for tank SX-111 from 1988 to 1989 are shown in Figure 7-7 showing no radioactivity detected in laterals 44-11-01 (Lateral 01) and 44-11-03 (Lateral 03). However, in lateral 44-11-02 (Lateral 02), a distinct peak in radioactivity is shown at a distance of ~130-ft (~33-ft from southeast edge) along the lateral approximately 15 years after the leak was initially detected.

**Figure 7-7. Tank SX-111 Lateral Survey Sample (1988-1989)
(RPP-RPT-27605 page 11)**

The tank SX-111 laterals were surveyed in May 2005 and reported in RPP-RPT-27605. The 2005 gamma survey of lateral 44-11-02 is shown in Figure 7-8 showing radioactivity detected along the lateral with the maximum Cs-137 concentration reported to be 6,200 pCi/g. The 2005 lateral surveys of 44-11-01 and 44-11-03 continued to detect no radioactivity above background (RPP-RPT-27605).

**Figure 7-8. Gamma Survey for Lateral 44-11-02 on Log Scale (May 2005)
(RPP-RPT-27605 page B-39)**

7.5.2 Drywells

There are seven drywells located around tank SX-111: 41-11-02, 41-11-03, 41-11-05, 41-11-06, 41-11-08, 41-11-09 installed in 1962, and 41-11-10 installed in 1956. All of the radiation readings in drywells are assumed to be maximum values or peak readings unless otherwise noted and are from the Red-GM probe unless otherwise indicated (see Section 3.3.2). The bottom of the tank footing is ~53-ft BGS. The following subsections report the available drywell information and the drywell summary section provides the analyses of the associated drywells with tank SX-111.

7.5.2.1 Drywell 41-11-02 (N33°E)

Drywell 41-11-02 was drilled March 14, 1962 with the first recoverable reading on April 8, 1968 with a peak of 11K cpm at 71-ft BGS (see Appendix E4). The next recoverable reading on October 7, 1968 reported the peak of 4K cpm at an unspecified BGS depth. Subsequent drywell data were all reported as less than values through June 1987 (see Appendix E4).

In December 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-11-02 at concentrations less than 1 pCi/g except at the ground surface (GJ-HAN-13). Document GJ-HAN-13 states, “*No evidence exists to support the conclusion that the Cs-137 contamination detected in this borehole originated from a subsurface source.*” Since historical records report little radioactivity in this drywell, drywell 41-11-02 is not included as part of the leak location for tank SX-111. Figure 7-9 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 7-9. Tank SX-111 Drywell 41-11-02 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

7.5.2.2 Drywell 41-11-03 (N82°E)

Drywell 41-11-03 was drilled March 15, 1962 with the first recoverable reading on April 8, 1968 with a peak of 12K cpm at 71-ft BGS. The next recoverable reading on October 7, 1968 and subsequent data through May 1987 are all reported as less than values (see Appendix E4).

In December 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-11-03 with subsurface concentrations typically less than 5 pCi/g (GJ-HAN-13). Document GJ-HAN-13 states, *“The Cs-137 contamination detected in this borehole originated near the surface. The increased Cs-137 concentrations near 19 ft might be due to a leak in the cascade line between tanks SX-110 and SX-111.”* Since historical records report little radioactivity in this drywell, drywell 41-11-03 is not included as part of the leak location for tank SX-111. Figure 7-10 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 7-10. Tank SX-111 Drywell 41-11-03 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

7.5.2.3 Drywell 41-11-05 (S40°E)

Drywell 41-11-05 was drilled March 8, 1962 with the first recoverable reading on April 4, 1968 reported as less than 9K cpm. Radioactivity continued to be reported as less than values through June 1987 (see Appendix E4).

In December 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-11-05 from the ground surface to 5-ft BGS, with isolated values near the detection limit to about 20-ft BGS (GJ-HAN-13). Document GJ-HAN-13 states, *“The contamination originated at the surface, and the log shows no evidence of any subsurface contamination from another source.”* Since historical records report little radioactivity in this drywell, drywell 41-11-05 is not included as part of the leak location for tank SX-111. Figure 7-11 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 7-11. Tank SX-111 Drywell 41-11-05 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

7.5.2.4 Drywell 41-11-06 (S0°)

Drywell 41-11-06 was drilled March 31, 1962 with the first recoverable reading on April 4, 1968 at 14K cpm at 73-ft BGS. The next recoverable reading on October 7, 1968 were reported as less than values and continued to be reported as less than values through June 1987 (see Appendix E4).

In December 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-11-06 from the ground surface to 20-ft BGS and from 60 to 75-ft BGS (GJ-HAN-13). The measured concentrations were less than 10 pCi/g for the supper zone and less than 30 pCi/g for the lower zone. Document GJ-HAN-13 states, *“The subsurface source could be SX-111 or other nearby tanks. However, the absence of increased count rates in measurements acquired in the most southern lateral under SX-111 appears unusual if tank SX-111 is indeed the source of the contamination at borehole 41-11-06.”*

Documents RPP-ENV-39658 and HNF-3136 state level Cs-137 concentrations at 75-ft BGS seen in drywell 41-11-06 are possibly associated with the leak from either tank SX-111 or tank SX-114. The low level and depth of radioactivity in drywell 41-11-06 along with possible timing could be associated with tank SX-114, however the tank SX-114 leak is on the opposite side of tank SX-114 from drywell 41-11-06 (see Tank SX-114 Segment). The peak in drywell 44-11-06 at 75-ft BGS could also be coming from the tank SX-111 leak detected in lateral 44-11-02; however, there doesn't appear to be a direct correlation to either tank SX-111 or SX-114. In any case, the radioactivity in drywell 41-11-06 does not appear to originate from tank SX-111. Therefore, drywell 41-11-06 is not being included as part of the leak location for SX-111. Figure 7-12 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 7-12. Tank SX-111 Drywell 41-11-06 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

7.5.2.5 Drywell 41-11-08 (S45°W)

Drywell 41-11-08 was drilled March 9, 1962 with the first recoverable reading on April 4, 1968 reported at 14K cpm at 132-ft BGS (see Appendix E4). The next recoverable reading on October 7, 1968 was reported as less than 4K cpm. No data were recovered until August 20, 1969 when a peak of 32K cpm was detected at 64-ft BGS and continued to be reported to March 15, 1971 at concentrations ranging from 50K to 80K cpm at ~64-ft BGS. No other readings were recovered until September 13, 1973 when radioactivity was reported as less than values through June 1987 indicating earlier radioactivity may have been due to short lived radioisotopes. This was probably associated with the tank SX-112 drywell 41-12-03 radioactivity, with similar timing and depth at ~64-ft BGS (see Tank SX-112 Segment). In addition, no radioactivity was found in the nearby lateral 44-11-01 under tank SX-111 (see Appendix D4).

In December 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-11-08 from the ground surface to 19-ft BGS (at concentrations less than 1 pCi/g) and at one depth (72-ft BGS) at a minimum detection limit (GJ-HAN-13). Document GJ-HAN-13 states, “*The logging data indicate no subsurface source of contamination.*” The above indicates that the radioactivity in drywell 41-11-08 does not originate from tank SX-111. Therefore, drywell 41-11-08 is not being included as part of the leak location for SX-111. Figure 7-13 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 7-13. Tank SX-111 Drywell 41-11-08 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

7.5.2.6 Drywell 41-11-09 (N82°W)

Drywell 41-11-09 was drilled March 12, 1962 with the first recoverable reading reported on April 8, 1968 at < 8K cpm (see Appendix E4). Readings continued to remain low until February 5, 1969 when a reading of >1,000K cpm was recorded at 64-ft BGS. Radiation levels gradually decreased and by March 15, 1971, the peak was at 46K cpm at 63-ft BGS. No other readings were recovered until September 13, 1973 and from September 1973 to June 1987 all readings were below 15K cpm indicating earlier radioactivity was likely due to short lived radioisotopes.

In December 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-11-09 from the ground surface to 7-ft BGS and from 62 to 75-ft BGS (GJ-HAN-13). The detected Cs-137 concentrations were less than 3pCi/g except at the ground surface. Document GJ-HAN-13 states, *"The apparent source of the lower contamination is tank SX-108, SX-111, or SX-112. Other nearby boreholes (41-11-10, 41-08-07, 41-12-02, and 41-12-03) also had Cs-137 contamination."*

The radioactivity in drywell 41-11-09 was probably associated with tank SX-112 drywell 41-12-03 radioactivity with similar timing and depth at 64-ft BGS (see Tank SX-112 Segment). There is also a remote possibility that the tank SX-108 and/or tank SX-109 leaks could have migrated to drywell 41-11-09. No radioactivity was found in the nearby lateral 44-11-01 under tank SX-111 (see Appendix D4). The above indicates that the radioactivity in drywell 41-11-09 does not originate from tank SX-111. Therefore, drywell 41-11-09 is not being included as part of the leak location for SX-111. Figure 7-14 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 7-14. Tank SX-111 Drywell 41-11-09 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

7.5.2.7 Drywell 41-11-10 (N46°W)

Drywell 41-11-10 was drilled March 7, 1956 and is one of the fifteen drywells that were drilled in and around SX Farm between 1954 and 1958. The first recoverable reading reported April 8, 1968 at >1,000K cpm at 62-ft to 71-ft BGS. The next recorded reading was on September 13, 1968 at 38K cpm at 67-ft BGS with a GM probe. The probe used in the earlier reading was not specified and the reason for the sudden decrease from April to September 1968 in radiation remains inconclusive. No other readings were recovered until April 24, 1970 (26K cpm at 69-ft BGS) and radiation readings gradually increased to 78K cpm at 68-ft BGS on January 29, 1971. Radioactivity appeared to remain steady relative to the 78K cpm reading until August 1973 and then slowly declined (see Appendix E4).

In December 1995, Cs-137 was the only man-made radionuclide detected in drywell 41-11-10 (GJ-HAN-13). The intervals of Cs-137 contamination occurred from 0 to 2-ft, 61 to 89.5-ft, and 123 to 124-ft BGS with the highest concentration of 600 pCi/g detected at 79-ft BGS. Document GJ-HAN-13 states, *"The contamination most likely originated from tank SX-108, SX-111, or SX-112 and has also appeared in other nearby boreholes (41-08-07, 41-12-02, and 41-12-03)."*

The radioactivity associated with this drywell is likely from the tank SX-108 and/or tank SX-109 leaks (see Tank SX-108 and Tank SX-109 Segments). The timing and the depth of radioactivity could correlate to either (or both) tank(s). The timing does not relate to the later (1974) tank SX-111 lateral 44-11-02 radioactivity. In addition, no radioactivity was found in the nearby lateral 44-11-02 under tank SX-111 (see Appendix D4). The above indicates that the radioactivity in drywell 41-11-10 does not originate from tank SX-111. Therefore, drywell 41-11-10 is not being included as part of the leak location for SX-111. Figure 7-15 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 7-15. Tank SX-111 Drywell 41-11-10 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

7.5.3 Tank SX-111 Drywell Summary

Tank SX-111 was first suspected of leaking at the end of April 1974 based on radioactivity detected in lateral 44-11-02 as well as liquid level decreases. The earliest drywell data were recovered in April 1968 for all the seven associated tank SX-111 drywells.

The tank SX-111 drywells 41-11-02, 41-11-03, and 41-11-05 do not indicate any radioactivity associated with a tank leak. All of the other four drywells 41-11-06, 41-11-08, 41-11-09, and 41-11-10 report some radioactivity. These four drywells appear to be associated with leaks in the surrounding tanks as described in Sections 7.5.2.4 to 7.5.2.7 above and is consistent with document GJ-HAN-13. The radioactivity in these drywells does not appear to originate from tank SX-111. Therefore, these drywells are not included in the leak location analysis for tank SX-111.

The tank SX-111 drywell analysis required a review of some of the drywells from the leaking tanks that are located around tank SX-111 (see Figure 7-16). The 1974 to 1977 tank SX-111 leak is also shown in Figure 7-16. Information from the tanks SX-108 and SX-109 segments was used to relate drywell radioactivity to the tank SX-111 drywells. The tanks SX-112 and SX-114 details are discussed in Sections 8.0 and 10.0. A review of the tanks SX-112 and SX-114 associated drywells was conducted as it relates to the four tank SX-111 drywells addressed above and was addressed in the individual drywell sections above.

The analysis of the drywell radioactivity relationships indicated there did not appear to be a separate distinct leak source from tank SX-111 that could be attributed to the tank SX-111 drywells. Therefore, the only leak source location would be described by the lateral radioactivity.

Figure 7-16. Tank SX-111 Leak Location with Surrounding Drywell Radioactivity

7.6 POSSIBLE TANK SX-111 LINER LEAK LOCATION(S)

The lateral radioactivity when first detected could be an indication of the location of a liner leak. However, the liner leak may have penetrated the waterproof membrane at any location or pooled on the waterproof membrane and followed concrete cracks or breaks to a different location including the top of the tank footing.

It is likely that the tank SX-111 leak occurred at or near the bottom of the tank because the initial indicator, lateral 44-11-02, is located below the bottom of the tank near the center of the tank. None of the tank SX-111 drywells indicated a tank SX-111 leak (see Section 7.5.3).

7.6.1 Leak Detected in April 1974, Site A

Waste solution from tank SX-111 first entered the soil before April 30, 1974 as indicated by radioactivity detected in lateral 44-11-02 in the southeast quadrant of the tank (see site A in Figure 7-17), ~23-ft under the tank from southeast edge. This radioactivity was found approximately ten years after nitrate leaching. No other radioactivity was detected in the other laterals or drywells that could be associated with the tank SX-111 leak.

Figure 7-17. Tank SX-111 Possible Leak Location (1974)
Tank inner ring is steel liner, outer ring is outer edge of tank footing

Radioactivity was first detected April 30, 1974 in lateral 44-11-02 approximately 23-ft from the southeast edge toward the center of the tank. No other radioactivity was detected in the other laterals or drywells that could be associated with the timing of the leak. First declared a confirmed leaker in May 1974.

7.6.2 Leak Detected in 1977, Site B

Radioactivity from site A in April 1974 (see Figure 7-17) apparently moved west to a location of ~30-ft from the southeast edge of the tank in lateral 44-11-02 on March 3, 1977, three years later, as shown by site B in Figure 7-18.

Figure 7-18. Tank SX-111 Possible Leak Location (1977)
Tank inner ring is steel liner, outer ring is outer edge of tank footing

Radioactivity levels increased in lateral 44-11-02 on March 3, 1977 at approximately 30-ft from the southeast edge of the tank toward the center, likely due to a new peak or possible spreading of radioactivity from the earlier leak. No other radioactivity was detected in the other laterals or drywells.

7.6.3 Leak Location Summary

Tank SX-111 leaked before April 30, 1974 based on radioactivity found to have started in the southeast quadrant at or near the tank footing as shown in Figure 7-17. By 1977, radioactivity migrated as shown by site B in Figure 7-18 with a peak reading at ~30-ft from the southeast edge of the tank in lateral 44-11-02.

Leak locations in Figure 7-19 are based on peak readings and are a representation of possible initial and subsequent boundaries of radioactivity.

There is a possibility of a liner bulge which has been indicated by ALC #1 and #3 (see Section 7.4.5); however, the possible locations remain inconclusive as these ALCs are not located near where radioactivity was detected in the laterals.

Figure 7-19. Tank SX-111 Possible Radial Leak Locations

7.7 POSSIBLE TANK SX-111 LINER LEAK CAUSE(S)

Tank SX-111 was exposed to five conditions that could contribute to a failed liner. Some or all of the factors can act together to contribute to tank liner failure.

7.7.1 Tank Design

The design of the SX Farm tanks was the first that diverged from the round bottom knuckle design used in the earlier waste tanks; the tank bottom liner intersects the sidewall liner orthogonally. A fillet weld was used to close the seam where the sidewall and the tank bottom liner meet. Several other SSTs with fillet welds failed during service (RPP-RPT-45921). Weld inspections were less rigorous. Additionally, the design discontinued the use of the three-ply asphaltic membrane waterproofing between the liner sidewall and the concrete shell. These features were inferior to others and could possibly increase the likelihood of failure of the tank liner from induced stresses (see Section 7.3.1).

7.7.2 Thermal Conditions

Temperature requirements in HW-59919 issued October 22, 1959 indicated that the self-boiling waste operating temperature should be maintained between 50°F and 220°F. The HW-59919 document recommended a uniform rate of temperature increase of 2°F per day and the maximum sludge temperature should not exceed 300°F.

The maximum temperature of 320°F was reported in January 1968 (see Section 5.4.2). The tank SX-111 exceeded the maximum sludge temperature on several subsequent occasions as discussed in Section 5.4.2.

Assuming a 55°F initial temperature of the tank liner when waste was first received on June 9, 1956 (HW-43895) and increased to ~158°F by June 27, 1956, 18 days later (see Figure B4). Tank SX-113 temperature recorded February 26, 1958 before receiving waste was 42°F, therefore 55°F may not be the worst case for ambient temperature for tank SX-111 in June 1956. No recording of tank SX-111 temperature was found before receiving waste. Over this 18 day period there was a temperature increase of 103°F, and the average rate of rise was ~5.7°F per day which is above the recommended rate of 2°F per day.

There were no other increases in temperatures that exceeded the initial average rate of rise of 5.7°F per day during the operation of tank SX-111. Exceeding the operating temperature requirements would create liner stress when thermally hot high level waste was received and stored in the tank especially without pre-heating. Note that the operating temperature limitations in HW-59919 were exceeded before issuing the document. The most severe temperatures for tank SX-111 occurred during the initial filling and then again when a maximum temperature of 320°F was recorded in January 1968. Thermal shock creates stress both from rapid temperature rise as well as waste-induced high temperatures.

7.7.3 Chemistry-Corrosion

Tank SX-111 was first filled with REDOX HLW (June 1956) which was stored in the tank for ~15 years total. In 1972, the tank was filled with RIX waste and was stored for approximately two years until tank SX-111 was first suspected of leaking in April 1974.

The REDOX HLW consisting of low concentrations of nitrite and hydroxide would have created an environment conducive to pitting and SCC (see Section 7.4.4). Under these conditions, there would be a high propensity for corrosion. Storage of RIX waste should not have been a concern for pitting and/or SCC.

Sodium nitrate leaching of tank SX-111 waste started in March 1964 with the transfer of supernatant from the tank. The remaining nitrate rich sludge was leached through June 1964 and the resulting sodium nitrate solution (leachate) was transferred out of the tank. Transfer of the supernatant prior to leaching decreased nitrite and hydroxide ion which are SCC inhibitors. Less than six months after leaching, the tank was refilled with REDOX HLW. There was evidence of a leak detected in lateral 44-11-02 in April 1974, approximately ten years after nitrate leaching. Loss of the protective nitrite and hydroxide ions would have created an environment conducive to SCC and/or pitting of the tank liner.

7.7.4 Liner Observations

The table in document RHO-R-39 (see Table A4) indicated there was no inspection for a bulge in tank SX-111. The free hanging ALC turnbuckle guy rod and bent piping indicate a liner bulge is possible in tank SX-111, but not conclusive (see Section 7.4.5).

Liner bulging coupled with other tank conditions could affect tank liner integrity, however, by itself bulging induces stresses that can cause breaching of the tank liner.

7.7.5 Tank Construction Temperature

Winter temperatures as low as -6°F occurred during the period when the SX tank farm liners were being constructed and leak tested (see Figure 3-4). The low temperatures experienced during construction were less than the current allowable 18°F temperature where impact loading had the potential for creating micro-fissures. The load of the steel liner wall on itself and the bottom liner along with filling the tank with water or other impact occurrences may have triggered fissures in the steel liner. Later, when the metal is subjected to high stress, it might be possible for the cracks to propagate through the metal, or possibly subject the weakened areas to increased corrosion.

7.8 TANK SX-111 CONCLUSIONS

Evidence indicates that the tank SX-111 liner leaked at or near the bottom of the tank in either one or two locations. Based on engineering judgment and available information the following conditions listed in the order of importance lead to the tank SX-111 failed liner:

1. Thermal conditions – rate of temperature rise and maximum temperature
2. Tank design – liner thermal expansion limiting design changes

3. Waste storage chemistry and nitrate leaching – corrosion - SCC and/or pitting
4. Construction conditions – ductile-to-brittle transition temperature

There are several liner leak cause conditions that were examined, but the primary cause of the tank SX-111 leak is thermal conditions experienced during the rapid addition of high temperature waste to a cold tank as well as waste storage temperatures. Also, the unique tank design did not allow for expansion of the bottom liner as the tank heated creating stresses. Storage of REDOX HLW at elevated temperatures and subsequent nitrate leaching created a chemical environment susceptible to nitrate-induced SCC and/or pitting attack on an already stressed metal liner. Tank construction occurred in winter under cold temperature conditions which could have affected the ductile-to-brittle steel transition temperature where metal loses its ability to absorb forces such as induced loads or the impact of falling objects creating micro-fissures or hairline cracks. In addition, a bulged bottom imparts stresses in the liner that could have predisposed it to SCC. However, a bulge was not confirmed in tank SX-111. Some or all of the factors can act serially or together to contribute to tank liner failure.

APPENDIX A4

TANK SX-111 BOILING WASTE OPERATIONAL HISTORY

Table A4-1. RHO-R-39 Boiling Waste Tank Operating Data Table

Tank No.	First Waste	Tank Pre-Heated	Pre-Heat Start	Liquid Heel Used	First Waste Rec'd From	Tank Failed	Inspected For Bulge	Bulge Present	Did Tank Boil on 1st Loading	Tank Started Boiling	Tank Emptied & Reused*	NaNO ₃ Leached from Sludge
101-SX	19 May 54	No	-	No	Redox	No	No	-	Yes	Nov 54	No	No
102-SX	Sep 54	No	-	No	101-SX, Cascade	No	No	-	No	-	No	No
103-SX	Nov 54	No	-	No	102-SX, Cascade	No	No	-	No	-	No	No
104-SX	2 Feb 55	No	-	No	Redox	No	No	-	Yes	Jun 55	No	No
105-SX	11 May 55	No	-	No	104-SX, Cascade	No	No	-	No	-	Yes	No
106-SX	Jun 54	No	-	No	Tank Farm Condensate	No	No	-	No	-	-	-
107-SX	3 Mar 56	No	-	Yes	Redox	Yes, 1964	Yes	Yes	Yes	Jun 56	Yes	Yes
108-SX	8 Nov 55	No	-	No	Redox	Yes, 1962	Yes	Yes	Yes	Jun 56	Yes	Yes
109-SX	20 Sep 55	No	-	Yes	Redox	Yes, 1965	Yes	No	Yes	Dec 55	Yes	No
110-SX	Nov 60	Yes	Apr 60	No	Redox	-	No	-	No	Between 1/61-6/61	Yes	No
111-SX	9 Jun 56	No	-	No	Redox	-	No	-	Yes	Nov 56	Yes	No
112-SX	13 Feb 56	No	-	No	Redox	Yes, 1969	Yes	Yes	Yes	Mar 56	Yes	No
113-SX	20 Feb 58	No	-	No	Redox	Yes, 1958	Yes	Yes	Yes	Apr 58	No	No
114-SX	Nov 56	No	-	No	Redox	-	No	-	Yes	Jun 57	Yes	Yes
115-SX	4 Nov 59	Yes	Sep 58	Yes	Redox	Yes, 1965	No	-	Yes	Nov 59	No	Yes
101-A	20 Jan 56	No	-	6" H ₂ O	Purex	No	Yes	No	Yes	Jul 57	Yes	No
102-A	20 Mar 56	No	-	6" H ₂ O	Purex	No	No	-	Yes	Jul 58	Yes	No
103-A	15 May 56	No	-	6" H ₂ O	Purex	No	No	-	Yes	Jul 56	Yes	No
104-A	30 Jun 59	No	-	6" H ₂ O	Purex	No	Yes	No	Yes	Aug 59	Yes	No
105-A	31 Jan 63	Yes	Jan 63	Yes	Purex	Yes, 1963	Yes	Yes	No***	Mar 63	No	No
106-A	31 Dec 60**	Yes	23 Feb 61	Yes	Purex	No	No	-	Yes	Aug 61	Yes	No
101-AX	1 Jun 65**	Yes	23 Nov 66	Yes	TK-103-A and TK-112-B	No	No	-	No***	Dec 66	Yes	No
102-AX	30 Sep 66**	Yes	2 Mar 69	Yes	TK-101-AX and TK-103-A	No	No	-	No***	Apr 69	No	No
103-AX	10 Feb 65	Yes	Nov 64	Yes	Purex	No	No	-	Yes	Apr 65	No	No
104-AX	9 Sep 66	Yes	Jun 66	Yes	Purex	No	No	-	Yes	Oct 66	No	No

* Emptied indicates supernatant was pumped out but sludge remained.

** Tanks used for temporary waste storage prior to the receipt of LWW or HLW.

*** Did not boil until LWW was routed to the tank.

Note: SX-111 was found to have been NaNO₃ Leached

APPENDIX B4

TANK SX-111 TEMPERATURES JANUARY 1956 – DECEMBER 1956

Figure B4-1. Tank SX-111 Temperature June 1956

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure B4-2. Tank SX-111 Temperature July to December 1956

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

APPENDIX C4

TANK SX-111 TEMPERATURE AUGUST 1956 – JUNE 1968

Figure C4-1. RHO-CD-1172 Tank SX-111 Temperature August 1956 through December 1956

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C4-2. RHO-CD-1172 Tank SX-111 Temperature January 1957 through July 1958

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C4-3. RHO-CD-1172 Tank SX-111 Temperature August 1958 through February 1960

Figure C4-4. RHO-CD-1172 Tank SX-111 Temperature March 1960 through September 1961

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C4-5. RHO-CD-1172 Tank SX-111 Temperature October 1961 through April 1963

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C4-6. RHO-CD-1172 Tank SX-111 Temperature May 1963 through November 1964

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C4-7. RHO-CD-1172 Tank SX-111 Temperature December 1964 through June 1966

Figure C4-8. RHO-CD-1172 Tank SX-111 Temperature July 1966 through January 1968

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C4-9. RHO-CD-1172 Tank SX-111 Temperature February 1968 through June 1968

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

APPENDIX D4

TANK SX-111 LATERAL ACTIVITY

**Table D4-1. Tank SX-111 Lateral Radioactivity (counts per minute)
February 1973 through June 1987 (SD-WM-TI-356)**

Date	SX-111		
	44-11-01	44-11-02	44-11-03
2/27/73	N/A ²	0	N/A ²
12/31/73	N/A ²	0	N/A ²
3/25/74	N/A ²	0	N/A ²
4/26/74	No reading above normal background	0	No reading above normal background
4/30/74	N/A ²	0.1 K at 23-ft	N/A ²
5/2/74	N/A ²	0.1 K	N/A ²
5/3/74	N/A ²	0.1 K	N/A ²
5/4/74	N/A ²	0.3 K	N/A ²
5/5/74	N/A ²	0.4 K	N/A ²
5/6/74	N/A ²	0.6 K at 23-ft	N/A ²
5/9/74	0	0.5 K at 23-ft	0
5/10/74	N/A ²	1.2 K at 23-ft	N/A ²
5/20/74	N/A ²	1.4 K	N/A ²
5/21/74	No reading above normal background	1.5 K at 28-ft	No reading above normal background
5/30/74	N/A ²	1.3 K at 28-ft	N/A ²
6/11/74	N/A ²	1.3 K at 28-ft	N/A ²
7/3/74	N/A ²	1.3 K at 28-ft	N/A ²
8/20/74	N/A ²	1.7 K at 28-ft	N/A ²
9/24/74	N/A ²	1.5 K at 28-ft	N/A ²
10/7/74	N/A ²	22.2 K at 28-ft	N/A ²
11/18/74	N/A ²	11.4 K at 28-ft	N/A ²
2/2/75	N/A ²	11.1 K at 28-ft	N/A ²
7/7/75	< 0.1 K	10.2 K at 28-ft	< 0.1 K
10/1/75	< 0.1 K	9.6 K at 28-ft	< 0.1 K
3/2/76	< 0.1 K	9 K at 28-ft	< 0.1 K
3/3/77	< 0.6 K ¹	60 K at 30-ft ¹	< 0.6 K ¹
7/10/78	< 0.8 K	66 K at 30-ft	< 0.6 K
7/31/79	N/A ²	64.8 K at 30-ft	N/A ²
7/11/80	< 0.6 K	67.5 K at 30-ft	< 0.6 K
6/15/81	< 0.6 K	48 K at 29-ft	< 0.6 K
7/26/82	< 0.6 K	55.2 K at 31-ft	< 0.6 K
6/16/83	< 0.6 K	92 K at 31-ft	< 0.6 K
6/7/84	< 0.6 K	46 K at 31-ft	N/A ²
6/17/85	< 0.6 K	42.4 K at 32-ft	< 0.6 K
6/11/86	< 0.6 K	44.4 K at 32-ft	< 0.6 K
6/23/87	< 0.6 K	43 K at 29-ft	< 0.6 K

Note: All measurements in lateral 44-11-02 are at a distance under the tank from southeast edge

¹New monitoring equipment

²N/A: Data not available

APPENDIX E4

TANK SX-111 GROSS GAMMA DRYWELL DATA

Table E4-1. Tank SX-111 Drywell Radioactivity (K counts per minute) (April 1968 to June 1987)
(Drywell Data Sheets Retrieved on March 11, 2011 and SD-WM-TI-356) (1 of 4 sheets)¹

41-11-02 ⁸			41-11-03 ⁸			41-11-05 ⁸		41-11-06 ⁸			41-11-08 ⁴			41-11-09 ⁵			41-11-10 ⁶		
Drilled 3/14/1962			Drilled 3/15/1962			Drilled 3/8/1962		Drilled 3/31/1962			Drilled 3/8/1962			Drilled 3/12/1962			Drilled 3/7/1956		
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)
4/8/68	11 ⁷	71	4/8/68	12 ⁷	71	4/4/68	< 9 ⁷	4/4/68	14 ⁷	73	4/4/68	14 ⁷	132	4/8/68	< 8 ⁷	N/A ³	4/8/68	> 1000 ⁷	62-71
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			9/13/68	38 ⁷	67
10/7/68	4 ⁷	N/A ³	10/7/68	< 3 ⁷	N/A ³	10/7/68	< 5 ⁷	10/7/68	< 3 ⁷	N/A ³	10/7/68	< 4 ⁷	N/A ³	10/7/68	< 3 ⁷	N/A ³	N/A ³		
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			1/21/69	13	71	N/A ³		
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			2/5/69	> 1000	64	N/A ³		
3/20/69	< 50	N/A ³	3/20/69	< 50	N/A ³	3/20/69	< 50	3/20/69	< 50	N/A ³	N/A ³			3/20/69	850	60-64	N/A ³		
4/3/69	< 50	N/A ³	4/3/69	< 50	N/A ³	4/3/69	< 50	4/3/69	< 50	N/A ³	N/A ³			4/8/69	880	64	N/A ³		
5/8/69	< 50	N/A ³	5/8/69	< 50	N/A ³	5/8/69	< 50	5/8/69	< 50	N/A ³	N/A ³			5/5/69	525	64	N/A ³		
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			6/12/69	350	64	N/A ³		
7/17/69	< 50	N/A ³	7/17/69	< 50	N/A ³	7/17/69	< 50	7/17/69	< 50	N/A ³	N/A ³			7/8/69	305	61	N/A ³		
8/20/69	< 50	N/A ³	8/20/69	< 50	N/A ³	8/20/69	< 50	8/20/69	< 50	N/A ³	8/20/69	32	64	8/11/69	265	64	N/A ³		
9/22/69	< 50	N/A ³	9/22/69	< 50	N/A ³	9/22/69	< 50	9/22/69	< 50	N/A ³	9/23/69	48	64	9/5/69	235	63	N/A ³		
10/17/69	< 50	N/A ³	10/17/69	< 50	N/A ³	10/17/69	< 50	10/17/69	< 50	N/A ³	10/17/69	53	64	10/22/69	248	64	N/A ³		
11/20/69	< 50	N/A ³	11/20/69	< 50	N/A ³	11/20/69	< 50	11/20/69	< 50	N/A ³	11/5/69	58	64	11/5/69	230	64	N/A ³		
12/22/69	< 50	N/A ³	12/22/69	< 50	N/A ³	12/18/69	< 50	12/22/69	< 50	N/A ³	12/3/69	68	64	12/3/69	223	64	N/A ³		
1/22/70	< 50	N/A ³	1/22/70	< 50	N/A ³	1/22/70	< 50	1/22/70	< 50	N/A ³	1/6/70	72	64	1/8/70	195	64	N/A ³		
2/24/70	< 50	N/A ³	2/24/70	< 50	N/A ³	2/24/70	< 50	2/24/70	< 50	N/A ³	2/2/70	76	64	2/2/70	185	63	N/A ³		
3/24/70	< 50	N/A ³	3/24/70	< 50	N/A ³	3/24/70	< 50	3/24/70	< 50	N/A ³	3/4/70	76	64	3/4/70	155	63	N/A ³		
4/21/70	< 50	N/A ³	4/21/70	< 50	N/A ³	4/21/70	< 50	4/21/70	< 50	N/A ³	4/8/70	80	64	4/1/70	145	63	4/24/70	26	69
5/19/70	< 50	N/A ³	5/19/70	< 50	N/A ³	5/19/70	< 50	5/19/70	< 50	N/A ³	5/3/70	76	64	5/3/70	113	63	5/21/70	24	69
6/29/70	< 50	N/A ³	6/29/70	< 50	N/A ³	6/26/70	< 50	6/26/70	< 50	N/A ³	6/17/70	78	64	6/4/70	120	63	6/22/70	31	67
7/27/70	< 50	N/A ³	7/27/70	< 50	N/A ³	N/A ³		7/27/70	< 50	N/A ³	N/A ³	63	64	7/1/70	105	63	7/1/70	30	67
8/24/70	< 50	N/A ³	8/24/70	< 50	N/A ³	8/24/70	< 50	8/24/70	< 50	N/A ³	8/4/70	74	64	8/4/70	80	63	8/3/70	47	67

Table E4-1. Tank SX-111 Drywell Radioactivity (K counts per minute) (April 1968 to June 1987)
(Drywell Data Sheets Retrieved on March 11, 2011 and SD-WM-TI-356) (2 of 4 sheets)¹

41-11-02 ⁸			41-11-03 ⁸			41-11-05 ⁸		41-11-06 ⁸			41-11-08 ⁴			41-11-09 ⁵			41-11-10 ⁶		
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)
9/28/70	< 50	N/A ³	9/28/70	< 50	N/A ³	9/28/70	< 50	9/28/70	< 50	N/A ³	9/3/70	64	64	9/3/70	75	63	9/11/70	44	67
10/20/70	< 50	N/A ³	10/20/70	< 50	N/A ³	10/20/70	< 50	10/20/70	< 50	N/A ³	10/1/70	64	64	10/1/70	85	63	10/1/70	41	67
N/A ³			N/A ³			N/A ³		N/A ³			11/4/70	61	64	11/4/70	77	63	11/3/70	30	67
12/29/70	< 50	N/A ³	12/29/70	< 50	N/A ³	12/29/70	< 50	12/29/70	< 50	N/A ³	12/10/70	58	64	12/10/70	67	63	12/10/70	19	67
1/18/71	< 50	N/A ³	1/18/71	< 50	N/A ³	1/18/71	< 50	1/18/71	< 50	N/A ³	1/6/71	57	64	1/6/71	64	63	1/21/71	36	67
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			1/29/71	78	68
N/A ³			N/A ³			N/A ³		N/A ³			2/5/71	54	64	2/5/71	56	63	2/3/71	52	67
3/29/71	< 50	N/A ³	3/29/71	< 50	N/A ³	3/29/71	< 50	3/29/71	< 50	N/A ³	3/15/71	44	64	3/15/71	46	63	3/1/71	61	67
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			4/12/71	61	67
5/3/71	< 50	N/A ³	5/3/71	< 50		5/3/71	< 50	5/3/71	< 50	N/A ³	N/A ³			N/A ³			5/24/71	66	67
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			6/3/71	70	67
7/29/71	< 50	N/A ³	7/29/71	< 50	N/A ³	7/29/71	< 50	7/29/71	< 50	N/A ³	N/A ³			N/A ³			N/A ³		
8/18/71	< 50	N/A ³	8/18/71	< 50	N/A ³	8/18/71	< 50	8/18/71	< 50	N/A ³	N/A ³			N/A ³			8/2/71	68	67
9/24/71	< 50	N/A ³	9/24/71	< 50	N/A ³	9/24/71	< 50	9/24/71	< 50	N/A ³	N/A ³			N/A ³			9/10/71	65	67
10/22/71	< 50	N/A ³	10/22/71	< 50	N/A ³	10/22/71	< 50	10/22/71	< 50	N/A ³	N/A ³			N/A ³			10/4/71	64	67
11/15/71	< 50	N/A ³	11/15/71	< 50	N/A ³	11/15/71	< 50	11/15/71	< 50	N/A ³	N/A ³			N/A ³			11/1/71	50	67
12/15/71	< 50	N/A ³	12/15/71	< 50	N/A ³	12/15/71	< 50	12/15/71	< 50	N/A ³	N/A ³			N/A ³			12/1/71	25	67
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			1/4/72	24	67
2/14/72	< 50	N/A ³	2/14/72	< 50	N/A ³	2/14/72	< 50	2/14/72	< 50	N/A ³	N/A ³			N/A ³			2/3/72	25	67
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			3/1/72	21	67
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			4/11/72	25	67
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			5/5/72	41	67
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			6/1/72	62	67
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			7/3/72	10	67
																		0.5	125

Table E4-1. Tank SX-111 Drywell Radioactivity (K counts per minute) (April 1968 to June 1987)
(Drywell Data Sheets Retrieved on March 11, 2011 and SD-WM-TI-356) (3 of 4 sheets)¹

41-11-02 ⁸			41-11-03 ⁸			41-11-05 ⁸		41-11-06 ⁸			41-11-08 ⁴			41-11-09 ⁵			41-11-10 ⁶		
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			8/14/72	9	67
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			9/12/72	28	67
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			10/2/72	35	65
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			11/6/72	30	65
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			12/1/72	36	65
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			1/3/73	38	65
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			2/6/73	77	65
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			3/5/73	93	65
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			4/2/73	81	65
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			5/7/73	55	65
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			6/4/73	63	65
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			7/2/73	90	65
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			8/3/73	63	63
9/13/73	< 12	N/A ³	9/13/73	< 12	N/A ³	9/13/73	< 12	9/13/73	< 12	N/A ³	9/13/73	< 12	N/A ³	9/13/73	< 12	N/A ³	9/12/73	62	65
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			10/2/73	11	60	1/2/74	50	67
4/10/74	< 12	N/A ³	4/10/74	< 12	N/A ³	4/10/74	< 15	4/10/74	< 15	N/A ³	4/10/74	< 15	N/A ³	4/10/74	14	63	4/4/74	66	69
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			4/18/74	47	70
N/A ³			7/12/74	< 3 ²	N/A ³	N/A ³		N/A ³			N/A ³			7/10/74	15	65	7/25/74	58	61
N/A ³			8/8/74	3	53	N/A ³		N/A ³			N/A ³			7/12/74	2 ²	64	N/A ³		
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			8/15/74	44 ²	69
1/22/75	< 3 ²	N/A ³	1/22/75	5	53	1/22/75	< 3	1/22/75	< 3 ²	N/A ³	1/22/75	< 3 ²	N/A ³	1/22/75	3	64	1/29/75	49	68
7/22/75	< 3	N/A ³	7/22/75	3	54	7/22/75	< 3	7/22/75	< 3	N/A ³	7/22/75	< 3	N/A ³	7/22/75	3	60	7/16/75	40	68
4/7/76	< 3	N/A ³	4/7/76	3	56	4/6/76	< 3	4/6/76	< 3	N/A ³	4/6/76	< 3	N/A ³	4/7/76	2	60	4/6/76	53	68
8/7/77	< 3	N/A ³	8/2/77	< 3	N/A ³	8/2/77	< 3	8/2/77	< 3	N/A ³	8/3/77	< 3	N/A ³	8/3/77	2	60	8/2/77	40	68

**Table E4-1. Tank SX-111 Drywell Radioactivity (K counts per minute) (April 1968 to June 1987)
(Drywell Data Sheets Retrieved on March 11, 2011 and SD-WM-TI-356) (4 of 4 sheets)¹**

41-11-02 ⁸			41-11-03 ⁸			41-11-05 ⁸		41-11-06 ⁸			41-11-08 ⁴			41-11-09 ⁵			41-11-10 ⁶		
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			3/7/78	35	66
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			4/4/78	12 ²	67
N/A ³			N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			7/4/78	12	66
7/3/78	< 3	N/A ³	7/3/78	< 3	N/A ³	7/3/78	< 3	7/3/78	< 3	N/A ³	6/6/78	< 3	N/A ³	7/3/78	3	60	N/A ³		
7/17/79	< 3	N/A ³	7/17/79	< 3	N/A ³	7/17/79	< 3	7/17/79	< 3	N/A ³	7/17/79	< 3	N/A ³	7/17/79	2	59	7/2/79	11	65
7/14/80	< 3	N/A ³	7/14/80	< 3	N/A ³	7/14/80	< 3	7/14/80	< 3	N/A ³	7/14/80	< 3	N/A ³	7/14/80	2	66	7/14/80	11	64
6/16/81	< 3	N/A ³	6/16/81	< 3	N/A ³	6/16/81	< 3	6/16/81	< 3	N/A ³	6/16/81	< 3	N/A ³	6/16/81	2	62	6/15/81	11	67
7/27/82	< 3	N/A ³	7/27/82	< 3	N/A ³	7/27/82	< 3	7/27/82	< 3	N/A ³	7/27/82	< 3	N/A ³	7/27/82	2	61	7/26/82	10	67
6/23/83	< 3	N/A ³	6/27/83	< 3	N/A ³	6/24/83	< 3	6/23/83	< 3	N/A ³	6/23/83	< 3	N/A ³	6/23/83	< 3	N/A ³	6/14/83	9	67
6/12/84	< 3	N/A ³	5/29/84	< 3	N/A ³	6/12/84	< 3	6/12/84	< 3	N/A ³	6/13/84	< 3	N/A ³	6/12/84	< 3	N/A ³	6/11/84	9	67
6/12/85	< 3	N/A ³	4/30/85	< 3	N/A ³	6/12/85	< 3	6/12/85	< 3	N/A ³	6/12/85	< 3	N/A ³	6/12/85	< 3	N/A ³	6/11/85	9	68
6/9/86	< 3	N/A ³	6/24/86	< 3	N/A ³	6/9/86	< 3	6/9/86	< 3	N/A ³	6/9/86	< 3	N/A ³	6/9/86	< 3	N/A ³	6/11/86	9	69
6/24/87	< 3	N/A ³	5/27/87	< 3	N/A ³	6/25/87	< 3	6/25/87	< 3	N/A ³	6/24/87	< 3	N/A ³	6/24/87	< 3	N/A ³	6/25/87	8	69

Note: ¹If Depths were not available, the column was omitted from the table

²New Monitoring Equipment

³N/A: Data not available

⁴Readings were recorded using the Scintillation Probe (SP) from August 1969 to March 1971.

⁵Readings were recorded using the SP from March 1969 to July 1974.

⁶All readings were recorded with a GMP.

⁷Referenced from RL Occurrence Report 74-38 (Final report May 5, 1974)

⁸Readings were recorded using the SP from March 1969 to February 1972. Probe not specified after 1972.

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8.1 TANK SX-112 BACKGROUND HISTORY

This section provides information on the historical waste loss event associated with SST 241-SX-112 (SX-112). Tank SX-112 has three laterals installed in 1963 about 10-ft under the tank (see Figure 8-1). There are seven drywells located around tank SX-112: 41-12-04 installed in 1956 and 41-12-02, 41-12-03, 41-12-06, 41-12-07, 41-12-09 and 41-12-10 installed in 1962.

The bottom of the tank footing is ~53-ft 1-in BGS with ~6-ft 7-in soil cover over the dome (WHC-SD-WM-TI-665). Inside tank SX-112 are four ALCs 18-in above the tank bottom and equally spaced on a 40-ft diameter circle as shown in Figure 8-1 (H-2-39951). Two ALCs are designated low ALCs (8-ft 6-in tall) and two are high ALCs (13-ft 6-in tall) (H-2-9950).

Figure 8-1. Tank SX-112 Associated Drywells and Laterals
Tank inner ring is steel liner, outer ring is outer edge of tank footing

8.2 TANK SX-112 OPERATIONS SUMMARY

Tank SX-112 was constructed from 1953 to 1954 and started receiving REDOX HLW on February 13, 1956 (HW-41812, *Separations Section Waste-Status Summary for February 1956*, page 8). Normally tanks receiving boiling waste were preheated prior to use to minimize transfer stresses. However, tanks in SX Farm were not fitted with steam coils and tank SX-112 was not preheated prior to use (RHO-R-39). Waste temperatures rose from an assumed ambient temperature of 55°F on February 13, 1956 to ~148°F by February 29, 1956 (see Figure B5).

Additional REDOX HLW was transferred to tank SX-112 in March 1956 and self-boiling was observed (HW-42394, *Separations Section Waste-Status Summary for March 1956*, page 2). The evaporation rate was moderate, reported as 11, 6, 0, 1, and 0 kgal for March, April, May, June and July 1956, respectively. The waste volume reported in tank SX-112 was 589 kgal as of July 1956 (HW-44860, *Separations Section Waste-Status Summary for July 1956*, page 8). No additional evaporation was reported until additional waste was added in October 1956.

In October and November 1956, REDOX HLW waste cascaded from tank SX-111 into tank SX-112, filling tank SX-112 to approximately 977 kgal (HW-46382, *Chemical Processing Department Waste-Status Summary for October 1956*, page 8; HW-47052, *Chemical Processing Department Waste-Status Summary for November 1956*, page 8; HW-50216, *Current Status of REDOX Waste Self-Concentration*, page 6). The waste in tank SX-112 began to boil in December 1956 and continued to self-concentrate through June 1959 (HW-61095, *Chemical Processing Department Waste Status Summary June 1, 1959- June 30, 1959*, page 2). The waste volume in tank SX-112 was 838 kgal in June 1959.

From November 1959 through March 1960 approximately 426 kgal of supernatant were transferred from tank SX-112 to tank SX-111 (HW-83906-D-RD, *Chemical Processing Department 200 West Area Tank Farm Inventory and Waste Reports January 1959 through June 1961*, pages 84, 92, 100, 108, 115, and 122). An additional 170 kgal of supernatant were transferred from tank SX-112 into tank SX-110 in April and May 1960, leaving 244 kgal of waste in tank SX-112 (HW-83906-D-RD, pages 124 and 131).

From July through November 1960, tank SX-112 received ~369 kgal of REDOX HLW (HW-83906-D-RD, pages 147, 155, 163, 171, 178). The waste in tank SX-112 began to boil in October 1960 (HW-67705, *Chemical Processing Department Waste-Status Summary October 1, 1960- October 31, 1960*, page 2). Tank SX-112 again received approximately 437 kgal of REDOX HLW from July through December 1961 (HW-83906-E-RD, pages 4 and 5).

In January 1962, ~276 kgal of REDOX HLW supernatant was transferred from tank SX-102 into tank SX-112 (HW-83906-E-RD, page 15). Water was added to tank SX-112 from February through May 1962 in order to maintain the waste temperature within operating limits (HW-83906-E-RD, pages 14 and 15). The waste in tank SX-112 was allowed to self-concentrate through boiling and evaporation, with periodic additions of water (or condensate from tank SX-106) and operation of ALCs until the first quarter of 1966 at which time 388 kgal of supernatant were transferred to tank SX-102 (ISO-226, *Chemical Processing Division Waste Status Summary January 1, 1966 Through March 31, 1966*, page 8). Tank SX-112 contained approximately 168 kgal of supernatant and 73 kgal of sludge following this transfer.

For the remainder of 1966, tank SX-112 received 638 kgal of REDOX HLW (ISO-404, *Chemical Processing Division Waste Status Summary April 1, 1966 Through June 30, 1966*, page 8; ISO-538, *Chemical Processing Division Waste Status Summary July 1, 1966, Through September 30, 1966*, page 8; ISO-674, *Chemical Processing Division Waste Status Summary October 1, 1966, Through December 31, 1966*, page 8). The waste in tank SX-112 began to boil in the third quarter of 1966, evaporating 220 kgal (average ~2,450 gal per day) and an additional 35 kgal in the fourth quarter of 1966. In the fourth quarter, 300 kgal of water were added to tank SX-112 for cooling. Evaporation of water from tank SX-112 continued through the second quarter of 1967 (ISO-967, *Chemical Processing Division Waste Status Summary April 1, 1967 Through June 30, 1967*, page 8).

No further additions of waste were made to tank SX-112 from 1967 through the third quarter of 1968. In the fourth quarter of 1968, 21 kgal of REDOX HLW were transferred from tank SX-107 into tank SX-112, as result of a suspect leak in tank SX-107 (ARH-1061, *Chemical Processing Division Waste Status Summary October 1, 1968 Through December 31, 1968*, page 10). After this transfer, tank SX-112 contained 636 kgal of supernatant and 46 kgal of sludge.

The tank SX-112 leak was first recorded on January 16, 1969 based on a liquid level decreases and increased radioactivity in the tank laterals (ARH-1023-DEL, *Chemical Processing Division Daily Production Reports January, 1969 through March, 1969*, page 21; ARH-1100-DEL, *200 Areas Operation Monthly Report January 1969*, page G-5). Thus, the supernatant was transferred to tanks SX-110, SX-111, and SX-114, leaving an estimated 82 kgal of supernatant and 39 kgal of sludge in tank SX-112 (ARH-1200 A, *Chemical Processing Division Waste Status Summary January 1, 1969 Through March 31, 1969*, page 10). Tank SX-112 was removed from service and was classified as a confirmed leaker in January 1969.

From 1969 to 1979, tank SX-112 was connected to a sludge cooler and by July 1979, no supernatant remained and the tank was administratively stabilized (HNF-SD-RE-TI-178, *Single-Shell Tank Interim Stabilization Record*, page 275). Tank SX-112 is estimated to contain 75 kgal of sludge, which consists of 6 kgal of drainable interstitial liquid (HNF-EP-0182, Rev. 304).

The operational history of tank SX-112 leak related details including temperature and liquid level is charted in Figure 8-2.

Figure 8-2. Operational Leak History of Tank SX-112

8.3 TANK DESIGN/CONSTRUCTION

8.3.1 Tank Design

The SX Farm tanks had multiple design features that could contribute to stresses or possible leak paths when the tank was being operated including:

- Orthogonal intersection between the steel bottom and the sidewall
- Fillet weld used between the bottom and sidewall intersection
- Less rigorous weld inspection testing
- Partial asphaltic membrane waterproofing
- Keyed construction joints in the sidewall

These features are common to all SX Farm tanks and additional details are discussed in Section 3.1.1.

8.3.2 Tank Construction Conditions

The outside temperature between January 16, 1954 and January 30, 1954 ranged from an average high of 24°F to an average low of 9°F. A picture of the SX Farm under construction (see Figure 3-4) taken January 20, 1954 (high 11°F low -6°F), shows several of the tanks full of water either undergoing leak testing or for concrete wall pouring. During this cold period snow covered ice is seen in the water filled tanks.

As described in Section 3.1.2, cold weather affects the ductile-to-brittle steel transition temperature, with 18°F being the assumed unrestricted low temperature construction limitation for the carbon steel liner, which could result in a fracture upon impact. Low temperatures experienced during construction at or less than the 18°F allowable temperature could cause impact loading (e.g. a dropped tool or piece of equipment from scaffolding) and result in the potential for creating micro-fissures weakening the steel liner.

8.4 TANK SX-112 IN-TANK DATA

8.4.1 Liquid Level

The first indication of a leak in tank SX-112 was reported to be due to a liquid level drop in January 1969 (ARH-1023-DEL, page 21). The 10-in decrease reported over 31 days was a drop of 2.3-in/week versus the normal action criteria of 0.5-in/week. Some of the decrease could probably be attributed to evaporation but no analysis was found to verify the evaporation rate at the relatively low temperatures found during the decrease. Appendix F5 provides the available information relating to this 10-in liquid level decrease between December 19, 1968 and January 15, 1969, subsequent lateral radiation increases, and the attendant pumping. The tank temperature had been in the range of 212°F to 215°F prior to the transfer of 21 kgal of waste from tank SX-107 to tank SX-112 on December 18, 1968 (see Figure 8-3). Water was apparently being added in the weeks prior to the transfer probably to maintain the temperature based on the increasing liquid level (WHC-SD-WM-TI-614, *Waste Status and Transactions Record Summary for the Southwest quadrant of the Hanford 200 Area*) and relatively stable temperature. After the

tank SX-107 transfer, the temperature rose to about 225°F which could have increased evaporation and with apparently no water or condensate being added after the transfer, could have resulted in some of the 10-in decrease; however, an analysis of the decrease was not found.

**Figure 8-3. SX-112 Surface Level
October 1968 to January 19, 1969**

Note: Data reported on a week day basis with some exceptions

The liquid level was pumped down to 8-ft 4-in from January 16-20, 1969 and was reported as appearing to be holding at 8-ft 4-in (see Figure 8-4); however, the radiation readings in the leak detection laterals began rising sharply in the following week. The unspecified laterals were probably 44-12-02 and 44-12-03 (see Section 8.5.1). The liquid level continued to drop ~2-in by January 23, 1969 and waste was then pumped to tank SX-110 resulting in an approximately 4-ft tank SX-112 waste level. The liquid level continued holding at 4-ft through the remainder of 1969 with condensate being added to compensate for boil off with a reported “excellent balance” indicating no additional leakage at the 4-ft level. The loss of hydraulic head and/or pluggage of the leak site could also be a part of the indication of stability.

**Figure 8-4. SX-112 Surface Level
January 19, 1969 to April 7, 1969**

The agitation of the waste within the boiling tank, the recycle of cool condensate, and evaporation made it very difficult to detect small leaks with liquid level measurements (ARH-R-43, Rev. 2). In quiescent storage conditions, liquid levels can be used in the analysis of the location of a sidewall tank leak when the leak site is above the sludge surface. If the tank SX-112 liquid level analysis above is correct, there may possibly be a tank sidewall leak above 48-in when the tank contained less than 24-in of sludge. However, lateral and drywell data indicate that the tank SX-112 leak was at or near the bottom of the tank.

The liquid level plot in Figure 8-5 indicates the transfer activity into and out of tank SX-112. The liquid levels are end of quarter levels so this figure may not reflect all transfers into and out of the tank that occurred during the operational history of the tank. See Figure 8-2 for historical monthly liquid level readings.

Figure 8-5. Tank SX-112 End of Quarter Surface Level

WHC-SD-WM-ER-352, Rev 0, June 30, 1994, Historical Tank Content Estimate for the Southwest Quadrant of the Hanford 200 West Area

8.4.2 Temperature

Tank SX-112 was not preheated prior to the initial filling of waste which was first received on February 13, 1956 (HW-41812, page 8). Temperature quickly rose to ~101°F two days later from a conservative assumed ambient ground temperature of 55°F and continued to increase to an equivalent boiling temperature of 240°F by May 16, 1956 (see Appendix B5). The continuing thermal history for tank SX-112 starts in August 1956 (RHO-CD-1172, *Survey of the Single-Shell Tank Thermal Histories*, pages B-73 to B-114). See Figure 8-2 for the combined available thermal history for tank SX-112. The tank SX-112 waste temperature exceeded the 300°F sludge temperature limit reaching a maximum temperature of ~316°F recorded in March 1962. Temperatures remained above the 300°F level for approximately one month (see Section 8.7.2).

After reaching initial boiling temperatures in May 1956, the waste temperature reached ~260°F in 1957 and gradually declined to ~135°F by July 1960. In June through November 1960, REDOX HLW was added again to tank SX-112 causing waste temperatures to rapidly increase from ~135°F in June 1960 to ~240°F in December 1960 (see Appendix C5). Waste temperatures

gradually declined until July 1961 when REDOX HLW was again added to tank SX-112 through January 1962. By the end of February 1962, waste temperatures were above 300°F and remained at this level throughout March 1962. Temperatures gradually decreased due to water additions in February through May 1962 to ~215°F at the beginning of January 1965. In 1966, REDOX HLW was routed to tank SX-112 and temperatures increased to ~260°F. Waste temperatures varied around 260°F until June 1968. The first indication of a leak in tank SX-112 was detected in January 1969 due to liquid level decreases and increased lateral radioactivity one week later.

8.4.3 Liner Observations

Photographs taken in January 1969 were reported to confirm the existence of a bulge (see Appendix A5) in the bottom liner based on the presence of twisted and broken pipes and equipment (ARH-1100-DEL, page G-4). Mapping of the bulged liner and sludge depth in March 1969 indicated that the sludge thickness in tank SX-112 varied from 0.0-ft to 3.1-ft (see Appendix F5); however, data from the mapping of the bulged liner and sludge was not found. A review of available photographs taken January 25, 1969 supports the presence of “twisted and broken pipes and equipment” in the southern portion of the tank as documented (see Section 8.4.5). However, it remains inconclusive whether or not a bulge is present and whether the presence of bent piping is indicative of a bulge. If a bulge did exist in tank SX-112, it is likely the bulge was located in the southern portion of the tank based on the location of the twisted and broken pipes and equipment.

Additional photographs were taken in July 1974 and show “... *what apparently is a crack in the tank liner. Enclosed is a copy of photograph No. 743054-3CN showing the crack above the 4th stiffener ring (about the 16 foot level in the tank). The fissure appears to be about 8 to 10 feet in length and may be as wide as 3 or 4 inches in places*” (Internal memo ARHCO-072674, “Apparent Liner Crack in 112 SX”). The photographs referred to one taken on May 2, 1974 (see Figure 8-9) showing the linear anomaly. Photographs taken in September 1971 did not show the anomaly was present earlier; however, it is possible the anomaly was present during this time but was undetectable due to the quality of the photographs. The linear indication in tank SX-112 remained present after 1974 in later photographs taken through March 1987, the last available photograph of the sidewall, and does not appear to be any larger than what was indicated in July 1974 (see Section 8.4.5).

8.4.4 Chemistry-Corrosion

Waste Chemistry

Tank SX-112 began receiving REDOX HLW (R) in February 1956 and stored only this waste type throughout operation (see Table 8-1). The typical concentration for nitrite, nitrate, and hydroxide for this waste type is shown in Table 8-2. Nitrite and hydroxide are known as nitrate-induced SCC inhibitors. One key characteristic for inhibiting SCC is to maintain a high nitrite concentration to nitrate concentration ratio (see Section 3.2.4).

Table 8-1. Tank SX-112 Waste Storage Chronology

Date	Waste Type	Length of Storage
February 1956 to March 1969	REDOX HLW	~ 13 years

Table 8-2. Waste Chemistries for Waste Types Stored in Tank SX-112

Waste Type	[NO ₃] ¹	[NO ₂] ¹	[OH] ¹	Meets Current DST Specification ²
R ³	4.83	0.74		No ⁴

1. Reference WHC-EP-0449, 1991, *The Sort on Radioactive Waste Type Model: A Method to Sort Single-Shell Tanks into Characteristic Groups*.
2. Reference OSD-T-151-00007, Rev. 12, (2013), *Operating Specifications for the Double-Shell Storage Tanks*.
3. Reference WHC-EP-0772, 1994, *Characterization of the Corrosion Behavior of the Carbon Steel Liner in Hanford Site Single-Shell Tanks*.
4. Does not meet the current DST specification since the hydroxide and nitrite concentrations are not greater than or equal to 1.2M.

Tank SX-112 stored only REDOX HLW throughout operation for a total of approximately 13 years until the tank was first suspected of leaking in January 1969 based on liquid level decreases and increased radioactivity in the laterals. REDOX HLW does not meet the current DST specification for waste chemistry due to low concentrations of the nitrate-induced SCC inhibitors, nitrite and hydroxide. Thus, these conditions of the REDOX HLW would likely create an environment conducive to SCC and/or pitting (see Section 3.2.4).

Nitrate Leaching

The review of operating transactions in Section 8.2 indicated there was no sodium nitrate sludge leaching of the waste in tank SX-112 or receiving of any nitrate leached waste from other tanks. In addition, document RHO-R-39 listed tank SX-112 sludge as not having been sodium nitrate leached (see Appendix A5). No data records were found for tank SX-112 waste samples.

8.4.5 Photographs

8.4.5.1 Air Lift Circulators

Photographs of tank SX-112 were taken in January 1969 were reported to show twisted and broken pipes and equipment apparently resulting from a raised liner (ARH-1100-DEL). Photographs taken on January 25, 1969 were reviewed and two photographs confirming twisted and broken pipes and equipment are shown below (see Figure 8-6 and Figure 8-7). Figure 8-6 shows ALC #3 apparently missing a turnbuckle guy rod in the southwest quadrant of the tank and Figure 8-7 shows bent piping extending down to ALC #4 in the southeast quadrant of the tank. The locations of all ALCs in tank SX-112 are shown in Figure 8-8 with the two ALCs (#3 and #4) located in the southern portion of the tank possibly showing evidence of a liner bulge. These are the only ALCs that have bent piping visible and detached turnbuckle guy rods during this time. This may be an indication of a liner bulge that could have resulted in failure of the turnbuckle guy rod bottom liner attachment. However, detachment of the ½-in turnbuckle guy rod as well as bent piping could also be the result of mixing the waste when the ALCs were operating with the resulting forces on internal equipment. It is possible the liner bulged in the

southern portion of the tank based on the ALCs with a missing turnbuckle guy rod and bent piping as well as most of the radioactivity detected in the laterals and drywells occurred in this area. However, the location of the liner bulge remains inconclusive.

**Figure 8-6. Tank SX-112 ALC #3 Photograph PNL0690404-36
January 25, 1969**

**Figure 8-7. Tank SX-112 ALC #4 Photograph PNL0690404-29
January 25, 1969**

Figure 8-8. Tank SX-112 Air Lift Circulator Locations

8.4.5.2 Linear Anomaly

Additional photographs taken in July 1974 show an “apparent crack” in the sidewall in the southern portion of tank SX-112 (see Figure 8-26 and Figure G5) (Internal memo ARHCO-072674). However, a review of photographs taken on May 2, 1974 also shows the presence of the anomaly as seen in Figure 8-9. It appears the linear anomaly became apparent sometime between September 1971 and May 1974 since photographs taken earlier on September 21, 1971 do not show this abnormality (see Figure 8-7). However, there is a possibility the anomaly in the sidewall was present before 1971 but was not detected due to the quality of the photographs. After the appearance of the linear anomaly, it remained present in later photographs with one photograph taken in 1984 shown in Figure 8-10 up to 1987, the last date photographs were taken, and appeared to be stable. It remains inconclusive whether the linear indication in the sidewall of tank SX-112 is indeed a crack.

Previous studies have been conducted on the underground waste storage tanks at the Savannah River Site (SRS), and several of the SRS tanks have observed SCC (Bruce Wiersma, *Stress Corrosion Cracking Experience and Effect on Design at the Savannah River Site*). Stress corrosion cracking is the failure of an alloy due to exposure to a corrosive environment and relatively low constant tensile stresses (*Principles and Prevention of Corrosion* [Jones 1996]). Stress corrosion cracking tends to propagate perpendicular to the principal tensile stress which is dependent on the type of alloy where pure metal is typically more resistant to SCC and results from the presence of a particular chemical species that is specifically aggressive to a particular alloy. Constant tensile stresses are also needed to induce SCC; however, slight, long-term variations in loading are known to accelerate the onset of SCC (Jones 1996).

**Figure 8-7. Tank SX-112 Photograph 714351-22CN
September 21, 1971**

**Figure 8-9. Tank SX-112 Photograph 743054-3CN
May 2, 1974**

**Figure 8-10. Tank SX-112 Photograph 8402746-13CN
April 18, 1984**

Tank 16 at the SRS was inspected for SCC and ~10 cracks were identified on the vertical seam weld with one crack shown in Figure 8-11. The cracks found in Tank 16 were perpendicular to the weld and the longest crack was ~6-in (Wiersma 2009). The linear indication in tank SX-112 appears mid-plate rather than across the weld seam and also is approximately 8 to 10-ft long. These observations do not appear to follow the trend seen in Tank 16 at the SRS. Photographs of tank SX-112 were informally reviewed by the SST Integrity Expert Panel, and the expert panel could neither confirm nor deny whether the linear indication in tank SX-112 can be classified as a crack. The linear anomaly is present in the following photographs: photograph 752902-4CN May 2, 1975, photograph 095685-19CN April 10, 1981, photograph 8402746-13CN

April 18, 1984 (see Figure 8-10), and the composite photograph March 10, 1987 shown in Figure G5 with photographs 8701439-21CN/22CN specifically showing the liner anomaly.

The earliest detection of a leak in tank SX-112 was in January 1969; therefore, the linear anomaly located in the southern portion of the tank (see Figure 8-22) does not appear to be the initial leak site as it did not appear until after September 1971. The liner anomaly in tank SX-112 is located in the southern portion of the tank near drywells 41-12-06 and 41-12-07. Activity seen in these two drywells was relatively low compared to the other drywells and was detected below 64-ft BGS, which does not correspond to the 16-ft BGS level of the linear anomaly (see Sections 8.5.2.4 and 8.5.2.7). Liquid level was pumped down to 4-ft in 1969, well below the linear anomaly more than two years before evidence of the anomaly appeared; therefore, the “apparent crack” does not appear to be associated with a separate tank SX-112 leak location.

Figure 8-11. An Example of Stress Corrosion Cracking in the Sidewall of Tank 16 from the Savannah River Site

Bruce Wiersma, *Stress Corrosion Cracking Experience and Effect on Design at the Savannah River Site*, January 26, 2009

8.5 TANK SX-112 EX-TANK DATA

8.5.1 Laterals

According to document RL-SEP-297, *REDOX Weekly Process Reports January through December, 1965*, No. 694, laterals under tank SX-112 were checked weekly during July 1965. However, this document appears to report only laterals with significant radioactivity. Since it was only reported that the laterals under SX-112 were monitored but no indication of radioactivity was recorded in the document, it is likely that no indication of a leak was detected in the laterals through January 1, 1966.

Approximately one week after a 10-in liquid level decrease was reported in January 1969, radioactivity was reported in the tank SX-112 laterals (ARH-1100-DEL, page G-4). Actual lateral data could not be recovered for this time frame. The first data recovered was on January 2, 1973, when lateral 44-12-02 peak radioactivity was reported at 1,929K cpm ~29-ft from the southeast edge of the tank (see Appendix D5). This was the only lateral reporting

activity during this time. Lateral 44-12-02 activity slowly decreased and had two peaks at ~32-ft and 34-ft at 540K cpm on October 11, 1974; only peak lateral data was available to 1987. Radioactivity continued to decrease and was 266K cpm at ~34-ft on February 1, 1977. Radioactivity then remained relatively stable through June 1987.

Lateral 44-12-03 was first reported on May 14, 1974, 16 months after the initial liquid level decrease, with two peaks at 6K cpm ~14-ft and 37-ft from the southeast edge of the tank. Radioactivity gradually increased to ~40K cpm by October 28, 1974 with the same peaks at ~14-ft and 37-ft. Radioactivity levels remained relatively stable through June 1987.

Radioactivity was first detected in lateral 44-12-01 on October 11, 1974 with a peak of 0.5K cpm at ~16.4-ft from the southeast edge of the tank. This is the first indication of radioactivity detected in lateral 44-12-01 as earlier data from February 1973 to September 1974 were reported as zero values. Peak readings gradually increased and were 3.6K cpm at ~16.4-ft on May 14, 1975 and peak readings remained at approximately this level through June 1987.

Lateral 44-12-02 was probably involved in the January 1969 liquid level decrease due to the reported sharp rise in leak detection laterals one week later and the subsequent high peak readings found beginning in January 1973. Lateral 44-12-03 could possibly be involved in the earlier 1969 liquid level decrease since document ARH-1100-DEL indicated an increase in laterals (more than one) in January 1969; however, peak readings were relatively low compared to lateral 44-12-02 when first recorded in May 1974 and remained relatively low through 1987 (see Appendix D5). Figure 8-12 shows the location of the peak readings for the first recovered data in the laterals in 1973 and 1974. Figure 8-13 is a time line plot of the lateral peak readings to indicate the relationship of the radioactive increases.

Figure 8-12. SX-112 Peak Lateral Radioactivity in 1973 and 1974

Note: A leak was first reported January 1969 due to decreases in liquid level. An increase in activity in the laterals was reported a week later; however, no actual lateral data were found until January 1973.

Figure 8-13. Peak Radioactivity in the Laterals Timeline

Since lateral 44-12-01 had zero readings from the first leak indication in January 1969 until October 1974, it is unlikely lateral 44-12-01 was involved in the earlier leak detected in January 1969 and therefore may subsequently be an indication of possible migration or a separate leak location. Occurrence Report (OR) 75-54, *Increasing Radiation in a Lateral beneath Tank 112-SX*, indicated that it was believed that the lateral 44-12-01 radiation increase in April 1975 was due to redistribution of preexisting contamination as none of the other laterals or drywells showed any increases. The conclusion of OR-75-54 is questionable as the radioactivity had been increasing in lateral 44-12-01 before 1975 and continued at a slower rate after 1975 with some indication of spreading in 1982 with the other laterals relatively stable. This could mean that the lateral 44-12-01 indicated a separate leak site.

Later lateral profiles with peak readings from May 2005 (RPP-RPT-27605) are shown in Figure 8-14 (see Appendix H5). The 2005 profiles around the earlier (1969 through 1987) radioactive locations appear to be fairly stable and separate from each other, e.g. not a single leak source from the tank concrete shell. Three additional distinct peak profiles of low level radioactivity near the south edge of the tank show up May 2005 at or beyond the tank shadow, one in each of the three laterals. These could be separate leak sites associated with the tank steel liner (lower sidewall or bottom) or possible seepage of tank waste pooled on the asphaltic membrane passing through or around the water stop and potential cracks in the footing. Cracks were found in the tank SX-108 footing associated with heat stress and are probably present in most of the high heat SX Farm tanks.

The radioactivity found in the three additional 2005 lateral radiation profiles apparently did not migrate to drywell 41-12-04 and was not recorded during earlier lateral readings up to 1987. This radioactivity was detected more than 35 years after the 1969 leak was first detected

suggesting another mechanism besides a sidewall leak is plausible as the liquid level was reduced in 1969. Radioactivity in lateral 44-12-03, seen outside the tank shadow, was relatively low compared to activity detected underneath the tank and it is possible this later radioactivity could have migrated from the earlier 1969 leak as indicated above.

Figure 8-14. Tank SX-112 Peak Lateral Radioactivity in 1973/1974 and May 2005

8.5.2 Drywells

There are seven drywells located around tank SX-112: 41-12-04 installed in 1956 and 41-12-02, 41-12-03, 41-12-06, 41-12-07, 41-12-09 and 41-12-10 installed in 1962. All of the radiation readings in drywells are assumed to be maximum values or peak readings unless otherwise noted and are from the Red-GM probe unless otherwise indicated (see Section 3.3.2). The bottom of

the tank footing is ~53-ft 1-in BGS. The following subsections report the available drywell information and the drywell summary section provides the analyses of the associated drywells with tank SX-112.

8.5.2.1 Drywell 41-12-02 (N50°E)

Drywell 41-12-02 was drilled March 26, 1962 with the first recoverable reading found on March 27, 1969 at 44K cpm at 71-ft BGS approximately two months after the January 1969 liquid level decrease (see Appendix E5). Radiation levels continued to increase and on August 3, 1970 were 375K cpm at 71-ft BGS. In September 1970, a second peak occurred at 75-ft BGS at 250K cpm. Radiation readings at both these depths continued to increase until November 1971. In February 1972 two additional peaks were detected at 101-ft and 120-ft BGS at 10K cpm and 11K cpm, respectively. Radiation readings remained relatively stable with most peaks recorded at the depth of 69 to 72-ft BGS from 1972 to 1987. The radioactivity associated with drywell 41-12-02 could be associated with the January 1969 liquid level decrease or possibly from the tank SX-108 leak discovered before March 1969 and/or tank SX-109 leaks discovered January 1965, in addition to tank SX-112 (see Figure 8-22). The timing and depth of radioactivity detected could correlate to either (or all) tank(s).

In January 1996, Cs-137 was the only man-made radionuclide detected in drywell 41-12-02 along the entire length of this drywell (GJ-HAN-14). In the upper part of the drywell, the largest Cs-137 concentration measured was about 360 pCi/g at 4-ft BGS. In the lower part of the drywell, the highest concentration measured was about 7,000 pCi/g near 109-ft BGS. Document GJ-HAN-14 states, “*The source of the contamination for borehole 41-12-02 is probably tank SX-112, although other nearby tanks cannot be ruled out as sources.*” Figure 8-15 shows the depths of radioactivity from 1975 to 1994 (HNF-3136).

Figure 8-15. Tank SX-112 Drywell 41-12-02 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft 1-in BGS

8.5.2.2 Drywell 41-12-03 (S69°E)

Drywell 41-12-03 was drilled March 26, 1962 with the first recoverable reading reported on March 24, 1969 at >1,000K cpm from 60 to 65-ft BGS, approximately two months after the January 1969 liquid level decrease (see Appendix E5). Radioactivity remained at this level through August 7, 1969. No data were recovered after August 7, 1969 until April 24, 1970 when a reading of 7K cpm was recorded at 65-ft BGS which could indicate earlier readings were possibly due to short lived radioisotopes. Readings taken in 1969 were recorded with a scintillation probe (SP); however, the probe used with readings taken from April to July 1970 was not stated.

Beginning on July 29, 1970 a new GM probe was used and radiation readings remained relatively stable at ~18K cpm at 64 to 65-ft BGS until May 1978. On May 25, 1978 a shielded SP was used in exchange for the GM probe and readings were recorded at 1425K cpm at 63-ft BGS and remained at this level through June 1987.

In January 1996, Cs-137 was the only man-made radionuclide detected in drywell 41-12-03 from the ground surface to 14-ft BGS and from 57-ft BGS to the total depth (GJ-HAN-14). The maximum Cs-137 concentration of 4,000 pCi/g was detected at 66-ft BGS. Cs-137 contamination was higher at 65-ft BGS but the detector was saturated and a concentration value could not be determined. The radioactivity associated with drywell 41-12-03 was probably from the tank SX-112 leak, although other nearby tanks (SX-108 and/or SX-109) could not be ruled out (GJ-HAN-14). The timing and depth of radioactivity could correlate to either (or all) tank(s). Figure 8-16 shows the depths of radioactivity from 1975 through 1994 (HNF-3136).

Figure 8-16. Tank SX-112 Drywell 41-12-03 (HNF-3136)

8.5.2.3 Drywell 41-12-04 (S45°E)

Drywell 41-12-04 was drilled March 31, 1956 and is one of fifteen drywells that were drilled in and around the SX Farm between 1954 and 1958. Radiation readings are all reported as less than values starting with the first recoverable reading on March 13, 1969 until June 24, 1987 (see Appendix E5). No data were recovered for February 1972 to September 1973.

In January 1996, Cs-137 was the only man-made radionuclide detected in drywell 41-12-04 at concentrations slightly above the minimum detection limit (GJ-HAN-14). Document GJ-HAN-14 states, "No evidence exists for a subsurface source of contamination near this borehole." Therefore, drywell 41-12-04 is not included as part of the leak location for tank SX-112. Figure 8-17 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 8-17. Tank SX-112 Drywell 41-12-04 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft 1-in BGS

8.5.2.4 Drywell 41-12-06 (S4°E)

Drywell 41-12-06 was drilled March 27, 1962 with the first recoverable reading reported on July 30, 1969 at 55K cpm at 64-ft BGS, six months after the January 1969 liquid level decrease (see Appendix E5). Radiation increased slightly to 82K cpm at 66-ft BGS in March 1970 and then slowly declined probably due to short lived radioisotopes. By April 13, 1971, radiation readings were reported as less than values (< 50K cpm) until February 1972. No data were recovered from February 1972 to September 1973. Only less than values were recorded from 1973 to June 1987 (see Appendix E5).

In January 1996, Cs-137 was the only man-made radionuclide detected in drywell 41-12-06 and was detected almost continuously from the ground surface to total depth of 75-ft BGS (GJ-HAN-14). The measured subsurface Cs-137 concentrations were less than 1 pCi/g. Document GJ-HAN-14 states, *“The continuity of the contamination suggests that it originated from the surface and was carried down during the drilling process or migrated down along the casing. Interestingly, the Tank Farms gross gamma-ray logs do not report this continuous contamination, probably because of the low concentration and the less efficient detector used by the Tank Farms logging system.”*

No radioactivity was found in the nearby lateral 44-12-01 during this time (see Appendix D5). Since historical records report little radioactivity in this drywell, drywell 41-12-06 is not being included as part of the leak location for tank SX-112. Figure 8-18 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 8-18. Tank SX-112 Drywell 41-12-06 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft 1-in BGS

8.5.2.5 Drywell 41-12-07 (S33°W)

Drywell 41-12-07 was drilled April 4, 1962 with the first recoverable reading reported on December 13, 1962 at a peak of 5.5K cpm at 64-ft BGS (see Appendix E5). The December 13, 1962 data was reported in WHC-MR-0300, *Tank 241-SX-108 Leak Assessment*, Supplement 1, page 7-2, as an anomalously high count that suggests the possibility of a tank SX-112 leak but was not high enough for positive proof and that monitoring should continue. No other readings were recovered until July 30, 1969, seven years later, when a peak of 100K cpm was reported at 64-ft BGS. Readings gradually increased to 135K cpm at 66-ft BGS by February and March 1970, then slowly decreased and were reported as less than values by October 1971 probably due to short lived radioisotopes. No readings were recovered from February 1972 until September 1973. Readings were reported as less than values from 1973 to 1987 (see Appendix E5).

In January 1996, Cs-137 was the only man-made radionuclide detected in drywell 41-12-07 from the ground surface to 16-ft BGS and intermittent occurrences near the minimum detection limit were recorded to 70-ft BGS (GJ-HAN-14). Document GJ-HAN-14 states, *“These data do not indicate a subsurface source of any contamination near this borehole.”*

No radioactivity was found in the nearby lateral 44-12-01 during this time (see Appendix D5). Since historical records report little radioactivity in this drywell, drywell 41-12-07 is not being included as part of the leak location for tank SX-112. Figure 8-19 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 8-19. Tank SX-112 Drywell 41-12-07 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft 1-in BGS

8.5.2.6 Drywell 41-12-09 (S75°W)

Drywell 41-12-09 was drilled March 27, 1962 and radiation readings are all reported as less than 50K cpm starting with the first recoverable reading on March 24, 1969 through June 24, 1987 (see Appendix E5). However, two readings were reported at 19K cpm on September 13, 1973 and 14K cpm on April 18, 1974 which are also both < 50K cpm.

In January 1996, Cs-137 was the only man-made radionuclide detected in drywell 41-12-09 from the ground surface to 16-ft BGS and from 18.5 to 24-ft BGS (GJ-HAN-14). Document GJ-HAN-14 states, *“Although a gap with no measured Cs-137 concentrations exists between these two zones, surface contamination that migrated downward is the likely source of all of the Cs-137 contamination. The highest measured Cs-137 concentration in the borehole was about 15 pCi/g at 2.5 ft.”* Since historical records report little radioactivity in this drywell, drywell 41-12-09 is not included as part of the leak location for tank SX-112. Figure 8-20 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 8-20. Tank SX-112 Drywell 41-12-09 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft 1-in BGS

8.5.2.7 Drywell 41-12-10 (N57°W)

Drywell 41-12-10 was drilled March 29, 1962 and radiation readings are all reported as less than values starting with the first recoverable reading on March 24, 1969 through June 24, 1987 (see Appendix E5). No readings were recovered from February 1972 to September 1973.

In January 1996, Cs-137 was the only man-made radionuclide detected in drywell 41-12-10 from the ground surface to 6-ft BGS at concentrations less than 2 pCi/g (GJ-HAN-14). Document GJ-HAN-14 states, "All Cs-137 contamination appeared to originate from the surface with no indication of any subsurface source." Therefore, drywell 41-12-09 is not included as part of the leak location for tank SX-112. Figure 8-21 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 8-21. Tank SX-112 Drywell 41-12-10 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft 1-in BGS

8.5.3 Tank SX-112 Drywell Summary

Tank SX-112 was first suspected of leaking in January 1969 due to a decrease in liquid level and increased radioactivity in the laterals. Tank SX-112 drywells 41-12-04, 41-12-09, and 41-12-10 do not indicate any radioactivity associated with a tank SX-112 leak. Early radioactivity reported in drywells 41-12-06 and 41-12-07 does not appear to originate from tank SX-112. Drywells 41-12-02 and 41-12-03 are the only tank SX-112 drywells that can be associated with the tank SX-112 leak.

Radioactivity in drywell 41-12-03 first appeared before March 1969 from 60 to 65-ft BGS. Drywell 41-12-02 shows radioactivity at a lower level compared to drywell 41-12-03 (71-ft BGS) and also first appeared before March 1969. Drywell 41-12-02 showed greater levels of radioactivity compared to drywell 41-12-03. However, it is also possible the radioactivity detected in these drywells could be associated with tank SX-108 and/or tank SX-109 leaks as indicated in the previous sections.

The tank SX-112 drywell analysis required a review of some of the drywells from the leaking tanks that are located around tank SX-112 (see Figure 8-22). The 1969-1983 tank SX-112 potential leak sites are also shown in Figure 8-22. Information from the tanks SX-108 and SX-109 segments was used to relate drywell radioactivity to the tank SX-112 drywells.

Figure 8-22. Tank SX-112 Leak Location with Surrounding Drywell Radioactivity

8.6 POSSIBLE TANK SX-112 LINER LEAK LOCATION(S)

The lateral radioactivity when first detected could be an indication of the location of a liner leak. However, the liner leak may have penetrated the waterproof membrane at any location or pooled on the waterproof membrane and followed concrete cracks or breaks to a different location including the top of the tank footing.

It is likely that the tank SX-112 leak occurred at or near the bottom of the tank because all of the leak indicators, three laterals and two drywells, were located at or near the tank bottom. There is a possibility of a sidewall leak above 48-in due to decreasing liquid levels but is unlikely as waste was pumped out of tank SX-112 shortly after the decline in liquid levels was observed and radioactivity continued to increase in the laterals after pumping (see Section 8.4.1).

8.6.1 Leak Detected in January 1969 to May 1974, Site A

The tank SX-112 leak was first detected in January 1969 based on a decrease in liquid level (see Section 8.4.1). One week later an increase in radioactivity was first reported in the laterals; however, no actual data were recovered for the laterals until January 1973. Site A in Figure 8-23 is based on first indications from 1969 and first reported peak radioactivity January 1973 and is a representation of the possible initial boundary. Radioactivity peaks were first reported before March 1969 in drywells 41-12-02 at 71-ft BGS and 41-12-03 from 60 to 65-ft BGS. Lateral 44-12-02 was already at a peak of 1925K cpm by January 1973 at ~29-ft toward the center of the tank from the southeast edge and readings were much higher compared to lateral 44-12-03. Lateral 44-12-03 peaked at ~14.2-ft and 37.2-ft from the southeast edge before May 1974. It was assumed initial activity detected in the laterals in January 1969 were referring to laterals 44-12-02 and 44-12-03 since lateral 44-12-01 readings were reported as zero values (see Section 8.5.1).

Figure 8-23. Tank SX-112 Possible Leak Location (January 1969 to May 1974)

Tank inner ring is steel liner, outer ring is outer edge of tank footing

Leak first detected Jan. 1969 due to increased activity in the laterals. Peaks detected in lateral 44-12-02 at ~29-ft before Jan. 1973 and lateral 44-12-03 before May 1974 at ~14-ft and 37-ft, from the southeast edge of the tank.

8.6.2 Leak Detected in October 1974, Site B

Radioactivity was first recovered for lateral 44-12-01 in October 1974, with a peak at ~16.4-ft toward the center of the tank from the southeast edge probably from migration of radioactivity from the earlier 1969 leak or possibly a new leak location. Site B in Figure 8-24 represents where the peak radioactivity was first detected in the lateral.

Figure 8-24. Tank SX-112 Possible Leak Location (October 1974)

Tank inner ring is steel liner, outer ring is outer edge of tank footing

Activity first detected in lateral 44-12-01 October 11, 1974 at ~16.4-ft from the southeast edge toward the center of the tank either from possibly a new leak location or from an earlier leak. No other radioactivity was detected in the drywells that could be associated with the timing of the leak.

8.6.3 Leak Detected in 1983, Site C

Peak radioactivity levels in lateral 44-12-01 increased in June 1983 as shown by site C in Figure 8-25 with a peak at ~21.4-ft from the southeast edge of the tank toward the center, likely from possible spreading of radioactivity from site B in October 1974 or could possibly be a new leak (see Figure 8-24).

Figure 8-25. Tank SX-112 Possible Leak Location (1983)
Tank inner ring is steel liner, outer ring is outer edge of tank footing

Radioactivity levels increased in lateral 44-12-01 in June 1983 at ~21.4-ft from the southeast edge of the tank toward the center, likely due to a new peak or possible spreading of radioactivity from the earlier leak.

8.6.4 Leak Location Summary

Tank SX-112 leak first occurred in January 1969 based on liquid level decreases. Increased radioactivity in the laterals was detected one week later; however, no data were recovered for the laterals until January 1973. Peak radioactivity was first recovered in March 1969 for the drywells. The leak was found to have started in the eastern portion of the tank as shown by site A at or near the bottom of the tank (see Figure 8-26). In October 1974, lateral 44-12-01 peak radioactivity was detected in the southern portion of the tank (site B) possibly from migration of the earlier leak or from a new leak location. In 1983, lateral 44-12-01 peaked at ~21.4-ft from the southeast edge (site C) either from possible spreading of radioactivity detected in 1974 or a new leak. Leak locations in Figure 8-26 are based on peak readings and are a representation of possible initial boundaries of radioactivity.

The possibility of a liner bulge in the southern portion of the tank has been indicated by ALC #3 and #4 (see Section 8.4.5) which are located in the same portion of the tank where radioactivity has been detected in the laterals. The linear anomaly located in the southern portion of the tank was above the waste level during the time the tank SX-112 leak was first detected (see Section 8.4.5.2), and does not appear to be a leak site. The two drywells and three laterals of tank SX-112 indicate the leak was at or near the tank bottom.

The 2005 lateral profiles (see Figure 8-14) appear to be fairly stable and separate from each other, e.g. not a single leak source from the tank concrete shell. Three additional distinct peak profiles, not shown in Figure 8-26, of low level radioactivity near the south edge of the tank show up in May 2005 at or beyond the tank shadow, one in each of the three laterals. This radioactivity was detected more than 35 years after the 1969 leak was first detected suggesting another mechanism besides a sidewall leak is plausible as the liquid level was reduced in 1969. These could be separate leak sites associated with the tank steel liner (lower sidewall or bottom) or possible seepage of tank waste pooled on the asphaltic membrane passing through or around the water stop and potential cracks in the footing (see Section 8.5.1).

Figure 8-26. Tank SX-112 Possible Radial Leak Locations
 Tank inner ring is steel liner, outer ring is outer edge of tank footing

8.7 POSSIBLE TANK SX-112 LINER LEAK CAUSE(S)

Tank SX-112 was exposed to five conditions that could contribute to a failed liner. Some or all of the factors can act together to contribute to tank liner failure.

8.7.1 Tank Design

The design of the SX Farm tanks was the first that diverged from the round bottom knuckle design used in the earlier waste tanks; the tank bottom liner intersects the sidewall liner orthogonally. A fillet weld was used to close the seam where the sidewall and the tank bottom liners meet. Several other SSTs with fillet welds failed during service (RPP-RPT-45921). Weld inspections were less rigorous. Additionally, the design discontinued the use of the three-ply asphaltic membrane waterproofing between the liner sidewall and the concrete shell. These features were inferior to earlier designs and could possibly increase the likelihood of failure of the tank liner from induced stresses (see Section 8.3.1).

8.7.2 Thermal Conditions

Temperature requirements in HW-59919 issued October 22, 1959 indicated that the self-boiling waste operating temperature should be maintained between 50°F and 220°F. The HW-59919 document recommended a uniform rate of temperature increase of 2°F per day and the maximum sludge temperature should not exceed 300°F.

The tank SX-112 bulb (sludge) temperatures are shown in Appendix B5 and Appendix C5. The maximum temperature of 316°F was reported on March 8, 1962. Tank SX-112 temperatures exceeded the maximum sludge temperature of 300°F on several occasions as discussed in Section 8.4.2.

Assuming a 55°F initial temperature of the tank liner when waste was first received on February 13, 1956 (HW-41812) and increased to ~148°F by February 29, 1956, 16 days later (see Figure B5). Tank SX-113 temperature recorded February 26, 1958 before receiving waste was 42°F, therefore 55°F may not be the worst case for ambient temperature for tank SX-112 in February 1956. No recording of tank SX-112 temperature was found before receiving waste. Over this 16 day period there was a temperature increase of 93°F, and the average rate of rise was ~5.8°F per day which is above the recommended rate of 2°F per day.

There were no other increases in temperatures that exceeded the initial average rate of rise of 5.8°F per day during the operation of tank SX-112. Exceeding the operating temperature requirements would create liner stress when thermally hot high level waste was received and stored in the tank especially without pre-heating. Note that the rate of temperature rise observed occurred before the operating temperature limitations published in HW-59919 were imposed. Thermal shock creates stress both from rapid temperature rise as well as high waste temperatures. The most severe incidences occurred during the initial waste receiving period and then again when a maximum temperature of 316°F was recorded in March 1962.

8.7.3 Chemistry-Corrosion

Tank SX-112 was first filled with REDOX HLW (February 1956) which was stored in the tank for about 13 years before the tank was suspected of leaking in January 1969. REDOX HLW was the only waste type stored in tank SX-112 throughout operation.

The REDOX HLW consisting of low concentrations of nitrite and hydroxide would have created an environment conducive to pitting and SCC (see Section 8.4.4). Under these conditions, there would be a high propensity for corrosion.

Nitrate leaching was not applied to tank SX-112 waste nor did tank SX-112 receive any nitrate leached waste from other tanks. No waste sample analyses of tank SX-112 were available for comparison.

8.7.4 Liner Observations

A review of photographic evidence seems to indicate a possible liner bulge as reported in ARH-1106-DEL, *200 Areas Operation Monthly Report July 1969*, and RHO-R-39 at least from an observation of bent piping. The evidence of a liner bulge is possible in the southern portion of tank SX-112, but not conclusive. Liner bulging coupled with other tank conditions could affect tank liner integrity; however, by itself bulging induces stresses that can cause breaching of the tank liner.

A linear anomaly in the tank liner first became apparent between September 1971 and May 1974. However, it appears unlikely to be a separate leak location as waste levels remained below the anomaly when it first appeared.

8.7.5 Tank Construction Temperature

Winter temperatures as low as -6°F occurred during the period when the SX Farm tank liners were being constructed and leak tested (see Figure 3-4). The low temperatures experienced during construction were less than the current 18°F allowable temperature where impact loading had the potential for creating micro-fissures. Impact occurrences could have occurred during cold temperatures that may have triggered fissures in the steel liner. Later, when the metal is subjected to high stress, it might be possible for the cracks to propagate through the metal, or possibly subject the weakened areas to increased corrosion.

8.8 TANK SX-112 CONCLUSIONS

Liquid level decrease and lateral peak radiation evidence indicates that the tank SX-112 liner leaked at or near the bottom of the tank in either two or three locations. Based on engineering judgment and available information the following conditions listed in the order of importance lead to the tank SX-112 failed liner:

1. Thermal conditions – rate of temperature rise and maximum temperature
2. Tank design – expansion limiting design changes
3. Waste storage chemistry - SCC and/or pitting
4. Construction conditions – ductile-to-brittle transition temperature

5. Bulging liner – an effect of primarily thermal conditions along with tank design

There are several liner leak cause conditions that were examined, but the primary cause is tank SX-112 thermal conditions caused by rapid addition of high temperature waste to a cold tank as well as waste storage temperatures. Also, the unique tank design did not allow for expansion of the bottom liner as the tank heated creating stresses, which is why tank design is the second most important condition. Storage of REDOX HLW at elevated temperatures created a chemical environment susceptible to nitrate-induced SCC and/or pitting attack on an already stressed metal liner. Tank construction occurred in winter under cold temperature conditions which could have affected the ductile-to-brittle steel transition temperature where metal loses its ability to absorb forces such as induced loads or the impact of falling objects creating micro-fissures or hairline cracks. In addition, a bulged bottom imparts stresses in the liner that could have predisposed it to SCC. Some or all of the factors can act serially or together to contribute to tank liner failure.

APPENDIX A5

TANK SX-112 BOILING WASTE OPERATIONAL HISTORY

Table A5-1. RHO-R-39 Boiling Waste Tank Operating Data Table

Tank No.	First Waste	Tank Pre-Heated	Pre-Heat Start	Liquid Heel Used	First Waste Rec'd From	Tank Failed	Inspected For Bulge	Bulge Present	Did Tank Boil on 1st Loading	Tank Started Boiling	Tank Emptied & Reused*	NaNO ₃ Leached from Sludge
101-SX	19 May 54	No	-	No	Redox	No	No	-	Yes	Nov 54	No	No
102-SX	Sep 54	No	-	No	101-SX, Cascade	No	No	-	No	-	No	No
103-SX	Nov 54	No	-	No	102-SX, Cascade	No	No	-	No	-	No	No
104-SX	2 Feb 55	No	-	No	Redox	No	No	-	Yes	Jun 55	No	No
105-SX	11 May 55	No	-	No	104-SX, Cascade	No	No	-	No	-	Yes	No
106-SX	Jun 54	No	-	No	Tank Farm Condensate	No	No	-	No	-	-	-
107-SX	3 Mar 56	No	-	Yes	Redox	Yes, 1964	Yes	Yes	Yes	Jun 56	Yes	Yes
108-SX	8 Nov 55	No	-	No	Redox	Yes, 1962	Yes	Yes	Yes	Jun 56	Yes	Yes
109-SX	20 Sep 55	No	-	Yes	Redox	Yes, 1965	Yes	No	Yes	Dec 55	Yes	No
110-SX	Nov 60	Yes	Apr 60	No	Redox	-	No	-	No	Between 1/61-6/61	Yes	No
111-SX	9 Jun 56	No	-	No	Redox	-	No	-	Yes	Nov 56	Yes	No
112-SX	13 Feb 56	No	-	No	Redox	Yes, 1969	Yes	Yes	Yes	Mar 56	Yes	No
113-SX	20 Feb 58	No	-	No	Redox	Yes, 1958	Yes	Yes	Yes	Apr 58	No	No
114-SX	Nov 56	No	-	No	Redox	-	No	-	Yes	Jun 57	Yes	Yes
115-SX	4 Nov 59	Yes	Sep 58	Yes	Redox	Yes, 1965	No	-	Yes	Nov 59	No	Yes
101-A	20 Jan 56	No	-	6" H ₂ O	Purex	No	Yes	No	Yes	Jul 57	Yes	No
102-A	20 Mar 56	No	-	6" H ₂ O	Purex	No	No	-	Yes	Jul 58	Yes	No
103-A	15 May 56	No	-	6" H ₂ O	Purex	No	No	-	Yes	Jul 56	Yes	No
104-A	30 Jun 59	No	-	6" H ₂ O	Purex	No	Yes	No	Yes	Aug 59	Yes	No
105-A	31 Jan 63	Yes	Jan 63	Yes	Purex	Yes, 1963	Yes	Yes	No***	Mar 63	No	No
106-A	31 Dec 60**	Yes	23 Feb 61	Yes	Purex	No	No	-	Yes	Aug 61	Yes	No
101-AX	1 Jun 65**	Yes	23 Nov 66	Yes	TK-103-A and TK-112-B	No	No	-	No***	Dec 66	Yes	No
102-AX	30 Sep 66**	Yes	2 Mar 69	Yes	TK-101-AX and TK-103-A	No	No	-	No***	Apr 69	No	No
103-AX	10 Feb 65	Yes	Nov 64	Yes	Purex	No	No	-	Yes	Apr 65	No	No
104-AX	9 Sep 66	Yes	Jun 66	Yes	Purex	No	No	-	Yes	Oct 66	No	No

* Emptied indicates supernatant was pumped out but sludge remained.

** Tanks used for temporary waste storage prior to the receipt of LWW or HLW.

*** Did not boil until LWW was routed to the tank.

Note: SX-111 was found to have been NaNO₃ Leached

Table A5-2. ARH-R-43 Waste Tank Leak Experience Table

TABLE 3. Underground Waste Storage Tank Leak Experience

Tank	Built	First Used	Type of Waste Stored	Service	Leak First Suspected	Reason for Suspicion	Leak Confirmed by	Bulge Found	Estimated Volume of Leak, gal	Associated Cs-137, kCi
104-U	1943-44	1947	Bismuth phosphate waste Uranium recovery waste	Nonboiling	1956	Bulged liner	Refill with water (1961)	Yes	55,000*	0.09
113-SX	1953-54	1958	Redox waste	Boiling	1958	Bulged liner	Refill with salt solution (1962)	Yes	15,000**	8
106-TV	1951-52	1953	TBP waste	Nonboiling	1959	Liquid level measurements	Soil radiation readings (1959)		20,000	2
101-U	1943-44	1946	Bismuth phosphate waste Uranium recovery waste Redox waste	Nonboiling	1959	Liquid level measurements	Liquid level measurements		30,000	23
105-TV	1951-52	1953	TBP waste	Nonboiling	1960	Liquid level measurements	Liquid level measurements		35,000	4
108-SX	1953-54	1955	Redox waste	Boiling	1962	Soil radiation readings	Liquid level measurements	Yes	3,400	17
105-A	1954-55	1963	Purex waste	Boiling	1963	Soil radiation readings	Soil radiation readings	Yes	Small	
107-SX	1953-54	1956	Redox waste	Boiling	1964	Soil radiation readings	Soil radiation readings	Yes	Small	
109-SX	1953-54	1955	Redox waste	Boiling	1965	Soil radiation readings	No further evidence	No	Small	
115-SX	1953-54	1958	Redox waste	Boiling	1965	Liquid level measurements	Soil radiation readings		50,000***	40
112-SX	1953-54	1956	Redox waste	Boiling	1969	Liquid level measurements	Soil radiation readings	Yes	30,000	45

* Contained water at time of leak.
 ** Contained NaNO_3 solution at time of leak, also some residual supernatant solution.
 *** Contained NaNO_3 solution at time of leak.

Note: See tank farm segments for information on individual specific tanks

APPENDIX B5

TANK SX-112 TEMPERATURES JANUARY 1956 – DECEMBER 1956

Figure B5-1. Tank SX-112 Temperature January to July 1956

Figure B5-2. Tank SX-112 Temperature July to December 1956

APPENDIX C5

TANK SX-112 TEMPERATURE AUGUST 1956 – JUNE 1968

Figure C5-1. RHO-CD-1172 Tank SX-112 Temperature August 1956 through December 1956

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C5-2. RHO-CD-1172 Tank SX-112 Temperature January 1957 through July 1958

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C5-3. RHO-CD-1172 Tank SX-112 Temperature August 1958 through February 1960

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C5-4. RHO-CD-1172 Tank SX-112 Temperature March 1960 through September 1961

Figure C5-5. RHO-CD-1172 Tank SX-112 Temperature October 1961 through April 1963

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C5-6. RHO-CD-1172 Tank SX-112 Temperature May 1963 through November 1964

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C5-7. RHO-CD-1172 Tank SX-112 Temperature December 1964 through July 1966

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C5-8. RHO-CD-1172 Tank SX-112 Temperature July 1966 through January 1968

Figure C5-9. RHO-CD-1172 Tank SX-112 Temperature February 1968 through June 1968

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

APPENDIX D5

TANK SX-112 LATERAL ACTIVITY

**Table D5-1. Tank SX-112 Lateral Radioactivity (K counts per minute)
(1973 to 1987) (SD-WM-TI-356) (1 of 2 sheets)**

44-12-01			44-12-02			44-12-03		
Date	Peak (K cpm)	Distance (ft) ¹	Date	Peak (K cpm)	Distance (ft) ¹	Date	Peak (K cpm)	Distance (ft) ¹
2/5/73	0	N/A ³	1/2/73	1929	28.9	N/A ³		
N/A ³			12/31/73	1485	33.9	N/A ³		
N/A ³			1/4/74	1485	33.9	N/A ³		
4/16/74	0	N/A ³	4/29/74	1320	33.9	N/A ³		
N/A ³			5/15/74	1350	N/A ³	5/14/74	6	14.2
							6	37.2
N/A ³			6/5/74	1350	N/A ³	6/4/74	5.4	14.2
N/A ³			7/19/74	1410	33.9		5.4	37.2
9/10/74	0	N/A ³	8/5/74	1125	N/A ³	N/A ³		
9/24/74	0	N/A ³	9/18/74	1650	33.9	N/A ³		
10/11/74	0.5	16.4	10/11/74	540	33.9	10/28/74	39	14.2
10/21/74	0.6	16.4		540	31.9		40	37.2
11/18/74	0.5	16.4	N/A ³			11/12/74	34	14.2
							36	37.2
12/17/74	0.6	16.4	12/2/74	645	33.9	12/10/74	34	14.2
				660	31.9		33	37.2
1/14/75	1.3	16.4	1/14/75	525	33.9	1/20/75	32	14.2
				540	31.9		32	37.2
2/3/75	1.8	16.4	2/11/75	182	33.9	2/3/75	34	14.2
							35	37.2
3/27/75	1	16.4	3/21/75	132	33.9	3/27/75	33	14.2
							30	37.2
4/15/75	1.9	16.4	4/15/75	128	33.9	4/15/75	37	14.2
							32	37.2
5/14/75	3.6	16.4	5/12/75	120	33.9	5/12/75	35	14.2
4/23/75	3.3	16.4					34	37.2
7/8/75	3.7	16.4	7/8/75	134	33.9	7/8/75	34	14.2
							35	37.2
10/2/75	4.1	16.4	10/2/75	131	33.9	10/2/75	38	14.2
							35	37.2
3/2/76	4.3	16.4	3/2/76	131	33.9	3/2/76	32	14.2
							35	37.2
5/4/77	3.5	16.4	2/1/77	266	33.9	5/4/77	31	14.2
							34	37.2

**Table D5-1. Tank SX-112 Lateral Radioactivity (K counts per minute)
(1973 to 1987) (SD-WM-TI-356) (2 of 2 Sheets)**

44-12-01			44-12-02			44-12-03		
Date	Peak (K cpm)	Distance (ft) ¹	Date	Peak (K cpm) ¹	Distance (ft)	Date	Peak (K cpm)	Distance (ft) ¹
7/11/78	3.6	16.4	7/10/78	261	33.9	7/11/78	36	14.2
						7/11/78	42	37.2
7/18/79	3.8	16.4	7/17/79	230	33.9	7/18/79	34	14.2
						7/18/79	36	37.2
7/8/80	3.4	16.4	7/8/80	185	33.9	7/8/80	30	14.2
						7/8/80	34	37.2
6/15/81	3.2	16.4	6/15/81	236	33.9	6/15/81	25	12.2
						6/15/81	33	34.2
7/26/82	4	19.4	7/26/82	222	35.9	7/26/82	30	14.2
						7/26/82	37	37.2
6/14/83	4.1	21.4	6/15/83	219	36.9	6/14/83	31	15.2
						6/14/83	35	38.2
6/13/84	4.1	21.4	6/13/84	207	36.9	6/13/84	30	17.2
						6/13/84	36	39.2
6/19/85	3.2	20.4	6/14/85	201	41.9	6/19/85	28	14.2
						6/19/85	32	38.2
6/12/86	3.8	20.4	6/13/86	198	35.9	6/12/86	32	15.2
						6/12/86	39	37.2
6/19/87	4.1	17.4	6/19/87	220	33.9	6/19/87	30	14.2
						6/19/87	41	34.2

Note: ¹Under the tank from southeast edge

²New monitoring equipment

³N/A: Data not available

APPENDIX E5

TANK SX-112 GROSS GAMMA DRYWELL DATA

Table E5-1. Tank SX-112 Drywell Radioactivity (K counts per minute) (March 1969 to June 1987)
(Drywell Data Sheets Retrieved March 22, 2011 and SD-WM-TI-356) (1 of 6 sheets)¹

41-12-02 ⁸			41-12-03 ⁵			41-12-04 ⁷		41-12-06 ⁶			41-12-07 ⁶			41-12-09 ⁷			41-12-10 ⁷		
Drilled 3/26/1962			Drilled 3/26/1962			Drilled 3/31/1956		Drilled 3/27/1962			Drilled 4/4/1962			Drilled 3/27/1962			Drilled 3/29/1962		
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	
N/A ³			N/A ³			N/A ³		N/A ³			12/13/62	5.5 ⁹	64	N/A ³			N/A ³		
3/27/69	44	71	3/24/69	> 1000	60-65	3/13/69	< 50	N/A ³			N/A ³			3/24/69	< 50	N/A ³	3/24/69	< 50	
4/2/69	57	71	4/8/69	> 1000	60-65	4/2/69	< 50	N/A ³			N/A ³			4/3/69	< 50	N/A ³	4/3/69	< 50	
5/7/69	71	71	5/5/69	> 1000	60-65	5/1/69	< 50	N/A ³			N/A ³			5/8/69	< 50	N/A ³	5/8/69	< 50	
6/11/69	90	71	6/12/69	> 1000	60-65	N/A ³		N/A ³			N/A ³			N/A ³			N/A ³		
7/1/69	150	69	7/8/69	> 1000	57-65	7/31/69	< 50	7/30/69	55	64	7/30/69	100	64	7/30/69	< 50	N/A ³	7/30/69	< 50	
8/8/69	143	71	8/7/69	> 1000	61-67	8/14/69	< 50	8/21/69	> 50	66	8/22/69	57	67	8/21/69	< 50	N/A ³	8/21/69	< 50	
9/1/69	84	71	N/A ³			9/22/69	< 50	9/5/69	73	66	9/5/69	115	67	9/22/69	< 50	N/A ³	9/22/69	< 50	
10/2/69	130	71	N/A ³			10/16/69	< 50	10/3/69	72	66	10/3/69	105	67	10/20/69	< 50	N/A ³	10/20/69	< 50	
11/6/69	145	71	N/A ³			11/20/69	< 50	11/5/69	78	66	11/5/69	110	67	11/20/69	< 50	N/A ³	11/20/69	< 50	
12/1/69	135	71	N/A ³			12/16/69	< 50	12/3/69	84	66	12/3/69	130	67	12/22/69	< 50	N/A ³	12/22/69	< 50	
1/6/70	148	71	N/A ³			1/23/70	< 50	1/8/70	80	66	1/8/70	130	67	1/26/70	< 50	N/A ³	2/24/70	< 50	
2/4/70	155	71	N/A ³			2/2/70	< 50	2/2/70	80	66	2/2/70	135	66	2/24/70	< 50	N/A ³	3/24/70	< 50	
3/5/70	180	71	N/A ³			3/2/70	< 50	3/4/70	82	66	3/4/70	135	66	3/24/70	< 50	N/A ³	4/22/70	< 50	
4/9/70	195	71	4/24/70	7	65	4/8/70	< 50	4/1/70	78	66	4/1/70	125	66	4/22/70	< 50	N/A ³	5/19/70	< 50	
5/1/70	200	71	5/1/70	6	65	5/3/70	< 50	5/3/70	70	66	5/4/70	125	66	5/19/70	< 50	N/A ³	6/29/70	< 50	
6/4/70	220	71	6/4/70	7	65	6/26/70	< 50	6/17/70	66	66	6/4/70	30	64	6/29/70	< 50	N/A ³	7/27/70	< 50	
7/22/70	208	71	7/29/70	18	65	7/27/70	< 50	7/1/70	68	65	7/1/70	110	66	7/27/70	< 50	N/A ³	8/24/70	< 50	
8/3/70	375	71	8/14/70	13	65	8/20/70	< 50	8/4/70	67	66	8/4/70	133	66	8/24/70	< 50	N/A ³	9/30/70	< 50	
9/11/70	268	71	9/11/70	15	65	9/28/70	< 50	9/3/70	66	66	9/3/70	105	66	9/30/70	< 50	N/A ³	10/20/70	< 50	
	250	75																	
10/7/70	163	71	10/7/70	12	65	10/19/70	< 50	10/1/70	53	66	10/1/70	93	66	10/20/70	< 50	N/A ³	N/A ³		
	160	75																	

Table E5-1. Tank SX-112 Drywell Radioactivity (K counts per minute) (March 1969 to June 1987)
(Drywell Data Sheets Retrieved March 22, 2011 and SD-WM-TI-356) (2 of 6 sheets)¹

41-12-02 ⁸			41-12-03 ⁵			41-12-04 ⁷		41-12-06 ⁶			41-12-07 ⁶			41-12-09 ⁷			41-12-10 ⁷	
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)
11/3/70	250	71	N/A ³			N/A ³		11/4/70	48	66	11/4/70	110	66	N/A ³			N/A ³	
	248	75																
12/11/70	153	71	12/11/70	5	65	12/23/70	< 50	12/10/70	52	66	12/10/70	88	67	12/29/70	< 50	N/A ³	12/29/70	< 50
	125	75																
1/5/71	160	71	1/5/71	6	65	1/12/71	< 50	1/6/71	49	66	1/6/71	90	67	1/18/71	< 50	N/A ³	1/18/71	< 50
	145	75							9	75								
2/3/71	500	71	2/3/71	17	65	N/A ³		2/5/71	48	66	2/5/71	90	60	N/A ³			N/A ³	
	490	75							9	75								
3/1/71	480	71	3/1/71	15	64	3/25/71	< 50	3/4/71	35	66	3/4/71	70	66	3/29/71	< 50	N/A ³	3/29/71	< 50
	480	75							7	75								
4/12/71	530	71	4/8/71	7	64	N/A ³		4/13/71	< 50	N/A ³	4/13/71	64	66	N/A ³			N/A ³	
	520	75																
5/24/71	535	71	5/24/71	15	64	5/3/71	< 50	5/24/71	< 50	N/A ³	5/24/71	53	66	5/3/71	< 50	N/A ³	5/3/71	< 50
	535	75												5/26/71	< 50	N/A ³	5/26/71	< 50
6/3/71	530	71	6/3/71	17	64	N/A ³		6/3/71	< 50	N/A ³	6/3/71	54	66	N/A ³			N/A ³	
	530	75																
7/9/71	535	71	7/9/71	15	64	7/14/71	< 50	7/29/71	< 50	N/A ³	7/9/71	60	66	7/29/71	< 50	N/A ³	7/29/71	< 50
	540	75																
8/2/71	550	71	8/2/71	17	64	8/17/71	< 50	8/30/71	< 50	N/A ³	8/2/71	52	66	8/18/71	< 50	N/A ³	8/18/71	< 50
	550	75																
9/10/71	560	71	9/10/71	16	64	9/23/71	< 50	9/28/71	< 50	N/A ³	9/8/71	51	66	9/28/71	< 50	N/A ³	9/28/71	< 50
	600	75																
10/6/71	540	71	10/6/71	16	64	10/20/71	< 50	10/22/71	< 50	N/A ³	10/4/71	< 50	N/A ³	10/25/71	< 50	N/A ³	10/25/71	< 50
	560	75																

Table E5-1. Tank SX-112 Drywell Radioactivity (K counts per minute) (March 1969 to June 1987)
(Drywell Data Sheets Retrieved March 22, 2011 and SD-WM-TI-356) (3 of 6 sheets)¹

41-12-02 ⁸			41-12-03 ⁵			41-12-04 ⁷		41-12-06 ⁶			41-12-07 ⁶			41-12-09 ⁷			41-12-10 ⁷	
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)
11/1/71	550	71	11/1/71	15	64	11/10/71	< 50	11/15/71	< 50	N/A ³	11/17/71	< 50	N/A ³	11/17/71	< 50	N/A ³	11/17/71	< 50
	600	75																
12/3/71	300	71	12/3/71	6	65	12/14/71	< 50	12/15/71	< 50	N/A ³	12/15/71	< 50	N/A ³	12/15/71	< 50	N/A ³	12/15/71	< 50
	290	75																
1/4/72	303	71	1/4/72	6	65	N/A ³		N/A ³			N/A ³			N/A ³			N/A ³	
	308	75																
2/2/72	230	70	2/6/72	12	64	2/8/72	< 50	2/15/72	< 50	N/A ³	2/15/72	< 50	N/A ³	2/15/72	< 50	N/A ³	2/15/72	< 50
	95	77																
	10	101																
	11	120																
4/11/72	260	70	4/11/72	7	64	N/A ³		N/A ³			N/A ³			N/A ³			N/A ³	
	105	77																
	15	120																
5/5/72	230	70	5/5/72	6	64	N/A ³		N/A ³			N/A ³			N/A ³			N/A ³	
	95	77																
	15	120																
6/1/72	228	70	6/1/72	5	64	N/A ³		N/A ³			N/A ³			N/A ³			N/A ³	
	95	77																
	15	120																
7/3/72	95	70	7/3/72	3	64	N/A ³		N/A ³			N/A ³			N/A ³			N/A ³	
	37	77																
	4	120																

Table E5-1. Tank SX-112 Drywell Radioactivity (K counts per minute) (March 1969 to June 1987)
(Drywell Data Sheets Retrieved March 22, 2011 and SD-WM-TI-356) (4 of 6 sheets)¹

41-12-02 ⁸			41-12-03 ⁵			41-12-04 ⁷		41-12-06 ⁶			41-12-07 ⁶			41-12-09 ⁷			41-12-10 ⁷	
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)
8/1/72	95	70	8/1/72	2	64	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³
	38	77																
	3	120																
9/13/72	350	70	9/12/72	14	64	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³
	115	77																
	10	120																
10/3/72	280	72	10/2/72	7	64	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³
	120	79																
	5	120																
11/7/72	298	72	11/6/72	9	64	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³
	120	79																
	3	120																
12/8/72	190	72	12/7/72	8	64	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³
	103	79																
	5	120																
1/3/73	260	72	1/3/73	6	64	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³
	153	79																
	15	120																
2/6/73	380	72	2/6/73	14	64	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³
	205	79																
	13	120																
3/5/73	41	72	3/5/73	15	64	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³	N/A ³
	250	79																

Table E5-1. Tank SX-112 Drywell Radioactivity (K counts per minute) (March 1969 to June 1987)
(Drywell Data Sheets Retrieved March 22, 2011 and SD-WM-TI-356) (5 of 6 sheets)¹

41-12-02 ⁸			41-12-03 ⁵			41-12-04 ⁷		41-12-06 ⁶			41-12-07 ⁶			41-12-09 ⁷			41-12-10 ⁷									
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)								
4/3/73	420	72	N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			N/A ³									
	225	79																								
5/1/73	380	72	N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			N/A ³									
	212	79																								
6/18/73	465	72	6/11/73	11	64	N/A ³		N/A ³			N/A ³			N/A ³			N/A ³									
	223	79																								
7/3/73	175	67	7/2/73	17	62	N/A ³		N/A ³			N/A ³			N/A ³			N/A ³									
	105	73																								
8/6/73	335	70	8/6/73	11	63	N/A ³		N/A ³			N/A ³			N/A ³			N/A ³									
	215	76																								
9/12/73	417	69	9/12/73	11	61	9/13/73	< 12	9/13/73	< 12	N/A ³	9/13/73	< 15	N/A ³	9/13/73	19	63	9/13/73	< 12								
	250	75																								
12/29/73	330	71-77	12/6/73	12	61	N/A ³		N/A ³			N/A ³			N/A ³			N/A ³									
N/A ³			2/11/74	11	62	N/A ³		N/A ³			N/A ³			N/A ³			N/A ³									
4/18/74	390	73-80	4/18/74	11	64	4/10/74	< 12	4/10/74	< 12	N/A ³	4/10/74	< 12	N/A ³	4/26/74	14	62	4/10/74	< 12								
8/9/74	245	69	N/A ³			7/12/74	< 3 ²	7/12/74	< 3 ²	N/A ³	7/12/74	< 4 ²	N/A ³	7/17/74	< 12	N/A ³	7/12/74	< 3 ²								
8/15/74	331	72	8/15/74	10 ²	65	N/A ³		N/A ³			N/A ³			N/A ³			N/A ³									
2/6/75	349	71	N/A ³			1/23/75	< 3	1/23/75	< 3	N/A ³	1/23/75	< 3	N/A ³	1/23/75	< 3	N/A ³	1/23/75	< 3								
7/16/75	296	70	7/6/75	10	65	7/22/75	< 3	7/22/75	< 3	N/A ³	7/22/75	< 3	N/A ³	7/22/75	< 3	N/A ³	7/22/75	< 3								
N/A ³			7/16/75	10	65	N/A ³		N/A ³			N/A ³			8/1/75	< 3 ²	N/A ³	N/A ³									
4/6/76	327	72	4/6/76	7	65	4/7/76	< 3	4/7/76	< 3	N/A ³	4/7/76	< 3	N/A ³	4/7/76	< 3	N/A ³	4/7/76	< 3								
5/4/76	369	69	N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			N/A ³									
8/3/76	338	70	N/A ³			N/A ³		N/A ³			N/A ³			N/A ³			N/A ³									
8/2/77	376	69	8/2/77	7	63	8/3/77	< 3	8/3/77	< 3	N/A ³	8/3/77	< 3	N/A ³	8/14/77	< 3	N/A ³	8/3/77	< 3								

Table E5-1. Tank SX-112 Drywell Radioactivity (K counts per minute) (March 1969 to June 1987)
(Drywell Data Sheets Retrieved March 22, 2011 and SD-WM-TI-356) (6 of 6 sheets)¹

41-12-02 ⁸			41-12-03 ⁵			41-12-04 ⁷		41-12-06 ⁶			41-12-07 ⁶			41-12-09 ⁷			41-12-10 ⁷	
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)
3/7/78	472	69	3/7/78	8	67	7/4/78	< 3	7/6/78	< 3	N/A ³	7/4/78	< 3	N/A ³	7/6/78	< 3	N/A ³	7/6/78	< 3
4/4/78	127 ²	69	5/25/78	1425 ⁴	63	N/A ³		N/A ³			N/A ³			N/A ³			N/A ³	
7/4/78	142	69	6/6/78	1775	63	N/A ³		N/A ³			N/A ³			N/A ³			N/A ³	
5/25/79	164	72	7/17/79	1663	62	7/17/79	< 3	7/17/79	< 3	N/A ³	7/17/79	< 3	N/A ³	7/17/79	< 3	N/A ³	7/17/79	< 3
7/14/80	158	68	7/14/80	1894	63	7/14/80	< 3	7/14/80	< 3	N/A ³	7/14/80	< 3	N/A ³	7/14/80	< 3	N/A ³	7/14/80	< 3
6/15/81	164	70	6/16/81	1890	64	6/16/81	< 3	6/16/81	< 3	N/A ³	6/16/81	< 3	N/A ³	6/16/81	< 3	N/A ³	6/16/81	< 3
7/26/82	169	70	7/28/82	1844	64	7/28/82	< 3	7/28/82	< 3	N/A ³	7/27/82	< 3	N/A ³	7/27/82	< 3	N/A ³	7/27/82	< 3
6/14/83	141	71	6/23/83	1861	65	6/23/83	< 3	6/23/83	< 3	N/A ³	6/23/83	< 3	N/A ³	6/23/83	< 3	N/A ³	6/23/83	< 3
6/11/84	105	70	6/12/84	1799	65	6/12/84	< 3	6/12/84	< 3	N/A ³	6/12/84	< 3	N/A ³	6/12/84	< 3	N/A ³	6/12/84	< 3
6/11/85	139	72	6/12/85	1899	66	6/12/85	< 3	6/12/85	< 3	N/A ³	6/12/85	< 3	N/A ³	6/12/85	< 3	N/A ³	6/12/85	< 3
6/11/86	145	72	6/10/86	1568	66	6/10/86	< 3	6/10/86	< 3	N/A ³	6/10/86	< 3	N/A ³	6/10/86	< 3	N/A ³	6/10/86	< 3
6/25/87	148	72	6/25/87	1348	67	6/24/87	< 3	6/24/87	< 3	N/A ³	6/24/87	< 3	N/A ³	6/24/87	< 3	N/A ³	6/24/87	< 3

Note: ¹If Depths were not available, the column was omitted from the table

²New Monitoring Equipment

³N/A: Data not available

⁴Changed from using a GMP to a SSP

⁵Readings were recorded using the Scintillation Probe (SP) from March 1969 to July 22, 1970. Then a GMP was used from July 1970 to March 1978.

⁶Readings were recorded using a SP from July 1969 to 1971. The type of probe used after 1971 was not specified.

⁷Readings were recorded using a SP from 1969 to February 1972. GMP used for the remainder of the time.

⁸Readings were recorded using a GMP

⁹Referenced from WHC-MR-0300 Supplement 1, page 7-2

APPENDIX F5

TANK SX-112 LEAK INFORMATION

**Table F5-1. Tank SX-112 Leak Information
(RPP-ENV-39658) (1 of 2 sheets)**

Date	Event as Described in Reference
1/16/1969 ^a	<p>1/16/69, Page 21: Due to liquid level drop in 112-SX, decided to pump tank contents to 114-SX. Jumper changes made and started pumping at 2310 on 1/16/69.</p> <p>1/19/69, Page 23: Transfer of some waste from 112 to 114-SX completed. 112 liquid level appears to be holding at 8 feet 4 inches.</p> <p>1/20/69, Page 25: Liquid level holding at 8 feet. However, routing has been established to pump 112-SX to 110-SX should it become necessary.</p> <p>1/21/69, 1/21/69: 112-SX Liquid level dropping slightly.</p> <p>1/22/69, 1/22/69: 112-SX liquid level dropped slightly (about one inch).</p> <p>1/23/69, Page 31: Pumping 112-SX to 110-SX.</p> <p>1/26/69, Page 33: 112-SX Portable exhaustor installed and pictures taken on 1/25/69. Some sludge exposed, but considered to be no problem.</p> <p>1/27/69, Page 35: 112-SX Liquid level holding at four feet.</p> <p>1/29/69, Page 39: 112-SX Liquid level holding at about 4 feet.</p> <p>1/30/69, Page 41: 112-SX Liquid level holding at about 4 feet.</p> <p>2/2/69, Page 43: 112-SX Liquid level holding at about 4 feet.</p> <p>2/9/69, Page 67: 112-SX Liquid level holding at 4 feet. Took pictures in 107, 108, 112-SX.</p>
1/1969 ^b	<p>Tank Leak, 241-SX-112</p> <p>A gradual liquid level decrease in TK-112-SX, first observed in mid-January, indicated the existence of a leak in the tank even though no increase in leak detection laterals readings were observed. Based on the liquid level measurements, up to 27,000 gallons of supernatant liquid containing about 40,000 curies of cesium-137 may have leaked from the tank. The 112-SX liquid level was reduced from about 20 feet to about 8 feet by pumping to other boiling tanks in the SX Farm. During the following week the tank level held essentially constant, but the radiation readings in the leak detection laterals began rising sharply, apparently as a result of the migration of activity from the initial leak. The liquid level was further reduced to four feet above the normal bottom liner location. Photographs showed twisted and broken pipes and equipment apparently resulting from a raised liner. The extent of the bulge is being mapped to determine the sludge thickness from which the feasibility of air cooling can be determined.</p>
2/1969 ^c	<p>After positive radiation readings were observed in the laterals beneath Tank 112-SX, the maximum liquid level was reduced to four feet to maintain the hydrostatic head at a minimum without exposing any sludge. The rate of rise of the radiation readings in the leak detection laterals has been drastically reduced, and an excellent material balance (condensate being added, compared to boiloff rate) indicates no additional leakage is occurring. Eight risers were installed through the dome, and the sludge surface has been mapped. A maximum sludge height variation of 30 inches was found, which is much less than that found in other SX farm tanks. Thermocouple trees have been installed in each of the eight risers. The forthcoming sludge temperature profiles and sludge thickness measurements will be analyzed to determine if air cooling can provide adequate heat removal for Tank 112-SX in the near future.</p>

**Table F5-1. Tank SX-112 Leak Information
(RPP-ENV-39658) (1 of 2 sheets)**

Date	Event as Described in Reference
3/1969 ^d	Sludge Removal, Tank 241-SX-112 - Mapping of the bulged liner and sludge depth indicates that Tank 112-SX sludge thickness varies from 0.0 to 3.1 feet. Heat transfer analyses indicate that the tank can be safely air cooled, and installation of necessary equipment is proceeding. The tank is being held at a reduced liquid level by recycling tank farm condensate to replace water evaporated by the decay heat.
7/1974 ^e	Photograph depicts an apparent crack in the sidewall of tank 241-SX-112 above the 4 th stiffer ring (about 16 foot level).

^a ARH-1023-DEL, *Chemical Processing Division Daily Production Reports January, 1969 through March, 1969*.

^b ARH-1100-DEL, *200 Areas Operation Monthly Report January 1969*, page G-4.

^c PR-REPORT-FEB69-DEL, *Monthly Status and Progress Report February 1969*, page AIV-5.

^d PR-REPORT-MAR69-DEL, *1969, Monthly Status and Progress Report March 1969*, page AIV-4.

^e Internal memo ARHCO-072674, "Apparent Liner Crack in 112 SX;" see Figure 5.7-3.

APPENDIX G5

TANK SX-112 WASTE SURFACE (MARCH 1987)

Figure G5-1. Tank SX-112 Waste Surface (March 1987)

APPENDIX H5
TANK SX-112 LATERAL GAMMA LOGGING

**Figure H5-1. Gamma Survey for Lateral 44-12-01 on Logarithmic Scale May 2005
(RPP-RPT-27605)**

**Figure H5-2. Gamma Survey for Lateral 44-12-02 on Logarithmic Scale May 2005
(RPP-RPT-27605)**

**Figure H5-3. Gamma Survey for Lateral 44-12-03 on Logarithmic Scale May 2005
(RPP-RPT-27605)**

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9.1 TANK SX-113 BACKGROUND HISTORY

This section provides information on the historical waste loss event associated with SST 241-SX-113 (SX-113). Tank SX-113 has five prototype laterals installed in December 1958 about 10-ft under the tank (see Figure 9-1). There are two drywells located around tank SX-113: 41-00-05 installed in 1956 and 41-13-10 installed in 1958.

The bottom of the tank footing is ~52-ft 8-in BGS with ~6-ft 7-in soil cover over the dome (WHC-SD-WM-TI-665). Inside tank SX-113 there are four ALCs 18-in above the tank bottom and equally spaced on a 40-ft diameter circle as shown in Figure 9-1 (H-2-39951). Two ALCs are designated low ALCs (8-ft 6-in tall) and two are high ALCs (13-ft 6-in tall) (H-2-9950).

Figure 9-1. Tank SX-113 Associated Drywells and Laterals
Tank inner ring is steel liner, outer ring is outer edge of tank footing

9.2 TANK SX-113 OPERATIONS SUMMARY

Tank SX-113 was constructed from 1953 to 1954 and started receiving REDOX HLW on February 20, 1958 (HW-57249, *Interim Report on Displacement of the REDOX 113-SX Waste Storage Tank Liner*). In later tank farms, tanks receiving boiling waste were preheated prior to use to minimize heat transfer stresses. However, tanks in the SX Farm were not fitted with steam coils and tank SX-113 was not preheated prior to use (RHO-R-39). This sequence of events is important because tank SX-113 was first connected to the exhaust ventilation system before receiving any waste.

After initially receiving waste, waste temperatures rose from 42°F on February 26, 1958 to ~155°F one week later on March 5, 1958 (see Figure 9-2 and Appendix B6). Tank SX-113 received approximately 483 kgal of REDOX HLW through June 2, 1958 with continuous self-boiling commencing April 22, 1958 (HW-57249, page 4).

Sometime prior to May 28, 1958, tank SX-113 liner bulged upwards and was the first tank to fail in SX Farm. Operations personnel observed “... *that the volume received in the tank exceeded slightly the volume sent, a condition not uncommon where interchange of water vapor is possible. Attempts, on May 28, 1958, to install an experimental, replaceable air-lift circulator in the newly activated 113-SX storage tank failed when the circulator encountered an obstruction. Subsequent soundings through several nearby openings in the tank*”, i.e., risers, “*indicated the steel lining of the tank to be elevated to a height greater than four feet above its original position. Measurements in several other tanks in the SX farm revealed no similar abnormality. Routing of waste to the 113-SX tank was terminated on June 2, 1958. During a seven-day period starting June 11, 1958, the liner returned to its original position with an apparent net loss in volume of approximately 63,000 gallons. The volume remaining following the collapse of the liner, however, was in good agreement with the volume sent, indicating the liner was probably intact. Because of the stresses suffered by the liner, the tank contents were pumped to another SX farm tank*”, i.e. SX-103, “*during a two-day period starting July 23, 1958*” (HW-57249, page 2).

Additional information on the chronology of events for tank SX-113 was located in several of the operating contractor monthly reports for the Hanford Site and is summarized in Appendix D6. The ALCs in tank SX-113 were operated from April 7, 1958 through July 22, 1958 to provide added waste cooling. The ALCs were shut off on July 22, 1958 to enable removal of tank contents to tank SX-103.

The leak integrity of tank SX-113 was uncertain following the events in 1958. Less than 0.1-mrem/hr gamma radioactivity was detected in the laterals installed December 1958 underneath tank SX-113 when first monitored in January 1959 (HW-59079-DEL, *Chemical Processing Department Monthly Report for January, 1959*, Page H-5), indicating the tank integrity was intact. Additional monitoring of the laterals underneath tank SX-113 reported no radiation was detected through August 2, 1962 (HW-74804, *Chemical Processing Department Monthly Report August, 1962*, page C-4). Further monitoring of the laterals under tank SX-113 and drywells 41-13-10 and 41-00-05 also failed to detect any radioactivity indicative of a leak from tank SX-113 (Internal letter LET-081562, “Leak Testing of the 113-SX Tank”). A leak test

was conducted on tank SX-113 in October 1962 in order to confirm its integrity and the possibility of resuming its use.

As reported in HW-75714, *Leak Testing of the 113-SX Tank*, leak testing of tank SX-113 began on October 10, 1962 and was terminated on November 13, 1962, following a liquid level decrease and an increase in activity in three of the laterals under the tank. Following the confirmation of the leak, the remaining contents of tank SX-113 were transferred to tank SX-114 on November 14 and 15, 1962.

Approximately 45 tons of diatomaceous earth was added to tank SX-113 in 1972 (ARH-CD-222, *Characterization of the Effects of Diatomaceous Earth Additions to Hanford Wastes*, page 4). The addition of the diatomaceous earth was conducted to adsorb and immobilize the liquid waste heel in tank SX-113 that could not be removed through pumping techniques available in 1972. The tank was air cooled and declared interim stabilized/partially isolated in 1978. As of 2007, tank SX-113 is estimated to contain 19 kgal of sludge comprised of 2 kgal of REDOX HLW sludge and 17 kgal of diatomaceous earth with adsorbed supernatant, equivalent to a depth of 15-in. No pumpable liquid remains in the tank (HNF-EP-0182, *Waste Status Summary Report for Month Ending January 31, 2009*).

The operational history of tank SX-113 leak related details including temperature and liquid level is charted in Figure 9-2.

Figure 9-2. Operational Leak History of Tank SX-113

9.3 TANK DESIGN/CONSTRUCTION

9.3.1 Tank Design

The SX Farm tanks had multiple design features that could contribute to stresses or possible leak paths when the tank was being operated including:

- Orthogonal intersection between the steel bottom and the sidewall
- Fillet weld used between the bottom and sidewall intersection
- Less rigorous weld inspection testing
- Partial asphaltic membrane waterproofing
- Keyed construction joints in the sidewall

These features are common to all SX Farm tanks and additional details are discussed in Section 3.1.1.

9.3.2 Tank Construction Conditions

The outside temperature between January 16, 1954 and January 30, 1954 ranged from an average high of 24°F to an average low of 9°F. A picture of the SX Farm under construction (see Figure 3-4) taken January 20, 1954 (high 11°F low -6°F), shows several of the tanks full of water either undergoing leak testing or for concrete wall pouring. During this cold period snow covered ice is seen in the water filled tanks.

As described in Section 3.1.2, cold weather affects the ductile-to-brittle steel transition temperature, with 18°F being the assumed unrestricted low temperature construction limitation for the carbon steel liner, which could result in a fracture upon impact. Low temperatures experienced during construction at or less than the 18°F allowable temperature could cause impact loading (e.g. a dropped tool or piece of equipment from scaffolding) and result in the potential for creating micro-fissures weakening the steel liner.

9.4 TANK SX-113 IN-TANK DATA

9.4.1 Liquid Level

Liquid level measurements of tank SX-113 were obtained by lowering an electrode until it touched the liquid surface. Liquid level was then calculated by difference from the reference elevation at the top of the tank with a precision of $\pm \frac{1}{4}$ -in (HW-57249, page 3). The first liquid level measurement taken on February 24, 1958 was reported at 1-ft 1 $\frac{1}{4}$ -in (21,602 gal) and according to the D-8 transfer records, 21,546 gal had been pumped to the tank. During a five day period in April 1958, liquid levels increased from 6-ft 8-in to 7-ft 5-in despite no waste transfers during this time. However, by April 11, 1958 liquid levels gradually decreased to 6-ft 7 $\frac{1}{2}$ -in. This liquid level change in April 1958 was believed to be due to a layer of foam in the tank and liquid levels returned back to approximately the original level as air was turned on to the ALCs (see Appendix F6). However, it is also possible that the liner bulged during this period causing these discrepancies in liquid level.

Liquid levels and bulb temperatures from 1958 for tank SX-113 are shown in Figure 9-3. After the possible bulge in February-April 1958, tank SX-113 started bulging again before May 28, 1958 as indicated by a positive tank SX-113 material balance. Waste transfers to tank SX-113 were stopped June 2, 1958 at which time the bulge was confirmed. Sixteen days later, the liner returned to its original position which was supported by soundings and the liquid level. Normal boil off occurred from June 18, 1958 until July 22, 1958. Tank SX-113 contents were then pumped to tank SX-103 over a two day period since the integrity of the liner was questionable. Approximately 16 days after the tank was emptied, the liner rose again to ~40-in and returned to its original position by the end of August (see Section 9.4.3, Appendix D6, and Appendix F6).

Figure 9-3. Tank SX-113 Liquid Level and Bulb Temperature (January 1958 to January 1959)

Tank SX-113 was the first tank to fail in SX Farm probably in May 1958 when the liner was first confirmed to have bulged upwards by ~4-ft. A leak detection system consisting of laterals was installed underneath the tank. Periodic monitoring of the five laterals and nearby drywells failed to detect any radioactivity indicative of a leak during this time.

To test the integrity of tank SX-113, leak testing began on October 10 and 11, 1962, and approximately 65 kgal of sodium nitrate leached waste from REDOX HLW sludge at 168°F was transferred from tank SX-114 to tank SX-113. Liquid level measurements in tank SX-113 indicated a volume decrease of ~2.8 kgal during the period October 11, 1962 through October 29, 1962. However, a leak in tank SX-113 remained inconclusive since 1.1 to 1.2 kgal of this volume decrease was attributed to cooling the solution from 168°F to 107°F and the measured volume of waste in tank SX-113 was greater than that initially transferred from tank SX-114 (HW-75714, page 4).

During the second stage of the leak testing, tank SX-113 was filled to the 80-in level when 143 kgal of additional waste was transferred from tank SX-114 to tank SX-113, beginning October 30, 1962 and completed November 2, 1962. A leak was indicated when the liquid level of tank SX-113 decreased 2-9/16-in, or ~7 kgal, in five days by November 7, 1962. A pump was then installed in tank SX-113 to transfer the remaining waste back to tank SX-114. Increasing activity of the laterals underneath tank SX-113 on November 13, 1962 confirmed the presence of a leak indicating a leak likely at or near the bottom of the tank as opposed to a sidewall leak (see Section 9.6). However, it is possible there may be a sidewall leak that was not detected in the drywells since low levels of radioactivity were detected in the laterals outside of the tank shadow (see Section 9.5.1). The supernatant was then pumped out of the tank to tank SX-114 from November 14-15, 1962 as shown in Figure 9-4 (HW-75714).

Figure 9-4. SX-113 Liquid Level Data
October 10, 1962 to November 15, 1962
(HW-75714)

The liquid level plot in Figure 9-5 indicates the transfer activity into and out of tank SX-113. The liquid levels are end of quarter levels so this figure may not reflect all transfers into and out of the tank that occurred during the operational history of the tank. See Figure 9-2 for historical monthly liquid level readings.

Figure 9-5. Tank SX-113 End of Quarter Surface Level

WHC-SD-WM-ER-352, Rev 0, June 30, 1994, Historical Tank Content Estimate for the Southwest Quadrant of the Hanford 200 West Area

9.4.2 Temperature

Tank SX-113 was not preheated prior to the initial filling of waste which was first received on February 20, 1958 (HW-57249). Temperatures quickly rose from ~42°F to ~155°F, 13 days later on February 26, 1958 and continued to increase to an equivalent boiling temperature of 240°F in July 1958. An initial sludge temperature of 42°F was recorded February 26, 1958 while the average February temperature of ~44.5°F (taken at the 3-ft level) was recorded at the Hanford Meteorological Station tower (PNNL-15160, *Hanford Site Climatological Summary 2004 with Historical Data*). Thus, it is possible temperatures prior to filling the tank could be below 42°F resulting in a larger initial rate of temperature increase. The available thermal history for tank SX-113 starts in February 1958 (see Appendix B6).

Waste temperature gradually increased and peaked to ~260°F in early July 1958, as the tank was filled for the first time with REDOX HLW. The supernatant was removed from tank SX-113 later that month after a liner bulge was found and the waste temperature began to slowly decline.

9.4.3 Liner Observations

A bulge in a tank liner may result in the direct failure of the liner or cause enough stress or thinning on the steel liner plates and welds that they become more susceptible to the effects of corrosion. Tank SX-113 experience indicates that bulging tends to be a dynamic phenomenon, and it is possible that a tank with no measured bulge at one point in time may actually have had a displaced liner that was not detected at another time. A bulge could result in a leak through the liner which may be detected in laterals or drywells.

A failed attempt to install an experimental replaceable ALC into tank SX-113 due to the circulator encountering an obstruction on May 28, 1958 led to the discovery of the steel liner bulging about four feet upwards from its normal position (HW-56218-DEL, *Chemical Processing Department Monthly Report for May 1958*, page D-4). The bulge was later confirmed in early June 1958 through subsequent soundings through several nearby openings in the tank (i.e. risers), and waste receipts stopped. The bulge apparently “formed an approximate simple curve and each quadrant of the tank was raised about the same direction” as indicated by document HW-56602-DEL, *Chemical Processing Department Monthly Report for June 1958*, page H-7. The spherical arc of the liner displacement extended to a distance of 20-ft from the center of tank SX-113 and calculations showed the length to exceed the original liner diameter by more than two inches. An elongation of two inches would require that either the liner be pulled away from the wall at the base or the steel in the bottom be stressed beyond the elastic limit (HW-57249, page 3). By the week of June 17, 1958, the tank bottom returned to its normal position; however, the integrity of the tank was in doubt and pumping of the contents in tank SX-113 to tank SX-103 began at the end of July 1958 (HW-56602-DEL).

Approximately 16 days after tank SX-113 was emptied leaving a heel of ~20 kgal, the liner rose again over a 15 day period to a height of approximately 40-in above its original position (HW-57328-DEL, *Chemical Processing Department Monthly Report for August 1958*). The temperature, as indicated by a mercury-filled thermometer, rose from an average of 218°F to 224°F approximately two days before the liner bulged. The liner returned to approximately normal position several days later.

In February 1962 a periscope was installed in tank SX-113 and no visible damage to the SX-113 tank liner was found (LET-081562). See Appendix D6 and Appendix F6 for further details regarding the bulging liner of tank SX-113.

The causes of the tank SX-113 liner bulging were reviewed and documented in HW-57274, *Instability of Steel Bottoms in Waste Storage Tanks*. Several liner bulging mechanisms were explored in this document. Heating of any water existing below the steel liner was described as trapping pressurized vapor which resulted in forces that caused the liner to deform (bulge). The design of the orthogonal sidewall to bottom joint was postulated to trap the pressurized vapor under the liner as opposed to previous knuckle designs. This in turn increased the temperature

due to the lower vapor space heat transfer coefficient which decreased the heat transfer from the bottom of the tank which compounded the situation.

The exhaust system butterfly valve was opened to tank SX-113 one day before waste was transferred to the tank (HW-57249, page 14). The bottom tank liner could be deflected (bulged upward) if the vacuum was high enough. Document OSD-T-151, Rev. F-0, *Operating Specifications for Single-Shell Waste Storage Tanks*, stated that... “*The fans on older ventilation systems, such as SX Farm, had a lower design capacity than fans currently in use and were capable of only pulling a vacuum in the range of -6-7 inches water gauge*”. Vacuum limits on SX Farm tanks were not found before January 1979 (RHO-MA-151, *Specifications and Standards for the Operation of Radioactive Waste Tank Farms and Associated Facilities*). Previous specification/limit documents for SX Farm did not address vacuum limitations (HW-59919; ARH-951; ARH-CD-309A, *Interim Criteria for Waste Storage in the 241-SX Tank Farm*). However, an allowable SX Farm tank vacuum of -6-in was found in a letter dated December 17, 1954 (LET-121754, “*Recording of Tank Pressures in the 241-SX Tank Farm*”). A vacuum limit of -6-in water gauge (w.g.) was required for A and AX Farms in 1965 (RL-SEP-269, *Specifications and Standards for Operational Control of the PUREX Self-Boiling Tank Farms*) which had a higher capacity and installed seal loops. A review of an early construction drawing H-2-39901, *Tanks (SX) 107-115 Manifold Facilities*, did not indicate any installed vacuum seal loops for vacuum control. The first vacuum operating specification limit found for SX Farm was -5.9-in w.g. in OSD-T-151, Rev. D-0; previous revisions did not address vacuum. The vacuum requirement was deleted in OSD-T-151, Rev. D-1. The vacuum limit was defined as -1.9-in w.g. in a subsequent OSD-T-151, Rev. E-0, and was increased to -2.4-in w.g. in later revisions (see Section 9.9.4). Therefore, there seems to be some capability of pulling a vacuum on an empty tank at or above the limit.

The initial liner bulge detected May 28, 1958 could have resulted from the presence of a vacuum on an empty tank resulting in the liner being displaced upwards at least to some degree. When waste was transferred into the tank conversion of moisture in the grout below the liner to steam probably continued the displacement of the liner to the final height of 48-in. It seems unlikely the presence of a vacuum in tank SX-113 caused the full height of the initial liner bulge since the first liquid level measurements were at elevations below the maximum elevation to which the liner was displaced at that location (HW-57249). The first liquid level measurements did show a slight positive discrepancy in tank SX-113 that increased with time. This indicates that most of the displacement of the liner occurred after waste was initially added to tank SX-113 (see Appendix F6). Thus, the initial liner bulge may have been both the result of vacuum on an empty tank and the heating of grout moisture below the liner. The subsequent liner bulge after pumping the tank was likely caused by moisture from a leaking liner as most or all of the grout moisture should have dissipated by that time.

9.4.4 Chemistry-Corrosion

Waste Chemistry

Tank SX-113 began receiving REDOX HLW (R) in February 1958 and stored only this waste type throughout operation except when nitrate leachate waste was used during the leak test in October 1962 (see Table 9-1). The typical concentrations for nitrite, nitrate, and hydroxide for

these waste types are shown in Table 9-2. Nitrite and hydroxide are known as nitrate-induced SCC inhibitors. One key characteristic for inhibiting SCC is to maintain a high nitrite concentration to nitrate concentration ratio (see Section 3.2.4).

Table 9-1. Tank SX-113 Waste Storage Chronology

Date	Waste Type	Length of Storage
February to July 1958	REDOX HLW	~ 6 months
October to November 1958	Nitrate leachate waste	~ 1 month

Table 9-2. Waste Chemistries for Waste Types Stored in Tank SX-113

Waste Type	[NO ₃] ¹	[NO ₂] ¹	[OH] ¹	Meets Current DST Specification ²
R ³	4.83	0.74		No ⁴

1. Reference WHC-EP-0449, 1991, *The Sort on Radioactive Waste Type Model: A Method to Sort Single-Shell Tanks into Characteristic Groups*.
2. Reference OSD-T-151-00007, Rev. 12, (2013), *Operating Specifications for the Double-Shell Storage Tanks*.
3. Reference WHC-EP-0772, 1994, *Characterization of the Corrosion Behavior of the Carbon Steel Liner in Hanford Site Single-Shell Tanks*.
4. Does not meet the current DST specification since the hydroxide and nitrite concentrations are not greater than or equal to 1.2M.

Tank SX-113 only stored waste for about 7 months total and REDOX HLW was the only waste stored during the first six months of operation before the bottom liner bulged. REDOX HLW does not meet the current DST specification for waste chemistry due to low concentrations of the nitrate-induced SCC inhibitors, nitrite and hydroxide. Thus, these conditions of the REDOX HLW would likely create an environment conducive to SCC and/or pitting (see Section 3.2.4).

Nitrate Leaching

The review of operating transactions in Section 9.2 indicated there was no sodium nitrate sludge leaching of the waste in tank SX-113. In addition, RHO-R-39 listed tank SX-113 sludge as not having been sodium nitrate leached (see Appendix A6). The waste from tank SX-114 transferred to tank SX-113 for leak testing in 1962 was nitrate leached waste, and temperatures ranged from 105°F to 117°F. The bulging of the liner could have caused stress locations which may have been more vulnerable to nitrate-induced SCC (see Section 9.4.3).

9.4.5 Photographs

There were no photographs taken during 1958 to confirm the presence of a liner bulge. Earliest photographs were taken in March 1968 but these photographs were foggy and could not validate that a liner bulge once existed in tank SX-113. Photographs of tank SX-113 taken on January 23, 1970 were reviewed and two photographs of ALCs with detached turnbuckle guy rods are shown in Figure 9-6 and Figure 9-7. Figure 9-6 shows ALC #2 apparently missing a turnbuckle guy rod in the northwest quadrant of the tank and Figure 9-7 shows ALC #3 apparently also missing a turnbuckle guy rod in the southwest quadrant of the tank.

The locations of all ALCs in tank SX-113 are shown in Figure 9-8 with the two ALCs (#2 and #3) located in the western portion of the tank possibly showing evidence of a liner bulge. These are the only ALCs that have visible detached turnbuckle guy rods during this time. This may be evidence of a liner bulge that could have resulted in failure of the turnbuckle guy rod bottom liner attachment. However, detachment of the ½-in diameter turnbuckle guy rod as well as bent piping could also be the result of mixing the waste when the ALCs were operating with the resulting forces on internal equipment. The locations of the previous bulges could not be determined after reviewing photographs of tank SX-113. The first bulge, approximately four feet upwards, was located in the central portion of the tank when equipment installation detected a bulge later confirmed by rodding the tank. Liner bulge measurements indicated an approximate simple curve with each quadrant of the tank raised about the same that extended 20-ft from the center of the tank (see Section 9.4.3). It appears the liner bulge did not affect the ALCs in the eastern portion of the tank (ALC #1 and #4) since all available photographs do not show any anomalies.

**Figure 9-6. Tank SX-113 ALC #2 Photograph 700374-25CN
January 23, 1970**

**Figure 9-7. Tank SX-113 ALC #3 Photograph 700374-32CN
January 23, 1970**

Figure 9-8. Tank SX-113 Air Lift Circulator (ALC) Locations
 Tank inner ring is steel liner, outer ring is outer edge of tank footing

9.5 TANK SX-113 EX-TANK DATA

9.5.1 Laterals

Tank SX-113 was the first SST to have a prototype leak detection system consisting of five laterals installed in December 1958, only seven months after the tank liner integrity was questioned as a result of liner bulge. Periodic monitoring of the laterals under the tank from January 1959 to August 1962 failed to detect any leakage from tank SX-113 (HW-75714, page 2). Lateral readings taken August 2, 1962 reported all values along the entire length of all the laterals as less than 100 cpm (LET-081562). These data sheets were not recovered.

Tank SX-113 prototype laterals were installed 10-ft under the tank and varied between 6-ft and 12-ft below the bottom of the tank over the course of a lateral (see Appendix E6). The horizontal alignment was calculated to be within ~2-ft (HW-60749, *Leak Detection System for Active Tanks Interim Report*). The alignment was addressed in HW-60749 which stated, "...*The subcontractor was permitted to complete the five laterals to the best of his ability without official alignment checks because of the short time limit of the construction schedule.*" The other SX Farm tank laterals were installed approximately four years later in 1962 and it was assumed installation of the laterals were improved as no records of vertical or horizontal variation were found.

Leak testing of tank SX-113 occurred during October and November 1962 and confirmed the presence of a leak in November 1962 due to a decrease in liquid level followed by increased radioactivity in the laterals on November 13, 1962 as shown in Figure 9-9 (HW-75714).

The peak activity detected was ~7.5K cpm in lateral 44-13-03 in Figure 9-9 at a distance of ~37-ft from the northwest edge of the tank. Lower levels of radioactivity were also recorded at 0.3K cpm at ~16-ft, 1.5K cpm at ~26-ft, and 0.5K cpm at ~46-ft from the northwest edge of the tank.

Radioactivity was detected in lateral 44-13-04 at 0.3 to 0.8K cpm at a distance of ~35.8 to 38.8-ft from the northwest edge of the tank. The peak radioactivity of 0.8K cpm in lateral 44-13-04 occurred at ~37.8-ft from the northwest edge of the tank. Very low levels of radioactivity were detected in lateral 44-13-05 at 0.05 to 0.15K cpm at a distance of ~2.7 to 6.7-ft south of the tank shadow. Readings in laterals 44-13-01 and 44-13-02 were below 0.5K cpm at this time. No other lateral data were recovered in addition to readings taken on August 2, 1962 and November 13, 1962.

Figure 9-9. Tank SX-113 Lateral Radioactivity (cpm) from November 1962 (HW-75714)

9.5.2 Drywells

The integrity of tank SX-113 was first questioned in July 1958 after a 4-ft bulge was discovered. The first indication of the tank SX-113 leak was in November 1962 after a leak test was performed. There are two drywells located around tank SX-113: 41-00-05 drilled in 1956 and drywell 41-13-10 drilled October 6, 1958 after the liner bulge was found on May 28, 1958 (see Section 9.4.3). All of the radiation readings in drywells are assumed to be maximum values or peak readings unless otherwise noted and are from the Red-GM probe unless otherwise indicated (see Section 3.3.2). The following subsections report the available drywell information and the drywell summary section provides the analyses of the associated drywells with tank SX-113.

9.5.2.1 Drywell 41-13-10 (N50°W)

Drywell 41-13-10 was drilled October 6, 1958 and radiation readings are all reported as less than values starting with the first recoverable reading on November 14, 1962 through June 24, 1987 (see Appendix C6).

In January 1996, Cs-137 was the only man-made radionuclide detected in drywell 41-13-10 from the ground surface to 2-ft BGS (GJ-HAN-15). Document GJ-HAN-15 states, "There is no evidence that any of the Cs-137 contamination identified in this borehole originated from a subsurface source." Since historical records report little radioactivity in this drywell, drywell 41-13-10 is not included as part of the leak location for tank SX-113. Figure 9-10 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 9-10. Tank SX-113 Drywell 41-13-10 (HNF-3136)

Note: Tank base 52-ft 8-in BGS

9.5.2.2 Drywell 41-00-05 (S56°E)

Drywell 41-00-05 was drilled in 1956 and is one of the fifteen drywells that were drilled in and around the SX Farm between 1954 and 1958. Radiation readings are all reported as less than values starting with the first recoverable reading on November 14, 1962 through June 23, 1987 (see Appendix C6). Figure 9-11 shows the depths of radioactivity from 1975 to 1995 (HNF-3136). Therefore, drywell 41-00-05 is not included as part of the leak location for tank SX-113. Drywell 41-00-05 was not logged with SGLS during the 1996 baseline efforts (GJ-HAN-15).

Figure 9-11. Tank SX-113 Drywell 41-00-05 (HNF-3136)

Note: Tank base 52-ft 8-in BGS

9.5.3 Tank SX-113 Drywell Summary

The tank SX-113 leak was confirmed in November 1962 during the leak test which resulted in a liquid level drop and subsequent radioactivity detected in the laterals. Drywells 41-13-10 and 41-00-05 are the only drywells near tank SX-113. These two drywells were monitored on November 14, 1962 and both were reported as having less than 50 cpm gamma activity during this time (HW-75714); all recovered data were reported as less than values from 1971 to 1987. Tank SX-113 drywells 41-13-10 and 41-00-05 do not indicate any radioactivity associated with a tank leak. Therefore, the only leak source location would be described by the lateral radioactivity.

There is a significant time lag from the start of a leak and the detection of gamma-emitting radionuclide through the soil column and the drywell encasement. This could be especially slow with the possibility of self-sealing of the waste in the tank liner, concrete shell, and soil. In addition, since the leak was detected and tank pumped within a short period of time from the start of the leak test there may not have been time for the leak to reach the drywells and be detected.

9.6 POSSIBLE TANK SX-113 LINER LEAK LOCATION(S)

The lateral radioactivity when first detected could be an indication of the location of a liner leak. However, the liner leak may have penetrated the waterproof membrane at any location or pooled on the waterproof membrane and followed concrete cracks or breaks to a different location including the top of the tank footing.

It is likely that the tank SX-113 leak occurred at or near the bottom of the tank because all of the leak indicators (three laterals) were located at or near the bottom of the tank and was closely coupled with the liquid level leak test decrease.

9.7 TANK SX-113 LEAK LOCATION SUMMARY

The tank SX-113 leak was verified November 7, 1962 based on a decrease in liquid level during a planned leak test. A tank leak was later confirmed on November 13, 1962 when activity was detected underneath tank SX-113 in the laterals (see Figure 9-12). Previous lateral readings were recorded as less than 100 cpm in August 1962. Radioactivity was first detected in three laterals (44-13-03, 44-13-04, and 44-13-05) simultaneously on November 13, 1962. The highest level of activity was detected in lateral 44-13-03 with a peak of 7,500 cpm. No activity was detected in laterals 44-13-01 and 44-13-02 and the nearby drywells during this time.

It is possible the leak started in the central portion of the tank due to high levels of radioactivity detected in lateral 44-13-03; however, it remains inconclusive since later lateral data is not available for tank SX-113.

The possibility of a liner bulge in the western portion of the tank has been indicated by ALC #2 and #3 (see Section 9.4.5) which are located in the same portion of the tank where radioactivity has been detected in the laterals. It was recorded the tank liner bulged at least two times and

receded to the original location. The location of the first liner bulge was recorded to be in the central portion of the tank which apparently did not affect ALC #1 and #4 (see Section 9.4.3).

Figure 9-12. Tank SX-113 Possible Radial Leak Locations
 Tank inner ring is steel liner, outer ring is outer edge of tank footing

Note: Laterals are numbered using the conventional numbering system

9.8 ESTIMATED LOCATION OF BULGE

The liner bulge documented in HW-56602-DEL indicated a bulge of approximately four feet in the central portion of the tank when equipment installation detected a bulge later confirmed by rodding the tank. The possible location of the liner bulge is superimposed in Figure 9-13 in relationship to the tank leak location.

Figure 9-13. Tank SX-113 Possible Radial Leak Locations with Estimated Bulge
Tank inner ring is steel liner, outer ring is outer edge of tank footing

9.9 POSSIBLE TANK SX-113 LINER LEAK CAUSE(S)

Tank SX-113 was exposed to five conditions that could contribute to a failed liner. Some or all of the factors can act together to contribute to tank liner failure.

9.9.1 Tank Design

The design of the SX Farm tanks was the first that diverged from the round bottom knuckle design used in the earlier waste tanks; the tank bottom liner intersects the sidewall liner orthogonally. A fillet weld was used to close the seam where the sidewall and the tank bottom liners meet. Several other SSTs with fillet welds failed during service (RPP-RPT-45921). Weld inspections were less rigorous. Additionally, the design discontinued the use of the three-ply asphaltic membrane waterproofing between the liner sidewall and the concrete shell. These features were inferior to earlier designs and could possibly increase the likelihood of failure of the tank liner from induced stresses (see Section 9.3.1).

9.9.2 Thermal Conditions

Temperature requirements in HW-59919 issued October 22, 1959 indicated that the self-boiling waste operating temperature should be maintained between 50°F and 220°F. The HW-59919 document recommended a uniform rate of temperature increase of 2°F per day and the maximum sludge temperature should not exceed 300°F.

The tank SX-113 bulb (sludge) temperatures are shown in Appendix B6. The maximum temperature of 254°F on July 9, 1958 did not exceed the maximum sludge temperature of 300°F.

Waste was first received on February 20, 1958 (HW-57249) and increased from ~42°F on February 26, 1958 to ~175°F by March 12, 1958 14 days later (see Table B6). Over the 14 day period there was a temperature increase of ~133°F, and the average rate of rise was ~9.7°F per day which is above the recommended rate of 2°F per day.

There were no other increases in temperatures that exceeded the initial average rate of rise of 9.7°F per day during the operation of tank SX-113. Exceeding the operating temperature requirements would create liner stress when thermally hot high level waste was received and stored in the tank especially without pre-heating. Note that the rate of temperature rise observed occurred before the operating temperature limitations published in HW-59919 were imposed. Thermal shock creates stress both from rapid temperature rise as well as waste-induced high temperatures. The most severe temperatures published for tank SX-113 occurred during the initial filling of the tank which was not preheated.

9.9.3 Chemistry-Corrosion

Tank SX-113 was first filled with REDOX HLW in February 1958 which was stored in the tank for only six months before a liner bulge was detected and the integrity of the tank became questionable. Tank SX-113 did not store any waste until October/November 1962 when a leak test was performed and nitrate leachate waste from tank SX-114 was pumped into the tank; nitrate leaching was not applied directly to tank SX-113. This waste was in tank SX-113 for only 36 days and would have consisted of low concentrations of nitrite and hydroxide.

Tank SX-113 only stored waste for about seven months total. Due to this short amount of time, it appears other factors likely contributed to the tank failure and waste chemistry probably did not play a significant role. However, the bulging of the liner likely caused stress to the liner making it more vulnerable to nitrate-induced SCC.

9.9.4 Liner Observations

The liner bulge documented in HW-56602-DEL indicated a bulge of approximately four feet in the central portion of the tank during equipment installation which was later confirmed by rodding the tank. Photographs taken in January 1970 indicated evidence of a bulge in the tank SX-113 bottom liner from apparent damage to two of the ALC turnbuckle guy rods. The liner bulge was first detected at the end of May 1958, and the liner returned to approximately its original position in June 1958. The tank liner bottom bulged a second time in August 1962 (LET-081562) and receded several days later (see Section 9.4.3).

The liner bulge was reported to have been caused by vaporization of water below the tank liner. There is also the possibility that vacuum placed on the empty tank prior to receiving waste could have deformed the liner (see Section 9.4.3). Subsequent liner bulges were not affected by the vacuum and probably are related to thermal conditions as the weight of the waste would have overcome the effects of the vacuum.

Liner bulging coupled with other tank conditions could affect tank liner integrity; however, by itself bulging can induce stresses that could result in locations that are more susceptible to corrosion.

9.9.5 Tank Construction Temperature

Winter temperatures as low as -6°F occurred during the period when the SX Farm tank liners were being constructed and leak tested (see Figure 3-4). The low temperatures experienced during construction were less than the current 18°F allowable temperature where impact loading had the potential for creating micro-fissures. Impact occurrences could have occurred during cold temperatures that may have triggered fissures in the steel liner. Later, when the metal is subjected to high stress, it might be possible for the cracks to propagate through the metal, or possibly subject the weakened areas to increased corrosion.

9.10 TANK SX-113 CONCLUSIONS

Evidence indicates that the tank SX-113 liner leaked at or near the bottom of the tank in one or possibly two locations. Based on engineering judgment and available information the following conditions listed in the order of importance lead to the tank SX-113 failed liner:

1. Thermal conditions – rate of temperature rise
2. Tank design – liner thermal expansion limiting design changes and possibly vacuum on the empty tank
3. Construction conditions – ductile-to-brittle transition temperature
4. Bulging liner – an effect of primarily thermal conditions along with tank design (see 2 above)

5. Waste storage chemistry – SCC and/or pitting but not a significant factor from limited exposure

There are several liner leak cause conditions that were examined, but the primary cause of the tank SX-113 leak is thermal conditions caused by rapid addition of high temperature waste to a cold tank. Also, the unique tank design did not allow for expansion of the bottom liner as the tank heated creating stresses. Tank construction occurred in winter under cold temperature conditions which could have affected the ductile-to-brittle steel transition temperature where metal loses its ability to absorb forces such as induced loads or the impact of falling objects creating micro-fissures or hairline cracks. In addition, a bulged bottom imparts stresses in the liner that could have predisposed it to SCC. While tank SX-113 was not nitrate leached it did receive ~220 kgal of nitrite and hydroxide depleted waste which would have increased the propensity for corrosion. Some or all of the factors can act serially or together to contribute to tank liner failure.

APPENDIX A6

TANK SX-113 BOILING WASTE OPERATIONAL HISTORY

Table A6-1. RHO-R-39 Boiling Waste Tank Operating Data Table

Tank No.	First Waste	Tank Pre-Heated	Pre-Heat Start	Liquid Heel Used	First Waste Rec'd From	Tank Failed	Inspected For Bulge	Bulge Present	Did Tank Boil on 1st Loading	Tank Started Boiling	Tank Emptied & Reused*	NaNO ₃ Leached from Sludge
101-SX	19 May 54	No	-	No	Redox	No	No	-	Yes	Nov 54	No	No
102-SX	Sep 54	No	-	No	101-SX, Cascade	No	No	-	No	-	No	No
103-SX	Nov 54	No	-	No	102-SX, Cascade	No	No	-	No	-	No	No
104-SX	2 Feb 55	No	-	No	Redox	No	No	-	Yes	Jun 55	No	No
105-SX	11 May 55	No	-	No	104-SX, Cascade	No	No	-	No	-	Yes	No
106-SX	Jun 54	No	-	No	Tank Farm Condensate	No	No	-	No	-	-	-
107-SX	3 Mar 56	No	-	Yes	Redox	Yes, 1964	Yes	Yes	Yes	Jun 56	Yes	Yes
108-SX	8 Nov 55	No	-	No	Redox	Yes, 1962	Yes	Yes	Yes	Jun 56	Yes	Yes
109-SX	20 Sep 55	No	-	Yes	Redox	Yes, 1965	Yes	No	Yes	Dec 55	Yes	No
110-SX	Nov 60	Yes	Apr 60	No	Redox	-	No	-	No	Between 1/61-6/61	Yes	No
111-SX	9 Jun 56	No	-	No	Redox	-	No	-	Yes	Nov 56	Yes	No
112-SX	13 Feb 56	No	-	No	Redox	Yes, 1969	Yes	Yes	Yes	Mar 56	Yes	No
113-SX	20 Feb 58	No	-	No	Redox	Yes, 1958	Yes	Yes	Yes	Apr 58	No	No
114-SX	Nov 56	No	-	No	Redox	-	No	-	Yes	Jun 57	Yes	Yes
115-SX	4 Nov 59	Yes	Sep 58	Yes	Redox	Yes, 1965	No	-	Yes	Nov 59	No	Yes
101-A	20 Jan 56	No	-	6" H ₂ O	Purex	No	Yes	No	Yes	Jul 57	Yes	No
102-A	20 Mar 56	No	-	6" H ₂ O	Purex	No	No	-	Yes	Jul 58	Yes	No
103-A	15 May 56	No	-	6" H ₂ O	Purex	No	No	-	Yes	Jul 56	Yes	No
104-A	30 Jun 59	No	-	6" H ₂ O	Purex	No	Yes	No	Yes	Aug 59	Yes	No
105-A	31 Jan 63	Yes	Jan 63	Yes	Purex	Yes, 1963	Yes	Yes	No***	Mar 63	No	No
106-A	31 Dec 60**	Yes	23 Feb 61	Yes	Purex	No	No	-	Yes	Aug 61	Yes	No
101-AX	1 Jun 65**	Yes	23 Nov 66	Yes	TK-103-A and TK-112-B	No	No	-	No***	Dec 66	Yes	No
102-AX	30 Sep 66**	Yes	2 Mar 69	Yes	TK-101-AX and TK-103-A	No	No	-	No***	Apr 69	No	No
103-AX	10 Feb 65	Yes	Nov 64	Yes	Purex	No	No	-	Yes	Apr 65	No	No
104-AX	9 Sep 66	Yes	Jun 66	Yes	Purex	No	No	-	Yes	Oct 66	No	No

* Emptied indicates supernatant was pumped out but sludge remained.

** Tanks used for temporary waste storage prior to the receipt of LWW or HLW.

*** Did not boil until LWW was routed to the tank.

Note: SX-111 was found to have been NaNO₃ Leached

Table A6-2. ARH-R-43 Waste Tank Leak Experience Table

TABLE 3. Underground Waste Storage Tank Leak Experience

Tank	Built	First Used	Type of Waste Stored	Service	Leak First Suspected	Reason for Suspicion	Leak Confirmed by	Bulge Found	Estimated Volume of Leak, gal	Associated Cs-137, kCi
104-U	1943-44	1947	Bismuth phosphate waste Uranium recovery waste	Nonboiling	1956	Bulged liner	Refill with water (1961)	Yes	55,000*	0.09
113-SX	1953-54	1958	Redox waste	Boiling	1958	Bulged liner	Refill with salt solution (1962)	Yes	15,000**	8
106-TV	1951-52	1953	TBP waste	Nonboiling	1959	Liquid level measurements	Soil radiation readings (1959)		20,000	2
101-U	1943-44	1946	Bismuth phosphate waste Uranium recovery waste Redox waste	Nonboiling	1959	Liquid level measurements	Liquid level measurements		30,000	23
105-TV	1951-52	1953	TBP waste	Nonboiling	1960	Liquid level measurements	Liquid level measurements		35,000	4
108-SX	1953-54	1955	Redox waste	Boiling	1962	Soil radiation readings	Liquid level measurements	Yes	3,400	17
105-A	1954-55	1963	Purex waste	Boiling	1963	Soil radiation readings	Soil radiation readings	Yes	Small	
107-SX	1953-54	1956	Redox waste	Boiling	1964	Soil radiation readings	Soil radiation readings	Yes	Small	
109-SX	1953-54	1955	Redox waste	Boiling	1965	Soil radiation readings	No further evidence	No	Small	
115-SX	1953-54	1958	Redox waste	Boiling	1965	Liquid level measurements	Soil radiation readings		50,000***	40
112-SX	1953-54	1956	Redox waste	Boiling	1969	Liquid level measurements	Soil radiation readings	Yes	30,000	45

* Contained water at time of leak.
 ** Contained NaNO_3 solution at time of leak, also some residual supernatant solution.
 *** Contained NaNO_3 solution at time of leak.

Note: See tank farm segments for information on individual specific tanks

APPENDIX B6

TANK SX-113 TEMPERATURE FEBRUARY 1958 – JUNE 1966

Table B6-1. REDOX Weekly Tank Farm Readings December 1957 to March 1958

REDOX TANK FARM READINGS - 1957 & 8 (cont.)																			
(Recorded once weekly on Wed.)																			
(TEMP. = BUBB. THERMOMETER READING)																			
TANK No.	12-4-57	12-11-57	12-18-57	12-26-57	12-31-57	1-8-58	1-15-58	1-22-58	1-29-58	2-5-58	2-12-58	2-19-58	2-26-58	3-5-58	3-12-58	3-19-58			
	FE IN	TEMP.	FE IN	TEMP.	FE IN	TEMP.	FE IN	TEMP.	FE IN	TEMP.	FE IN	TEMP.	FE IN	TEMP.	FE IN	TEMP.	FE IN	TEMP.	FE IN
101-S	23' 4"		23' 4"		23' 4"		23' 3 1/2"		23' 3 1/2"		23' 4"		23' 10 1/2"		23' 10 1/2"		23' 10"		23' 10"
102-S	23' 0"		23' 0"		23' 0"		23' 0"		23' 0"		23' 0"		23' 0"		23' 0"		23' 0"		23' 0"
103-S	23' 4"		23' 4"		23' 4"		23' 4"		23' 4"		23' 4"		23' 4"		23' 4"		23' 4"		23' 4"
104-S	22' 8 1/2"		22' 8 1/2"		22' 8 1/2"		22' 8 1/2"		22' 8 1/2"		22' 7 1/2"		22' 7 1/2"		22' 7 1/2"		22' 7 1/2"		22' 7 1/2"
105-S	22' 5 1/2"		22' 5 1/2"		22' 5 1/2"		22' 5 1/2"		22' 5 1/2"		22' 5 1/2"		22' 5 1/2"		22' 5 1/2"		22' 5 1/2"		22' 5 1/2"
106-S	23' 3 1/2"		23' 3 1/2"		23' 3 1/2"		23' 3 1/2"		23' 3 1/2"		23' 3 1/2"		23' 3 1/2"		23' 3 1/2"		23' 3 1/2"		23' 3 1/2"
107-S	20' 7"		20' 10 1/2"		21' 2 1/2"	21' 3"	21' 6 1/2"	15' 4"	21' 6"	21' 7"	15' 2"	21' 9 1/2"	22' 1"	22' 3 1/2"	22' 4"	22' 6"	22' 6"	22' 6"	22' 6"
108-S	23' 8 1/2"		23' 8 1/2"		23' 8 1/2"		23' 8 1/2"		23' 8 1/2"		23' 8 1/2"		23' 8 1/2"		23' 8 1/2"		23' 8 1/2"		23' 8 1/2"
109-S	23' 9"		23' 9"		23' 9"		23' 9"		23' 9"		23' 9"		23' 9"		23' 9"		23' 9"		23' 9"
110-S	24' 3"		24' 3"		24' 3"		24' 3"	12' 5"	24' 3"		24' 3"		24' 2 1/2"		24' 2 1/2"		24' 2 1/2"		24' 2 1/2"
111-S	23' 8"		23' 8"		23' 8"		23' 8"		23' 8"		23' 8"		23' 8"		23' 8"		23' 8"		23' 8"
112-S	24' 2 1/2"		24' 2 1/2"		24' 2 1/2"		24' 2 1/2"		24' 2 1/2"		24' 2 1/2"		24' 2 1/2"		24' 2 1/2"		24' 2 1/2"		24' 2 1/2"
101-SX	15' 4 1/2"		15' 3 1/4"	310' 15' 3 1/4"	307' 15' 3"	320' 15' 2 1/2"	317' 15' 2 1/2"	320' 15' 2"	285' 15' 1 1/2"	312' 15' 1 1/4"	305' 15' 3/4"	307' 15' 1/2"	310' 15' 0"	305' 14' 11 1/4"	307' 15' 0"	305' 14' 11"	305' 14' 10 1/2"	305' 14' 10"	305' 14' 10"
102-SX	30' 7"		30' 7"	135' 30' 7"	135' 30' 7"	30' 6 1/4"	135' 30' 7"	30' 6 1/4"	135' 30' 7"	135' 30' 7"	133' 30' 7"	132' 30' 7"	30' 6 1/2"	130' 30' 6 1/2"	130' 30' 6 1/2"	130' 30' 6 1/2"	130' 30' 6 1/2"	130' 30' 6 1/2"	130' 30' 6 1/2"
103-SX	29' 1 1/2"		29' 1 1/2"	107' 29' 1 1/2"	106' 29' 1 1/2"	29' 1 1/2"	107' 29' 1 1/2"	29' 1 1/2"	185' 29' 1 1/2"	105' 29' 1 1/2"	105' 29' 1 1/2"	105' 29' 1 1/2"	105' 29' 1 1/2"	105' 29' 1 1/2"	105' 29' 1 1/2"	105' 29' 1 1/2"	105' 29' 1 1/2"	105' 29' 1 1/2"	105' 29' 1 1/2"
104-SX	28' 0"		23' 11 1/2"	275' 23' 4"	273' 23' 11 1/2"	273' 23' 11"	275' 23' 10 1/4"	272' 23' 10 1/4"	267' 23' 10"	267' 23' 9 1/4"	270' 23' 9 1/4"	267' 23' 8 1/2"	267' 23' 8 1/2"	260' 23' 8"	260' 23' 7 1/2"	260' 23' 7"	260' 23' 8 1/2"	257' 23' 8 1/2"	257' 23' 8 1/2"
105-SX	28' 8"		28' 8"	138' 28' 7 1/2"	138' 28' 7 1/2"	135' 28' 7"	137' 28' 7"	135' 28' 6 1/2"	140' 28' 6 1/2"	138' 28' 6 1/2"	137' 28' 6 1/2"	135' 28' 5 1/2"	137' 28' 5 1/2"	135' 28' 5 1/2"	135' 28' 5 1/2"	135' 28' 5 1/2"	130' 28' 5 1/2"	130' 28' 5 1/2"	130' 28' 5 1/2"
106-SX	9' 1"		9' 5"	183' 9' 8"	183' 9' 8"	183' 11' 1"	187' 10' 6"	188' 10' 10"	188' 11' 1"	187' 11' 4"	187' 7' 16"	186' 6' 8"	187' 6' 11"	185' 7' 3"	185' 7' 6"	182' 7' 7"	182' 7' 9"	182' 7' 9"	182' 7' 9"
107-SX	16' 6"		17' 11 1/2"	280' 18' 5"	253' 19' 11"	253' 19' 6"	255' 19' 1"	260' 18' 5"	265' 18' 1"	320' 17' 5"	17' 11"	390' 14' 7"	390' 19' 5"	325' 19' 2"	310' 18' 11"	310' 18' 7 1/2"	300' 18' 7"	295' 18' 7"	295' 18' 7"
108-SX	21' 4 1/2"		20' 7"	280' 20' 8"	281' 19' 7"	283' 19' 5 1/2"	286' 19' 0"	282' 18' 7 1/2"	288' 18' 3"	290' 17' 10 1/4"	290' 17' 5 1/4"	292' 17' 3"	295' 16' 11 1/2"	307' 16' 7"	300' 17' 11 1/2"	290' 17' 9"	280' 17' 6 1/2"	285' 17' 6 1/2"	285' 17' 6 1/2"
109-SX	29' 7"		29' 7"	228' 29' 7"	227' 29' 7"	226' 29' 7"	227' 29' 7"	225' 29' 7"	225' 29' 7"	225' 29' 7"	225' 29' 7"	225' 29' 7"	222' 29' 7 1/2"	220' 19' 7 1/2"	220' 24' 7 1/2"	220' 24' 7 1/2"	225' 29' 7 1/2"	220' 29' 7 1/2"	220' 29' 7 1/2"
110-SX	21' 3 1/4"		21' 2 1/2"	243' 21' 1 1/2"	245' 21' 1 1/2"	243' 21' 1 1/2"	242' 21' 0"	240' 20' 11 1/2"	240' 20' 10 1/2"	239' 20' 10"	238' 20' 9 1/2"	237' 20' 9"	235' 20' 8 3/4"	235' 20' 8 3/4"	235' 20' 7 1/2"	235' 20' 7 1/2"	230' 20' 6 1/2"	233' 20' 6 1/2"	233' 20' 6 1/2"
111-SX	26' 10 1/2"		26' 10 1/2"	228' 26' 10 1/2"	227' 26' 9 1/2"	226' 26' 9 1/2"	227' 26' 9 1/2"	225' 26' 9"	225' 26' 9"	225' 26' 9"	225' 26' 8 1/2"	225' 26' 8 1/2"	220' 26' 8 1/2"	212' 26' 8"	220' 26' 8"	215' 26' 7 1/2"	215' 26' 7 1/2"	213' 26' 7 1/2"	213' 26' 7 1/2"
113-SX	18' 10 1/2"		23' 8"	18' 10 1/2"	239' 18' 8 1/2"	245' 19' 6"	243' 18' 8 1/2"	245' 19' 3 1/4"	248' 18' 0"	250' 19' 2 1/4"	253' 20' 8 1/4"	257' 21' 9 1/4"	260' 21' 8"	265' 20' 11"	270' 26' 5"	255' 18' 7 1/2"	250' 19' 0 1/2"	255' 19' 0 1/2"	255' 19' 0 1/2"
114-SX	29' 5 1/2"		18' 10 1/2"	23' 8"	18' 10 1/2"	239' 18' 8 1/2"	245' 19' 6"	243' 18' 8 1/2"	245' 19' 3 1/4"	248' 18' 0"	250' 19' 2 1/4"	253' 20' 8 1/4"	257' 21' 9 1/4"	260' 21' 8"	265' 20' 11"	270' 26' 5"	255' 18' 7 1/2"	250' 19' 0 1/2"	255' 19' 0 1/2"
115-SX	29' 5 1/2"		18' 10 1/2"	23' 8"	18' 10 1/2"	239' 18' 8 1/2"	245' 19' 6"	243' 18' 8 1/2"	245' 19' 3 1/4"	248' 18' 0"	250' 19' 2 1/4"	253' 20' 8 1/4"	257' 21' 9 1/4"	260' 21' 8"	265' 20' 11"	270' 26' 5"	255' 18' 7 1/2"	250' 19' 0 1/2"	255' 19' 0 1/2"
* 10,500 gal to 104-SX from tank 101.																			

Table B6-2. REDOX Weekly Tank Farm Readings March to July 1958

REDOX TANK FARM READINGS - 1958 (cont.)

(Bulb Temp. Thermometer Rdy.)

	3-26-58	4-2-58	4-9-58	4-16-58	4-23-58	4-30-58	5-7-58	5-14-58	5-21-58	5-28-58	6-4-58	6-11-58	6-18-58	6-25-58	7-2-58	7-9-58				
TANK NO.	Fe:In Temp	Fe:In Temp	Fe:In Temp	Fe:In Temp	Fe:In Temp	Fe:In Temp	Fe:In Temp	Fe:In Temp	Fe:In Temp	Fe:In Temp	Fe:In Temp	Fe:In Temp	Fe:In Temp	Fe:In Temp	Fe:In Temp	Fe:In Temp				
101-S	23' 10 1/4	23' 10 1/4	23' 10 1/4	23' 10 1/4	23' 10 1/4	23' 10 1/4	23' 10 1/4	23' 10 1/4	23' 10 1/4	23' 10 1/4	23' 10 1/4	23' 10 1/4	23' 10 1/4	23' 10 1/4	23' 10 1/4	23' 10 1/4				
102-S	23' 0"	23' 0"	23' 0"	23' 0"	23' 0"	23' 0"	23' 0"	23' 0"	23' 0"	23' 0"	23' 0"	23' 0"	23' 0"	23' 0"	23' 0"	23' 0"				
103-S	23' 3 3/4	23' 3 3/4	23' 3 3/4	23' 3 3/4	23' 3 3/4	23' 3 3/4	23' 3 3/4	23' 3 3/4	23' 3 3/4	23' 3 3/4	23' 3 3/4	23' 3 3/4	23' 3 3/4	23' 3 3/4	23' 3 3/4	23' 3 3/4				
104-S	22' 7 1/4	22' 7 1/4	22' 7 1/4	22' 7 1/4	22' 7 1/4	22' 7 1/4	22' 7 1/4	22' 7 1/4	22' 7 1/4	22' 7 1/4	22' 7 1/4	22' 7 1/4	22' 7 1/4	22' 7 1/4	22' 7 1/4	22' 7 1/4				
105-S	22' 5"	22' 5"	22' 5"	22' 5"	22' 5"	22' 5"	22' 5"	22' 5"	22' 5"	22' 5"	22' 5"	22' 5"	22' 5"	22' 5"	22' 5"	22' 5"				
106-S	23' 3"	23' 3"	23' 3"	23' 3"	23' 3"	23' 3"	23' 3"	23' 3"	23' 3"	23' 3"	23' 3"	23' 3"	23' 3"	23' 3"	23' 3"	23' 3"				
107-S	20' 5 1/4	20' 5 1/4	20' 5 1/4	20' 5 1/4	20' 5 1/4	20' 5 1/4	20' 5 1/4	20' 5 1/4	20' 5 1/4	20' 5 1/4	20' 5 1/4	20' 5 1/4	20' 5 1/4	20' 5 1/4	20' 5 1/4	20' 5 1/4				
108-S	23' 8"	23' 8"	23' 8"	23' 8"	23' 8"	23' 8"	23' 8"	23' 8"	23' 8"	23' 8"	23' 8"	23' 8"	23' 8"	23' 8"	23' 8"	23' 8"				
109-S	23' 8 1/2	23' 8 1/2	23' 8 1/2	23' 8 1/2	23' 8 1/2	23' 8 1/2	23' 8 1/2	23' 8 1/2	23' 8 1/2	23' 8 1/2	23' 8 1/2	23' 8 1/2	23' 8 1/2	23' 8 1/2	23' 8 1/2	23' 8 1/2				
110-S	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4				
111-S	23' 7 1/2	23' 7 1/2	23' 7 1/2	23' 7 1/2	23' 7 1/2	23' 7 1/2	23' 7 1/2	23' 7 1/2	23' 7 1/2	23' 7 1/2	23' 7 1/2	23' 7 1/2	23' 7 1/2	23' 7 1/2	23' 7 1/2	23' 7 1/2				
112-S	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4	24' 2 1/4				
101-SX	14' 10 1/4	300	14' 10 1/4	252	14' 9 1/4	300	14' 9 1/4	299	14' 8 1/4	299	14' 8 1/4	299	14' 7 1/2	299	14' 7 1/2	299				
102-SX	30' 6 1/2	130	30' 6 1/2	150	30' 6 1/2	128	30' 6 1/2	128	30' 6 1/2	130	30' 6 1/2	125	30' 6 1/2	125	30' 6 1/2	123				
103-SX	29' 1 1/2	100	29' 1 1/2	105	29' 1 1/2	102	29' 1 1/2	103	29' 1 1/2	104	29' 1 1/2	100	29' 1 1/2	100	29' 1 1/2	98				
104-SX	23' 5 1/2	252	23' 5 1/2	255	23' 5 1/2	250	23' 5 1/2	253	23' 5 1/2	261	23' 5 1/2	252	23' 5 1/2	251	23' 5 1/2	250				
105-SX	28' 5 1/4	130	28' 5 1/4	134	28' 5 1/4	131	28' 5 1/4	131	28' 5 1/4	136	28' 5 1/4	127	28' 5 1/4	128	28' 5 1/4	125				
106-SX	7' 7"	182	7' 10 1/2	183	8' 3"	184	8' 6"	186	8' 5 1/2	188	8' 9"	185	8' 8"	185	8' 7 1/2	186				
107-SX	19' 0"	292	19' 1 1/4	294	18' 8 1/4	296	18' 7 1/4	298	18' 3 3/4	299	18' 0"	302	17' 10 1/2	304	17' 4 1/2	316				
108-SX	17' 3"	280	16' 11"	275	16' 8 1/4	277	16' 5 1/4	280	16' 7"	282	16' 1 1/2	291	16' 2 1/4	304	18' 4 1/2	300				
109-SX	24' 7 1/2	218	24' 7 1/2	217	24' 7 1/2	216	24' 7 1/2	214	24' 7 1/2	215	24' 8"	214	24' 8"	214	24' 8"	214				
110-SX	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
111-SX	20' 5 1/4	232	20' 5 1/4	232	20' 4 1/2	232	20' 4"	230	20' 3 1/2	229	20' 2 3/4	229	20' 2 1/2	227	20' 2 1/4	227				
112-SX	26' 7 1/2	212	26' 7 1/2	211	26' 7 1/2	212	26' 7"	210	26' 6 1/2	209	26' 5 1/2	208	26' 6 1/2	208	26' 6 1/2	207				
113-SX	5' 11"	198	6' 8"	212	6' 11 1/2	214	7' 6 1/4	209	9' 0"	215	10' 8 1/2	224	10' 8"	224	10' 7 1/4	222				
114-SX	18' 5 1/2	257	17' 11 1/2	262	17' 8 1/4	265	17' 1"	270	16' 8 1/2	275	16' 3 1/2	284	15' 11"	273	15' 7 1/4	287				
115-SX	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				

* Condensate - reflux

** Reading 108-SX direct vice sub, 17"

(See July 1957)

* Pumping 103-SX to 101-U started 5-22-58

Approximately 72,500 gal of Redox Cond. waste was transferred 107-SX tank, 7-9 & 7-11.

Figure B6-1. RHO-CD-1172 Tank SX-113 Temperature January 1957 through July 1958

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure B6-2. RHO-CD-1172 Tank SX-113 Temperature August 1958 through February 1960

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure B6-3. RHO-CD-1172 Tank SX-113 Temperature March 1960 through September 1961

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure B6-4. RHO-CD-1172 Tank SX-113 Temperature October 1961 through April 1963

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure B6-5. RHO-CD-1172 Tank SX-113 Temperature May 1963 through November 1964

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure B6-6. RHO-CD-1172 Tank SX-113 Temperature December 1964 through June 1966

APPENDIX C6

TANK SX-113 GROSS GAMMA DRYWELL DATA

Table C6-1. Tank SX-113 Drywell Radioactivity (K counts per minute)
(November 1962 to June 1987)
(Drywell Data Sheets Retrieved March 22, 2011 and SD-WM-TI-356)

41-13-10		41-00-05	
Drilled 10/6/1958		Drilled 1956	
Date	Peak (K cpm)	Date	Peak (K cpm)
11/14/62	< 0.05 ¹	11/14/62	< 0.05 ¹
3/25/71	< 50	NA ²	
9/13/73	< 15	9/13/73	< 18
4/10/74	< 12	4/10/74	< 15
7/31/74	< 3 ³	6/29/74	< 3 ³
1/22/75	< 3	1/22/75	< 3
7/22/75	< 3	7/22/75	< 3
4/6/76	< 3	4/6/76	< 3
7/13/77	< 3	8/4/77	< 3
7/4/78	< 3	7/3/78	< 3
7/17/79	< 3	7/16/79	< 3
7/14/80	< 3	7/14/80	< 3
6/15/81	< 3	6/15/81	< 3
7/27/82	< 3	7/27/82	< 3
6/23/83	< 3	6/23/83	< 3
6/12/84	< 3	6/12/84	< 3
6/12/85	< 3	6/11/85	< 3
6/9/86	< 3	6/9/86	< 3
6/24/87	< 3	6/23/87	< 3

Note: ¹HW-75714 unknown probe all others SP

²N/A: Data not available

³New Monitoring Equipment

APPENDIX D6

TANK SX-113 LEAK INFORMATION

**Table D6-1. Tank SX-113 Leak Information
(RPP-ENV-39658) (1 of 5 sheets)**

Date	Event Described Verbatim from Reference
5-1958 ^a	<p>On 5-28-58 a prototype air-lift circulator was installed in the 113-SX pump pit. However, the assembly lacked approximately three feet of seating on the riser flange, indicating either an obstruction in the tank or that the tank bottom has buckled. Further checks are being made at month end to determine the exact trouble. An extensive leak check of the 113-SX tank has been started and plans to route the salt waste to another tank are currently being made</p>
6-1958 ^b	<p>Page A-4: The steel liner in waste storage tank 113-SX was found to be bulged about four feet upwards of its normal position. Liquid between the concrete supporting structure and the steel liner appears to be the most plausible explanation for the observed condition. During the month, the liner returned to its normal position. The situation is under investigation with the objective of getting further data required to fully explain and understand the condition.</p> <p>Page B-2: Early in June a suspected bulge in the bottom of the 113-SX waste storage tank was confirmed. Waste was diverted to another storage tank and continuous soundings of the 113-SX tank were made. By the week of June 17, the tank bottom had returned to its normal position; however the integrity of the vessel was in doubt. Prior to the discovery of this condition, the contents of the vessel had been boiling for about 2 ½ months. Although monitoring of fourteen adjacent wells in SX tank farm showed no contamination, no conclusive evidence was found to assure that the tank was not leaking. Tentative plans have been made to transfer the waste in the 113-SX tank to another waste storage tank.</p> <p>Page D-3: As reported during May, unsuccessful attempt to install prototype removable circulators in the 113-SX tank led to the discovery that the tank bottom had buckled to a maximum height of approximately four feet above its normal position. Investigation by the Redox Technology Operation indicates the presence of liquid between the concrete shell and the liner to be the most likely cause of the displacement. Further investigation of this condition during June has revealed that the tank bottom has returned to essentially normal position in all quadrants of the tank. Extensive leak checks have been made, however, dry well checks have all been negative and tank electrode readings indicate no leakage. Well points were also driven to a depth of 50 feet on the northwest side of the tank and to a depth of 24 feet by the tank fill line. No evidence of ground contamination has been detected. However, as a precautionary measure, plans to route the salt waste to another tank are proceeding.</p> <p>Page H-7: An upward bulge of approximately four feet (3 feet above a horizontal plane) was detected in the Redox 113-SX tank when trying to install a prototype replaceable circulator through the riser in the pump pit. Additional reading indicated the bulge formed an approximate simple curve and each quadrant of the tank was raised about the same direction. The movement of the sidewalls, if any, was not detectable. There was about 460,000 gallons (electrode reading) of high level wastes at a maximum temperature of 236 °F in the tank at the time the bulge was discovered.</p> <p>Sometime during June 17 or 18, the east half of the tank bottom settled to about five inches above the original position of the bottom and the west half to about three inches above, with the sounding at the south 4-inch riser about ¾ of an inch lower than the original bottom position.</p> <p>No indications of a leak have been detected with present leak detection methods. It is planned to transfer the wastes from 113-SX to 103-SX to permit further evaluation of the tank.</p>

**Table D6-1. Tank SX-113 Leak Information
(RPP-ENV-39658) (2 of 5 sheets)**

Date	Event Described Verbatim from Reference
6-1958 ^b	Page J-8: Unsuccessful attempts at the end of May to install prototype removable circulators in the 113-SX tank led to the discovery that the tank liner had been elevated to a maximum height of approximately 4 feet above its original position. Extensive evaluation of material balances and temperature data indicates the presence of liquid between the concrete shell and the liner to be the most likely cause of the displacement. The liner returned to essentially normal position during June with a corresponding decrease in the liquid level within the tank. Investigation of the liner movement is being investigated extensively.
7-1958 ^c	<p>The questionable integrity of Tank 113-SX remains unchanged. Attempts to sink well points near the tank met with only moderate success, 48 feet being the maximum depth attained. Monitoring at this level detected no contamination; however, it is doubtful that sufficient depth was reached to permit detection of activity, assuming it to be present.</p> <p>A second well point was successfully sunk to and slightly below the tank fill line for monitoring purposes, since if a leak had occurred, the fill line was a logical source. In view of the fact that contamination was not found at this site either, it seems safe to proceed with excavation as soon as the tank can be emptied. Pumping of the liquid to Tank 103-SX started July 23 and was expected to be completed before month-end.</p>
7-1958 ^d	<p>The bulge in the bottom of the 241-SX-113 tank (Redox buried waste) collapsed during June, and as the bottom plate resumed its normal shape, the rate of apparent liquid loss observed during the collapse (12,000 – 15,000 gallons per day for approximately five days) dropped sharply to 3,000 – 3,500 gallons per day where it remained essentially constant until the tank was emptied by pump near the end of July. This rate of decrease represents normal boil-off, thus indicating that the steel liner was intact and that no liquid was escaping to the soil during this period. However, the most painstaking calculations show that approximately 40,000 gallons of waste remained unaccounted for. This is consistent with the theory that the bulge was caused by liquid (under the bottom of the liner) which subsequently escaped to the soil through a fault in the concrete, thus allowing the steel plate to resume its normal position. At the beginning of the final week of the month, approximately 270,000 gallons of the tank's contents were pumped to another tank, leaving a heel of approximately 20,000 gallons in 113-SX. This liquid level has continued to drop slowly but steadily at an evaporation rate of about 1,200 gallons per day, and will be permitted to continue until the tank is dry. At such time, inspection of the interior of the tank (by periscope or photographic techniques) can be started. Meanwhile excavation has been started for the purpose of exposing the influent line so that a postulated mechanism for the formation of the bulge can be investigated.</p>
8-1958 ^{e,1}	<p>Page A-4: Waste tank 113-SX continued to exhibit bottom movement. Sixteen days after emptying, the bottom again started to rise, reaching 40 inches above normal within the next 15 days. This movement raised the sluice pump and caused it to become inoperable. Further inspection of this tank is delayed until the pump can be replaced and sluicing can be done.</p> <p>Page B-3: After completing the transfer of waste in 113-SX, the soil was excavated to the encasement. A hole was then drilled through the encasement to permit swabbing. Negative monitoring results indicated no leak at this point. During the week ending August 17, there were indications that the tank bottom bulged again to a height of approximately one foot. Liquid and/or sludge content of the tank was less than 5,000 gallons. Current plans are to install a periscope and inspect the tank interior before taking further action.</p>

**Table D6-1. Tank SX-113 Leak Information
(RPP-ENV-39658) (3 of 5 sheets)**

Date	Event Described Verbatim from Reference
8-1958 ^{e,1}	<p>Page D-3: The investigation for possible causes which may have resulted in the buckling of the tank bottom on the 113-SX salt waste storage tank (May 1958) was continued this month. Excavation of the fill line at the tank revealed that the line was in good repair and no traces of moisture or radiation, that would normally be expected to accompany a leak, were found. Further investigation of the tank bottom distortion will depend on the successful installation and use of a periscope in the 113-SX tank.</p> <p>Page J-8: Starting approximately 16 days after the 113-SX tank was emptied the liner again rose, over a 15-day period, to a height 40 inches above its original position. The temperature, as indicated by the mercury-filled thermometer, rose from an average of 218 °F to 224 °F about two days prior to the movement of the liner. The liner returned to approximately normal position near the month end several days after an apparent decrease in temperature. During the course of the second rise of the liner, it lifted the pump (used to empty the tank in July) about eight inches despite the fact that it was still attached to the discharge jumper. The pump had not been bolted down. Since the pump will not now run, it is presumed that the shaft was bent by the pressure, and thus it appears that a replacement pump will be necessary before sluicing and sludge removal can be started.</p>
8-13-1958 ^f	<p>Summary</p> <p>During the initial filling of the 113-SX tank, started on February 20, 1958, it was observed that the volume received in the tank exceeded slightly the volume sent, a condition not uncommon where interchange of water vapor is possible. Attempts, on May 28, 1958, to install an experimental, replaceable air-lift circulator in the newly-activated 113-SX storage tank failed when the circulator encountered an obstruction. Subsequent soundings through several nearby openings in the tank indicated the steel lining of the tank to be elevated to a height greater than four feet above its original position. Measurements in several other tanks in the SX farm revealed no similar abnormality. Routing of waste to the 113-SX tank was terminated on June 2, 1958. During a seven-day period starting June 11, 1958, the liner returned to its original position with an apparent net loss in volume of approximately 63,000 gallons. The volume remaining following the collapse of the liner, however, was in good agreement with the volume sent, indicating the liner was probably intact. There were no subsequent indications of loss of waste from the tank. Because of the stresses suffered by the liner, the tank contents were pumped to another SX farm tank during a two-day period starting July 23, 1958. A chronological history of the 113-SX tank is presented in the appendix.</p> <p>As yet there is no conclusive evidence as to the cause of the displacement of the liner. The possibility that waste had been introduced below the liner, due to a fault in fabrication, was virtually eliminated when investigation revealed the most likely point of ingress to be free of radioactive contamination. Photographic inspection of the tank interior will be employed in the near future in a further effort to determine the cause of the displacement and the extent of the damage sustained.</p> <p>.... [Comment: Report contains additional details on liner displacement, tank temperature, and material balance estimates.]</p>
9-1958 ^g	<p>Page B-3: Since efforts to inspect the empty 110-SX tank by periscope were unsuccessful, no attempt was made to inspect 113-SX. Present plans are to check the 113-SX tank for a leak by adding water periodically. A pump will be installed for transferring the liquid in the event a leak is detected. Further efforts to monitor soil at depth will be made upon completion of another monitoring well. The contractor is scheduled to start drilling 9-29-58, and the job should be completed in three to four days. The well will be located northwest of 113-SX, about ten feet from the tank.</p>

**Table D6-1. Tank SX-113 Leak Information
(RPP-ENV-39658) (4 of 5 sheets)**

Date	Event Described Verbatim from Reference
10-1958 ^h	<p>Page B-3: Drilling of the 100 foot monitoring well immediately northwest of Tank 113-SX was completed 10-7-58 and subsequent monitoring of the soil showed negative results insofar as a leak in the tank is concerned. Further investigation of the tank condition is underway.</p> <p>Page D-2: Daily electrode checking of the 113-SX tank indicated that the tank bottom remained static during the month. The leak detection program started late in September is progressing satisfactorily. The test well drilled northwest of the 113-SX tank to determine the extent of ground contamination was completed without finding a trace of contamination. A caisson, twelve feet in diameter will be sunk at the same site as the test well with laterals radiating out under the tank from the bottom of the caisson.</p>
12-1958 ⁱ	<p>Page A-4: The contractor has experienced considerable difficulty installing the five lateral pipe lines under the 113-SX waste storage tank. The fourth line was not completed beyond 100 feet as a result of damage to the augering equipment and cutting shoe on the pipe. The contractor is now preparing as-built data showing location of the lateral pipes.</p> <p>Page D-3: The 113-SX tank bottom remained static during the month. Drilling of the five horizontal laterals at an elevation of approximately 10 feet below the bottom of the tank was completed by Engineering Limited of Seattle. No soil contamination was encountered.</p>
1-1959 ^{j,2}	<p>Page D-2: The 113-SX tank bottom remained static during the month. Radiation readings taken inside the five horizontal laterals, which were drilled ten feet below the tank bottom during December gave no indication of a leak in the tank bottom. The addition of water to the tank to verify the presence (or absence) of a leak has been delayed pending more favorable weather conditions.</p> <p>Page H-5: Measurements were made of gamma radiation level in the lateral test holes under the 113-SX tank. At all five points it was less than 0.1-mr/hour. Steps are being taken to provide greater sensitivity in the instrument for additional experimental testing.</p>
2-1962 ^k	<p>A periscope and light-bar were installed in the 113 tank, 241-SX Tank Farm to assist the Waste Handling and Decontamination Operations in determining the extend of damages to the tank pump. The pump shaft housing is bent to such an extend that it cannot be withdrawn through the tank nozzle in the conventional manner. No conclusion had been reached at month-end as to how the problem will be resolved.</p>
4-1962 ^l	<p>The Hayden Well Drilling Company completed drilling of 49 vertical monitoring wells within the SX Tank Farm. There were no radiation dose rates involved in this work nor was there any detectable contamination encountered.</p> <p>The demonstration lateral under the 110-SX waste tank, from the existing caisson at 113-SX, was completed this month. The work, which was done by the Boring and Tunneling Company, Houston, Texas, was completed per contract date despite the one-week exclusion from the 200-W Area as a result of the Z-Plant criticality incident. The lateral met project specifications.</p>
5-1962 ^m	<p>A grossly contaminated 50-foot pump was removed from 113 tank at the 241-SX Tank Farm, and disposed of by burial in the conventional manner. Evidence indicated the pump had received irreparable damage when the bottom of the tank buckled.</p>
7-1962 ⁿ	<p>The Bore-Tun Company completed drilling of the laterals under the 110 and 111-SX waste tanks and completed the first of three vertical caissons (located between 109 and 115-SX tanks) on July 26. To date no significant ground contamination has been detected. However, a surface dose rate of 5r/hr was detected on two condensate recycle lines which were uncovered at a depth of four feet in one of the caissons. An effort is currently being made to relocate the caissons.</p>

**Table D6-1. Tank SX-113 Leak Information
(RPP-ENV-39658) (5 of 5 sheets)**

8-1962 ^o	In preparation for a full-scale leak test of the 113-SX tank, Redox and Facilities Engineering personnel completed the monitoring of the laterals under the tank in 8-2-62. No radiation was detected. The leak test is expected to begin next month with the transfer of recovered sodium nitrate solution from the 114-SX tank into 113-SX.
8-15-1962 ^p	<p>During 1958, shortly after waste capable of self-concentration was routed to the 113-SX tank, the tank liner bottom bulged. Although the bulge receded several days later, the boiling waste was pumped to another tank. The tank liner bottom bulged a second time after the contents were pumped out. This bulge also receded over a period of several days; however, the 113-SX tank has not been re-used or tested to determine whether it leaks.</p> <p>Currently, prototype facilities are being installed to route dissolved sludge, high in sodium nitrate, from the 114-SX tank to the Redox plant, for use as a hydrogen suppressant during aluminum jacket dissolution. If it can be determined that the 113-SX tank does not leak, its use for storage of the sodium nitrate solution in place of the 114-SX tank would be very desirable.</p> <p>Periscopic inspection, completed several months ago, found no visible damage to the 113-SX tank liner. The pump, which was damaged when the second bulge occurred, was removed without incident. Monitoring of the five laterals under the tank in January 1959, and in August 1962, together with periodic monitoring of the test wells in the vicinity of the tank, has failed to detect any contamination indicative of a leak from this tank. However, proof of the tank's integrity can only be obtained by adding liquid to the tank and measuring the liquid level over a reasonable period of time.</p> <p>The following program for leak testing the 113-SX tank is recommended:</p>
10-1962 ^q	Leak checking the 113-SX Tank began on October 10, when 63,000 gallons of wastes were transferred from 241-SX-114.
10-1962 ^{r,3}	Leak testing of the 113-SX tank was started on October 10, 1962, and was terminated on November 13, 1962. A leak, indicated by liquid level measurements, was confirmed by monitoring the horizontal laterals under the tank. The 113-SX tank contents were returned to the 114-SX tank on November 14 and 15, 1962, except for a heel of 9-3/16 inches (approximately 10,000 gallons, corrected for the 2-inch sludge level). Calculations show that approximately 15,000 gallons of solution containing 7800 curies of gamma activity (>99% Cs-137) were lost to the ground. The 113-SX tank is therefore considered unusable. The major portion of the leakage occurred after November 2, 1962, at a rate of 1200 – 1400 gallons per day. The leak test also proved the efficacy of the horizontal lateral leak detection system in confirming the presence of a leak.
11-1962 ^s	Leak checking of the previously deformed 113-SX waste storage tank was completed this month and the tank was found to be leaking.

Notes:

1. Periscope inspection of tank 113 SX was not conducted due to poor periscope visibility observed during testing in tank SX-110 (see HW 57640-DEL page B-3).
2. HW-60749 (June 1959) page 3 and 4 state a scintillation probe was used to scan the laterals beneath tank SX-113.
3. HW 75714 provides the composition of the supernatant added to tank 241-SX-113 for the leak check.

References cited:

- ^aHW-56218-DEL, *Chemical Processing Department Monthly Report for May, 1958*, page D-4
- ^bHW-56602-DEL, *Chemical Processing Department Monthly Report for June, 1958*
- ^cHW-56972-DEL, *Chemical Processing Department Monthly Report for July, 1958*, page B-2
- ^dHW-56972-DEL, page J-8
- ^eHW-57328-DEL, 1958, *Chemical Processing Department Monthly Report for August, 1958*
- ^fHW-57640-DEL, *Chemical Processing Department Monthly Report for September, 1958*
- ^gHW-57249, *Interim Report on Displacement of the REDOX 113-SX Waste Storage Tank Liner*
- ^hHW-58051-DEL, *Chemical Processing Department Monthly Report for October, 1958*
- ⁱHW-58711-DEL, *Chemical Processing Department Monthly Report for December, 1958*
- ^jHW-59079-DEL, *Chemical Processing Department Monthly Report for January, 1959*

^kHW-72890, *Chemical Processing Department Monthly Report February, 1962*, page E-3

^lHW-73525, *Chemical Processing Department Monthly Report April, 1962*, page C-3

^mHW-73884, *Chemical Processing Department Monthly Report May, 1962*, page E-2

ⁿHW-74505, *Chemical Processing Department Monthly Report July, 1962*, page C-3

^oHW-74804, *Chemical Processing Department Monthly Report August, 1962*, page C-4

^pInternal letter LET-081562, "Leak Testing of the 113-SX Tank" (LET-081562 - Letter)

^qHW-75470, *Chemical Processing Department Monthly Report October, 1962*, page F-5

^rHW-75714, *Leak Testing of the 113-SX Tank*

^sHW-75702, *Chemical Processing Department Monthly Report November, 1962*

APPENDIX E6

INSTALLATION OF THE TANK SX-113 LATERALS

E.6 Installation of the SX-113 Laterals

The five laterals installed December 1958 under tank SX-113 were the first prototype laterals of SX farm. The vertical alignment of the horizontal laterals are shown in Figure E6-1 and they range from 6-ft to 12-ft below the bottom of tank SX-113. The horizontal alignment was calculated to be within ~2-ft (see Section 9.5.1). The straight line horizontal lateral distances measured in Figure E6-1 (feet from lateral pipe flange) were used as the horizontal distances of the laterals in the figures for this document. The numbering of the laterals in Figure E6-1 uses the original numbering system which numbers the laterals 1 to 5 counterclockwise; however, the conventional lateral numbering system was used throughout the document.

Figure E6-1. Vertical Alignment of the Horizontal Laterals under Tank SX-113 (HW-60749)

APPENDIX F6

**TANK SX-113 CHRONOLOGY
FEBRUARY TO AUGUST 1958**

Table F6-1. SX-113 Chronology February to August 1958
(HW-57249) (Sheet 1 of 5)

113-SX Chronology	
2-19-58	The 241-SX-151 diversion box manifold jumper valving was changed to allow pumping of Redox neutralized waste from the 202-S Building (D-8 tank) to the 113-SX tank, and the 24-inch vapor header butterfly valve was opened to the 113-SX tank.
2-20-58	The first batch of neutralized waste was received.
2-24-58	The first liquid level measurement taken gave 1' 1-1/4" (21,602 gallons); at this time 21,546 gallons had been pumped to the tank according to D-8 transfer records.
3-2 - 3-8 58	Although no waste was received during this period, the tank volume increased by approximately 4,800 gallons. This discrepancy was explained as condensate dropout from the vapor header system previously experienced in the filling of other 241-SX tanks.
4-2 - 4-7 58	During this period of no waste transfers the in-tank volume as measured by the electrode increased steadily from 6'6" (205,517 gal.) to 7'5" (230,316 gallons).
4-7-58	The vapor header butterfly valve was throttled and air was turned on the circulators in an effort to prevent vapor header condensate from flowing to the tank.
4-7 - 4-11 58	No waste was transferred to the tank during this period. The in-tank volume, as measured by the electrode, decreased steadily from 7'5" (230,316 gal.) to 6'7-1/2" (204,140 gallons). Although the electrode readings taken during the period 4-2 - 4-7-58 gave a solid contact, indicative of touching liquid, it was reasoned that there could have been a layer of conductive foam in the tank responsible for these readings. The liquid level readings decreased as circulation of the tank contents dissipated the foam or displaced it from the vicinity of the liquid level electrode riser.
4-23 - 4-30 58	During this period the tank contents began to boil. The liquid level electrode indicated a volume of 339,151 gallons in the tank. A total of 290,934 gallons (corrected to 113-SX tank temperature) had been transferred from the D-8 tank.

Table F6-1. SX-113 Chronology February to August 1958
(HW-57249) (Sheet 2 of 5)

5-16-58	A 45'3" long, 10" diameter prototype air circulator and a 45'2" long, 2" diameter air sparger were delivered to the 241-SX tank farm for installation in the 113-SX tank pump pit risers.
5-28-58	An attempt was made to install the prototype air circulator in the 12" pump pit riser (located 5' east of the tank center). This circulator was designed to sit one-foot off the tank bottom. When the circulator was positioned in the riser, it protruded about 3 feet above the riser flange. The circulator was flushed with water via the air supply line and the spray ring, removed from the pump pit riser and placed in the above-ground west 12" riser. Since the circulator length had been checked at the shop prior to delivery and the distance from the pump pit riser flange to the tank bottom had been determined from blueprints by several individuals, independently, a bulge in the tank liner bottom was suspected.
6-2-58	<p>The bulged tank liner bottom was confirmed by sounding the tank at the 4" pump pit riser (located 8' east of the tank center) using the 45'2" long air sparger as a probe. The distance from the tank bottom to the top of the riser flange was found to be 42'6". A sounding at the same riser of the unused 110-SX tank measured 46'7" from the tank bottom to the top of the riser flange. Since these two measurements differed by 4'1" (49"), the 113-SX tank liner bottom was bulged 49" at the 4" pump pit riser.</p> <p>A sounding at the south 12" riser, located 11' 10" south of the tank center, indicated a bulge of 48 1/2" in this position.</p> <p>After removal of a 3'8" section from the 2" air sparger, it was installed in the 4" pump pit riser.</p> <p>Routing of waste to the 113-SX tank was discontinued. From 2-19-58 - 6-2-58, the 113-SX tank had received the waste from processing approximately 440 tons of uranium and as of 6-2-58 contained an estimated 44,000,000 BTU/day of fission product heat.</p>
6-5-58	<p>Soundings in the 108-SX and 114-SX tanks, containing boiling waste, and in the 110-SX and 115-SX tanks, as yet unused, gave no indication of bulged tank liner bottoms.</p> <p>The 241-SX-151 diversion box manifold jumper valving was changed to route Redox neutralized waste to the 114-SX tank.</p> <p>The 113-SX bulb thermometer was removed and found to be free of contamination, therefore, the thermowell was intact.</p>

Table F6-1. SX-113 Chronology February to August 1958
(HW-57249) (Sheet 3 of 5)

6-9-58 Static pressure readings taken on the specific gravity dip tubes, differential pressure taps, and air supply lines to the circulators indicated no broken lines in the 113-SX tank. An air leak between the 113-SX tank and the 113-SX specific gravity instrument in the 402 Building was found to be responsible for the inability to measure specific gravity in the 113-SX tank, rather than a failed line in the tank as previously suspected.

6-10-58 The specific gravity instrument was repaired and a specific gravity of 1.325 was measured. Static pressure measurements on the air circulator differential pressure taps, together with the specific gravity and liquid level measurements, were used to calculate apparent bulge heights at the 4 circulators located on a 40' diameter circle as shown in the attached sketch. The bulge heights, liquid levels, and specific gravities are given in the Table below.

Date	Liquid Level	Sp.Gr.	Bulge Height At Circulators				Bulge Height at South 4" Riser
			1	2	3	4	
6/9	14'1 1/2"	1.325	38 1/2"	38 1/2"	38 3/4"	38 3/4"	---
6/10	13'11 1/2"	1.325	40 3/4"	36 1/2"	36 1/2"	36 3/4"	---
6/13	13'7"	1.333	39 3/4"	34"	31 3/4"	34 3/4"	42"
6/14	13'4 1/4"	--	--	--	--	--	---
6/15	12'11"	--	--	--	--	--	---
6/16	12'1 1/2"	1.333	18"	4 1/4"	3"	17 1/2"	5 1/2"
6/17	11'10 3/4"	1.36	15"	3 3/4"	4 1/2"	11"	-3/4"
6/18	11'5 1/2"	1.355	4"	1 3/4"	2 1/2"	3 3/4"	"
6/19	11'4"	1.36	5 3/4"	--	1"	3 1/4"	"
6/20	11'4 1/2"	1.36	5"	2 3/4"	3 1/2"	4 1/4"	"
6/23	11'0"	1.36	4 3/4"	1"	1 1/2"	3 1/4"	"
6/27	10'8 1/4"	1.375	6 1/4"	--	--	--	"
7/2	10'3"	1.403	5 1/2"	--	--	--	"
7/11	*10'1 1/4"	1.39	3/4"	--	--	--	"
7/15	9'10 1/4"	1.40	1 1/4"	--	--	--	"
7/18	9' 7 1/2"	1.419	1 1/2"	--	--	--	"

* Only 1 3/4" decrease in liquid level 7-2 - 7-11 due to H₂O flush of 10" prototype circulator prior to removal to 103-SX tank, plus backflushing of pump in 113-SX tank.

Table F6-1. SX-113 Chronology February to August 1958
(HW-57249) (Sheet 4 of 5)

6-11 - 6-13 58	The decrease in liquid level, as measured by the liquid level electrode, indicated a 4 gallon per minute volume loss. A calculation of bulge heights from the static pressure measurements on the air circulator differential pressure taps and a sounding at the liquid level electrode riser indicated that the bulge was receding. See above table.
6-13 - 6-18 58	Soundings at the south 4" riser together with liquid level measurements and calculated bulge heights from static pressure measurements on the air circulators show a rapid recession of the bulge. Data in the table indicate the tank liner bottom had returned to near its original position.
6-30-58	Monitoring of wells in the vicinity of the 113-SX tank, to date, has shown no detectable contamination. Since the nearest well is about 50' from the 113-SX tank, an attempt was made to drive a 3" well to a depth of 60', 5 feet from the outside wall of the tank in the Northwest quadrant. This effort failed when a solid obstruction was encountered at a depth of 48'. A 3" well was driven to a depth of 25' near the fill line and encasement entering the tank. No contamination was found in either well.
7/2/58	The waste removal pump was moved from the 103-SX tank to the 113-SX tank and installed in the east 12" pump pit riser.
7/8/58	The 10" prototype air circulator was moved from the west 12" riser of the 113-SX tank and installed in the east 12" pump pit riser of the 103-SX tank. The waste removal pump installed in the 113-SX tank on 7-2-58 would not pump the boiling contents from the tank.
7-22-58	<p>The waste removal pump was moved from the 113-SX tank and installed in the 111-SX tank. The spare waste removal pump, which had been modified to include water injection and a foot valve on the intake, was then installed in the 113-SX tank. The new pump measured 45'10" from the bottom of the flange to the bottom of the intake. A sounding taken at the east 12" pump pit riser gave 46'8" from the tank bottom to the top of the riser flange compared with 42'6" on 6-2-58.</p> <p>The 113-SX air circulators were shut off.</p>
7/23-58	The waste removal pump in the 113-SX tank was turned on at 1100 and began pumping the 113-SX tank contents to the 103-SX tank. Water injection was used. The 10" prototype air circulator in the 103-SX tank was put in operation when the pumping began. The 113-SX tank contained 294,379 gallons of waste at the start of pumping. The 103-SX tank contained 441,789 gallons of waste prior to receiving the 113-SX tank contents.

Table F6-1. SX-113 Chronology February to August 1958
(HW-57249) (Sheet 5 of 5)

7-25-58	The 113-SX waste removal pump was shut off at 0400 and back-flushed with the flushes going to the 113-SX tank; the line was flushed, with the flushes going to the 103-SX tank. The 113-SX tank was emptied to 1' 1 1/2" (22,291 gallons). The 103-SX tank was filled to 23' 5 1/2" (760,719 gallons). During the 40 hours of pumping, waste was removed from the 113-SX tank at a rate of 109 gallons per minute excluding 20 gallons per minute of injected water.
8-1 - 8-5 58	One theory advanced to explain the bulged 113-SX tank liner bottom was that the fill line had leaked into the encasement and the liquid from the encasement had entered the tank between the steel liner and the concrete shell. The fill line and encasement were uncovered and a 5/8" hole was drilled in the encasement approximately 15' from the tank wall. When a smear taken inside the encasement gave no evidence of gross fission product contamination, this theory was discarded.

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10.1 TANK SX-114 BACKGROUND HISTORY

This section provides information on the historical waste loss event associated with SST 241-SX-114 (SX-114). Tank SX-114 has three laterals installed in 1963 about 10-ft under the tank (see Figure 10-1). There are seven drywells located around tank SX-114: 41-14-04 installed in 1956 and 41-14-02, 41-14-03, 41-14-06, 41-14-08, 41-14-09 and 41-14-11 installed in 1962.

The bottom of the tank footing is ~53-ft BGS with ~6-ft 6-in soil cover over the dome (WHC-SD-WM-TI-665). Inside tank SX-114 are four ALCs 18-in above the tank bottom and equally spaced on a 40-ft diameter circle as shown in Figure 10-1 (H-2-39951. Two ALCs are designated low ALCs (8-ft 6-in tall) and two are high ALCs (13-ft 6-in tall) (H-2-9950).

Figure 10-1. Tank SX-114 Associated Drywells and Laterals
Tank inner ring is steel liner, outer ring is outer edge of tank footing

10.2 TANK SX-114 OPERATIONS SUMMARY

Tank SX-114 was constructed from 1953 to 1954 and started receiving REDOX HLW on November 5, 1956 (HW-1991-DEL, *CPD Waste Storage and Experience*). Normally tanks receiving boiling waste were preheated prior to use to minimize transfer stresses. However, tanks in the SX Farm were not fitted with steam coils and SX-114 was not preheated prior to use (RHO-R-39). Waste temperatures rose from an assumed conservative ambient temperature of 55°F on November 5, 1956 to ~120°F by November 14, 1956 (see Figure B7-1).

Condensate from the self-boiling waste tanks in SX Farm was collected in tank SX-106. The condensate was either discharged to a crib or a portion returned to the self-boiling waste tanks in SX Farm to maintain the waste temperature below a maximum operating limit. The ALCs were operated in tank SX-114 to provide added waste cooling.

The concentration of radionuclides present in the REDOX HLW received into tank SX-114 was sufficient to promote self-boiling of this waste, which was first observed in June 1957 (HWN-1991-DEL, *Chemical Processing Division - Waste Storage and Experience*). Periodic transfers of REDOX HLW into tank SX-114 continued to be made through August 1958, as space was made available by self-evaporation of the waste.

During the week of August 18, 1958, temperatures in tank SX-114 gradually increased in spite of the fact that four ALCs were operating in the tank (WHC-MR-0135, *Radiation Occurrence-Spread of Contamination from a Radiation Zone*). On August 22, 1958, the air was shut off and replaced with water to each of the ALCs. Temperatures in tank SX-114 were recorded to be 357°F at this time. Shortly afterwards, tank SX-114 “bumped” (pressure surge) three times which was believed to be due to turning off the air to the ALCs and on August 25, 1958 tank SX-114 bumped again resulting in a maximum reported pressure of 71-in of water (~2.6 psi) and steam escaping from two risers on tank SX-113 (see Section 3.2.2). Waste additions to tank SX-114 were then halted due to the pressurization event (WHC-MR-0135).

In August 1958, tank SX-114 contained ~676 kgal of waste. Over the next three years the tank was operated as a boiling waste tank with frequent additions of water or condensate from tank SX-106 to replace condensate losses. By July 1961, tank SX-114 contained ~807 kgal of waste, which corresponds to a waste height of ~24.9-ft (HW-71610, *Chemical Processing Department Waste Status Summary January 1, 1961 Through June 30, 1961*, page 8).

Nitrate leaching of the waste began when ~724 kgal of REDOX HLW supernatant was transferred from tank SX-114 to tank SX-103 in August and September 1961, leaving ~83 kgal of waste in tank SX-114. Approximately 295 kgal of condensate from tank SX-106 was transferred into tank SX-114 for nitrate leaching from September through December 1961, which continued to boil and evaporate waste for two months.

In July and August 1962, ~204.5 kgal of REDOX nitrate leachate waste was transferred from tank SX-108 into tank SX-114. Approximately 57 kgal of waste was transferred to tank SX-113 in November 1962 and then 180 kgal of waste was transferred back into tank SX-114 from tank SX-113 while performing the leak testing of tank SX-113. As of December 31, 1962, tank SX-114 contained ~480 kgal of waste (~15.1-ft).

In January 1963, ~219 kgal of nitrate leachate waste was transferred from tank SX-107 into tank SX-114. During the next three months, a total of ~57 kgal of nitrate leachate waste in tank SX-114 was transferred to the REDOX Plant for reuse in the fuel cladding dissolution process. The remaining nitrate leachate waste, ~619.4 kgal, was transferred from tank SX-114 to tank SX-105 in May 1963 leaving ~16 kgal of waste in tank SX-114. No further waste transfers occurred in 1963.

In April through June 1964, tank SX-114 received ~285 kgal of REDOX HLW, 104 kgal of condensate from tank SX-106, and 33 kgal of water. The condensate from tank SX-106 was added to tank SX-114 prior to the addition of REDOX HLW to avoid thermal shocking of the tank (HW-80202, *REDOX Weekly Process Reports January through December, 1964*, page 74). Periodic additions of REDOX HLW, condensate from tank SX-106, and water were made to tank SX-114 from July 1964 through 1965. No waste was added to tank SX-114 in 1966, although water was periodically added to maintain the tank level at ~650 kgal (~20.3-ft). No other additions were made to tank SX-114 for 1967 through 1968.

In January 1969, tank SX-114 received 248 kgal of REDOX HLW from tank SX-112, which was determined to be leaking (RPP-RPT-29191, *Supplemental Information Hanford Tank Waste Leaks*, page 45). The waste volume in tank SX-114 was reported to be 935 kgal (~28.9-ft) after this transfer. No other additions were made to the tank for the remainder of 1969 through November 1971. However, waste volumes were reported to be between 935 kgal and 950 kgal (~29.4-ft), the highest recorded waste volume for this tank. In December 1971, 492 kgal of REDOX HLW were transferred from tank SX-114 to tank SX-102 leaving 249 kgal of supernatant and 200 kgal of sludge in the tank (PPD-489-DEL, *Monthly Status and Progress Report December 1971*, page AIV-17; ARH-2074 D, *Chemical Processing Division Waste Status Summary October 1, 1971 through December 31, 1971*). An additional 171 kgal of REDOX HLW was transferred from tank SX-114 to tank SX-102 in January 1972 (PPD-493-1-DEL, *Monthly Status and Progress Report January 1972*; AIV-15; PPD-493-2-DEL, *Monthly Status and Progress Report February 1972*, page AIV-14; ARH-2456 A, *Chemical Processing Division Waste Status Summary January 1, 1972 Through March 31, 1972*). Tank SX-114 contained approximately 38 kgal of REDOX HLW supernatant and 200 kgal of sludge following these transfers.

Following removal of the REDOX HLW supernatant, tank SX-114 was used to receive waste from the cesium IX process (designated as RIX waste) conducted in B Plant. RIX waste is cesium denuded HLW supernatant. Beginning in the first quarter of 1972 (ARH-2456 A), tank SX-114 began receiving RIX waste that was generated from processing REDOX HLW supernatant in B Plant. The RIX waste was collected in tank BX-101 and then transferred to tank SX-105. After filling tank SX-105, the RIX waste was then transferred to tank SX-106, which pumped waste to tank SX-114. Tank SX-114 continued to receive RIX waste through April 1972 (PPD-493-4-DEL, *Monthly Status and Progress Report April 1972*, page AIV-18; ARH-2456 B, *Chemical Processing Division Waste Status Summary April 1, 1972 Through June 30, 1972*), by which time tank SX-114 contained 200 kgal of sludge and 737 kgal of supernatant for a total waste volume of 937 kgal (~29-ft).

Tank SX-114 was classified a potentially leaking tank in August 1972 based on gamma activity detected in drywell 41-14-06 (Internal letter LET-081072 "TK-114-SX Leak Status and

Recommendations”). The supernatant (737 kgal) in tank SX-114 was pumped to tank T-101 in August and September 1972 (ARH-2456-B) leaving a minimum heel of 200 kgal of solids (or ~6.8-ft above the tank bottom) and the tank was removed from service in 1975. Tank SX-114 was connected to sludge cooler to remove excess heat and water vapor. In January 1979, a photo of the tank contents was obtained showing no liquid remaining, and the tank was administratively interim stabilized in July 1979 (HNF-SD-RE-TI-178, *Single Shell Tank Leak Stabilization Record*, page 279). Tank SX-114 is estimated to contain 66 kgal of sludge, 175 kgal of saltcake, and no supernatant (HNF-EP-0182, Rev. 304).

The operational leak history of tank SX-114 leak related details including temperature and liquid level is charted in Figure 10-2.

Figure 10-2. Operational Leak History of Tank SX-114

10.3 TANK DESIGN/CONSTRUCTION

10.3.1 Tank Design

The SX Farm tanks had multiple design features that could contribute to stresses or possible leak paths when the tank was being operated including:

- Orthogonal intersection between the steel bottom and the sidewall
- Fillet weld used between the bottom and sidewall intersection
- Less rigorous weld inspection testing
- Partial asphaltic membrane waterproofing
- Keyed construction joints in the sidewall

These features are common to all SX Farm tanks and additional details are discussed in Section 3.1.1.

10.3.2 Tank Construction Conditions

The outside temperature between January 16, 1954 and January 30, 1954 ranged from an average high of 24°F to an average low of 9°F. A picture of the SX Farm under construction (see Figure 3-4) taken January 20, 1954 (high 11°F low -6°F), shows several of the tanks full of water either undergoing leak testing or for concrete wall pouring. During this cold period snow covered ice is seen in the water filled tanks.

As described in Section 3.1.2, cold weather affects the ductile-to-brittle steel transition temperature, with 18°F being the assumed unrestricted low temperature construction limitation for the carbon steel liner, which could result in a fracture upon impact. Low temperatures experienced during construction at or less than the 18°F allowable temperature could cause impact loading (e.g. a dropped tool or piece of equipment from scaffolding) and result in the potential for creating micro-fissures weakening the steel liner.

10.4 TANK SX-114 IN-TANK DATA

10.4.1 Liquid Level

The tank SX-114 liquid level was apparently not reviewed for a decrease when radioactivity was first detected in drywell 41-14-06 (with the peak reported at the equivalent 16-ft liquid level) in August 1972 as no mention was found in any of the monthly reports, individual letters, or previous leak assessment reports examined for this report. The near constant transfers into and out of the tank including caustic for pH control and water for cooling probably interfered with any meaningful liquid level analysis for a tank leak. In addition, the liquid level measurement under self-boiling conditions (evaporation) coupled with ALC operation results in data uncertainties that render the results unusable for determining liquid level losses associated with a tank leak.

The liquid level plot in Figure 10-3 indicates the transfer activity into and out of tank SX-114. The liquid levels are end of quarter levels so this figure may not reflect all transfers into and out

of the tank that occurred during the operational history of the tank. See Figure 10-2 for historical monthly liquid level readings.

Figure 10-3. Tank SX-114 End of Quarter Surface Level

WHC-SD-WM-ER-352, Rev 0, June 30, 1994, Historical Tank Content Estimate for the Southwest Quadrant of the Hanford 200 West Area

10.4.2 Temperature

Tank SX-114 was not preheated prior to the initial filling of waste which was first received on November 5, 1956 (HWN-1991-DEL). Temperatures quickly rose to ~120°F nine days later from an assumed conservative ambient ground temperature of 55°F and continued to increase to an equivalent boiling temperature of 240°F in September 1957. The available thermal history for tank SX-114 starts in November 1956 and continues through 1977 (see Appendix B7, Appendix C7, and PCSACS).

Waste temperature gradually increased and peaked at ~305°F in May 1958, as the tank was filled for the first time with REDOX HLW. As addition of REDOX HLW to tank SX-114 continued through August 1958, a temperature excursion to 357°F occurred (see Section 10.2). The waste temperature was moderated by operation of the ALCs and addition of water and/or condensate.

The tank continued to operate as a boiling waste tank through August 1961, as evident by the waste temperature being controlled between ~260 to 320°F during this period. The waste temperature began to decline in October 1961 as the REDOX HLW supernatant was transferred out of tank SX-114 and temperatures reached ~160°F in January 1962 where it remained until May 1964. Beginning in May 1964, tank SX-114 received REDOX HLW and temperatures rose steadily to ~260°F in October 1964. The waste temperature continued to increase and then was controlled between ~300 to 320°F from January 1965 through November 1967. In December 1967, the tank SX-114 waste temperature was reduced to ~270°F and remained at this temperature until 1970, the last available temperature data for tank SX-114.

The tank SX-114 pressurization event was experienced in August 1958, which resulted in a maximum reported pressure of 71-in of water (~2.1 psi) and steam escaping from two risers on tank SX-113 (WHC-MR-0135) leading to ground contamination. This event was believed to be the result of turning off the air supply to the ALC and replacing with water (WHC-MR-0135). Tank SX-114 contained ~676 kgal (~21-ft) of REDOX HLW at 357°F when the 1958 pressurization occurred.

10.4.3 Liner Observations

A bulge in a tank liner may result in the direct failure of the liner or cause enough stress or thinning on the steel liner plates and welds that they become more susceptible to the effects of corrosion. Experience indicates that bulging tends to be a dynamic phenomenon, and it is possible that a tank with no measured bulge at one point in time may actually have had a displaced liner that was not detected at another time.

Document RHO-R-39 lists tank SX-114 not having been inspected for a liner bulge (see Appendix A7) and no documentation was found indicating a bottom liner bulge in tank SX-114. A review of tank SX-114 photographs indicates there is the possibility a bulge was present at one time due to the presence of a failed ALC turnbuckle guy rod attachment (see Section 10.4.5). The pressurization event may have affected the ALC.

No other liner observations relating to a tank SX-114 leak have been found.

10.4.4 Chemistry-Corrosion

Waste Chemistry

Tank SX-114 began receiving REDOX HLW (R) in November 1956 and stored various waste types as shown in Table 10-1. The typical concentrations for nitrite, nitrate, and hydroxide for these waste types are shown in Table 10-2. Nitrite and hydroxide are known as nitrate-induced SCC inhibitors. One key characteristic for inhibiting SCC is to maintain a high nitrite concentration to nitrate concentration ratio (see Section 3.2.4).

Table 10-1. Tank SX-114 Waste Storage Chronology

Date	Waste Type	Length of Storage
November 1956 to August 1961	REDOX HLW	~ 5 years
September 1961 to May 1963	Nitrate Leachate	~ 2 years
May 1963 to April 1964	Nitrate Leachate heel	~ 1 year
April 1964 to January 1972	REDOX HLW	~ 8 years
January 1972 to August 1972	RIX	~ 8 months

Table 10-2. Waste Chemistries for Waste Types Stored in Tank SX-114

Waste Type	[NO ₃ ⁻] ¹	[NO ₂ ⁻] ¹	[OH ⁻] ¹	Meets Current DST Specification ²
RIX ¹	1.97	0.27	0.69	Yes
R ³	4.83	0.74		No ⁴

1. Reference WHC-EP-0449, 1991, *The Sort on Radioactive Waste Type Model: A Method to Sort Single-Shell Tanks into Characteristic Groups*.
2. Reference OSD-T-151-00007, Rev. 12, (2013), *Operating Specifications for the Double-Shell Storage Tanks*.
3. Reference WHC-EP-0772, 1994, *Characterization of the Corrosion Behavior of the Carbon Steel Liner in Hanford Site Single-Shell Tanks*.
4. Does not meet the current DST specification since the hydroxide and nitrite concentrations are not greater than or equal to 1.2M.

Tank SX-114 stored mostly REDOX HLW throughout operation for about 13 years total. REDOX HLW does not meet the current DST specification for waste chemistry due to low concentrations of the nitrate-induced SCC inhibitors, nitrite and hydroxide. Thus, these conditions of the REDOX HLW would likely create an environment conducive to SCC and/or pitting (see Section 3.2.4).

Tank SX-114 was also nitrate leached (discussed in detail below) and stored leachate waste for about three years total. This waste type would have had low concentrations of nitrite and hydroxide. Supernatant and sludge sample results from 1961 are shown in Table 10-3. The supernatant results were obtained before the tank underwent sodium nitrate sludge leaching and the sludge sample results were obtained during the nitrate leaching process. These results indicate the supernatant and sludge would not meet the current DST specification (OSD-T-151-00007, Rev. 12). For the supernatant, the nitrate concentration exceeds the maximum allowable limit of 5.5 M, and the concentration of nitrite and hydroxide in the sludge are below the minimum limit. Under these conditions, the tank would be vulnerable to SCC and/or pitting.

Table 10-3. Tank SX-114 Sample Results 1961

Date	Layer	Temperature	[OH ⁻] M	[NO ₂ ⁻] M	[NO ₃ ⁻] M
April 1961 ¹	Supernatant	297°F	1.53	0.45	8.15
October 1961 ²	Sludge	255°F	0.16	0.05	1.64
November 1961 ²	Sludge	216°F	0.22	0.07	3.47

1. Referenced from HW-64993, *Chemical Processing Department Monthly Report April, 1961*, page G-5.
2. Referenced from HW-71895, *Chemical Processing Department Monthly Report November, 1961*, page G-4.

Nitrate Leaching

Tank SX-114 was listed as one of the tanks that underwent sodium nitrate sludge leaching (RHO-R-39) which started after supernatant removal and subsequent transfer of condensate from tank SX-106 in September 1961. The tank continued at boiling temperatures (average temperature ~175°F) for two months after the transfer. Additional nitrate leachate waste was transferred into tank SX-114 from tanks SX-107 and SX-108 to a total volume of ~699 kgal (see Table 10-4). Leachate was transferred from tank SX-114 in May 1963 down to ~16 kgal and REDOX HLW was transferred into the tank on April 30, 1964 approximately one year after leachate was transferred. Nitrate leachate waste was stored in tank SX-114 for about 20 months (average temperature of ~160°F) with an additional 11 months at the 16 kgal level. Nitrate leachate was in the tank for a period of approximately 2 years 7 months. The first indication of a leak in tank SX-114 was detected in drywell 41-14-06 in August 1972, approximately 11 years after the start of leaching tank SX-114 waste and approximately 9 years after most of the leachate was removed. REDOX HLW was received on top of the 16 kgal leachate heel starting in April 1964.

Table 10-4. Tank SX-114 Nitrate Leaching Chronology

Date	Transfer/Comments	Duration	Reference
August/ September 1961	Transferred 724 kgal of supernatant from tank SX-114 to tank SX-103 leaving ~83 kgal heel	N/A	RPP-ENV-39658
September- December 1961	Transferred 295 kgal condensate to tank SX-114 from tank SX-106	N/A	RPP-ENV-39658
July/August 1962	Transferred 204.5 kgal nitrate leachate waste to tank SX-114 from tank SX-108	Nitrate leachate waste 11 mo from September 1961	RPP-ENV-39658
November/ December 1962	Transferred 57 kgal nitrate leachate waste to tank SX-113 then 180 kgal of nitrate leachate waste back from tank SX-113	Nitrate leachate waste 15 mo from September 1961	RPP-ENV-39658
January 1963	Transferred 219 kgal nitrate leachate waste to tank SX-114 from tank SX-107	Nitrate leachate waste 16 mo from September 1961	RPP-ENV-39658
February-May 1963	Transferred ~676 kgal of nitrate leachate waste SX-105 Leaving a 16 kgal heel	Nitrate leachate waste 20 mo from September 1961	RPP-ENV-39658
April 1964	Started receiving REDOX HLW	Nitrate leachate waste 31 mo from September 1961	RPP-ENV-39658
August 1972	Earliest indication of a tank SX-114 leak	11 years from start of leaching	Current analysis

Sodium nitrate leaching reduces nitrite and hydroxide concentrations which would increase the propensity for corrosion especially at the relatively high temperatures experienced in tank SX-114.

10.4.5 Photographs

Earliest available photographs of tank SX-114 taken on May 8, 1974 were reviewed. One photograph of ALC #4 with a turnbuckle guy rod hanging free in the southeast quadrant of the tank is shown in Figure 10-4. The locations of all ALCs in tank SX-114 are shown in Figure 10-5 with the ALC #4 located in the southeast quadrant of the tank. This is the only ALC with a failed turnbuckle guy rod during this time. This may be evidence of a liner bulge that could have resulted in failure of the turnbuckle guy rod bottom liner attachment. However, detachment of the ½-in diameter turnbuckle guy rod as well as bent piping could also be the result of mixing the waste when the ALCs were operating with the resulting forces on internal equipment. However, it remains inconclusive after reviewing available photographs since no other documentation was found indicating evidence of a liner bulge for tank SX-114.

**Figure 10-4. Tank SX-114 ALC #4 Photograph 742991-25CN
May 8, 1974**

Figure 10-5. Tank SX-114 Air Lift Circulator (ALC) Locations
 Tank inner ring is steel liner, outer ring is outer edge of tank footing

10.5 TANK SX-114 EX-TANK DATA

10.5.1 Laterals

In February 1964, gamma activity was first reported in lateral 44-14-03: “No changes noted except for a 550 c/m reading detected in the South lateral under the 114-SX Tank. Daily checking revealed no change at the end of the month” (*Monthly Report Waste Handling and Decontamination Operation REDOX Operation February 1964, Rough Draft* [Harmon 1964], page 2). The location under the tank was not identified. No further information was located for this lateral until 1973 when all laterals were reported as zero values (see Appendix D7). It appears the initial reading from February 1964 did not increase from 1964 to 1973 as tank

SX-114 continued to be kept in service and subsequent readings on June 15, 1973 and April 30, 1974 were recorded as zero values.

The next indication of radioactivity in lateral 44-14-03 was recorded on May 14, 1974 at 0.1K cpm at the end of the lateral, two years after the initial indication of a leak was detected in the nearby drywell 41-14-06. Radioactivity levels at the end of lateral 44-14-03 increased to 1.1K cpm by October 11, 1974 and then slowly decreased to less than values by June 1981. Laterals 44-14-01 and 44-14-02 were reported as having less than 0.1K cpm from June 1973 to June 1987 and therefore are not included as part of the leak location for tank SX-114. No later lateral scans were performed after 1987. All of the radiation readings in laterals are assumed to be maximum peak readings unless otherwise noted. The lateral notation indicating “no increase” or “no change” is commonly used to mean that the previous reading has not changed.

10.5.2 Drywells

There are seven drywells located around tank SX-114: 41-14-04 installed in 1956 and 41-14-02, 41-14-03, 41-14-06, 41-14-08, 41-14-09 and 41-14-11 installed in 1962. All of the radiation readings in drywells are assumed to be maximum values or peak readings unless otherwise noted and are from the Red-GM probe unless otherwise indicated (see Section 3.3.2). The bottom of the tank footing is ~53-ft BGS. The following subsections report the available drywell information and the drywell summary section provides the analyses of the associated drywells with tank SX-114.

10.5.2.1 Drywell 41-14-02 (N50°E)

Drywell 41-14-02 was drilled March 9, 1962 and radiation readings are all reported as less than values starting with the first recoverable reading on March 20, 1969 through June 24, 1987 (see Appendix E7). No data were recovered for February 1972 to September 1973.

In January 1996, Cs-137 was the only man-made radionuclide detected in drywell 41-14-02 and was measured almost continuously from the ground surface to the total depth of 76.7-ft BGS (GJ-HAN-16). The Cs-137 concentrations were typically less than 1 pCi/g with the maximum value reported at 76.7-ft BGS at 4 pCi/g. Document GJ-HAN-16 states, "Cs-137 contamination measured from the surface to TD may be the result of contamination inside the casing, contaminants that have migrated down along the outside of the casing, or redistribution of surface contaminants during drilling operations."

Since historical records report little radioactivity in this drywell, drywell 41-14-02 is not included as part of the leak location for tank SX-107. Figure 10-6 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 10-6. Tank SX-114 Drywell 41-14-02 (HNF-3136)

10.5.2.2 Drywell 41-14-03 (S75°E)

Drywell 41-14-03 was drilled March 1, 1962 and radiation readings are all reported as less than values starting with the first recoverable reading on March 19, 1969 through June 24, 1987 (see Appendix E7). No data were recovered for February 1972 to September 1973.

In January 1996, Cs-137 was the only man-made radionuclide detected in this drywell (GJ-HAN-16). Cs-137 was detected at the ground surface and from 3 to 58-ft BGS at concentrations typically less than 1 pCi/g except at the bottom of the drywell (75-ft BGS) where the maximum concentration of 4.5 pCi/g was measured. Document GJ-HAN-16 states, *“The Cs-137 contamination measured sporadically from the surface to about 58 ft may be the result of contamination within the casing, contaminants that have migrated down along the outside of the casing, or redistribution of surface contaminants during drilling operations. The contamination from 58 to TD could be the result of a distant subsurface source of contamination that has migrated to this depth because of lithologic variations. The elevated Cs-137 concentration at TD may indicate a zone of more significant contamination that the borehole has not penetrated.”*

Since historical records report little radioactivity in this drywell, drywell 41-14-03 is not included as part of the leak location for tank SX-114. Figure 10-7 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 10-7. Tank SX-114 Drywell 41-14-03 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

10.5.2.3 Drywell 41-14-04 (S36°E)

Drywell 41-14-04 was first drilled March 20, 1956 with the first recoverable radiation readings reported on September 25, 1972 as < 50K cpm (see Appendix E7). One month later readings were reported at 195K cpm at 57-ft BGS and slowly increased to 500K cpm by March 1, 1973. Radiation levels then slowly decreased and were reported as less than values by July 1978 possibly due to short lived radioisotopes which appear to fit the Ru-106 decay curve (HNF-3136) (see Section 10.7).

In January 1996, Cs-137 was the only man-made radionuclide detected in drywell 41-14-04 (GJ-HAN-16). Concentrations of Cs-137 were measured from the ground surface to 6-ft BGS and at the bottom of the drywell (123.7-ft BGS) and were less than 10 pCi/g near the ground surface and less than 1 pCi/g near the bottom. Document GJ-HAN-16 states, “Log data indicate no subsurface source of contamination near this borehole. The Cs-137 concentrations at the bottom of the borehole may be the result of contamination inside the casing.” Figure 10-8 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 10-8. Tank SX-114 Drywell 41-14-04 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

10.5.2.4 Drywell 41-14-06 (S7°W)

Drywell 41-14-06 was drilled March 2, 1962 with the first recoverable reading reported on March 20, 1969 at less than 50K cpm (see Appendix E7). Radiation levels remained at this level until July 10, 1972 when readings were reported as >1,000K cpm at 34-ft BGS with a SP which was the first indication of the tank SX-114 leak. A new peak developed one month later at 72K cpm at 51-ft BGS likely associated with surface water transporting radioactivity down through the soil column resulting in accumulation of soil moisture at the base of the tank farm excavation (RPP-ENV-39658). Development of a separate leak at 51-ft BGS within the same time frame as a leak at the higher elevation cannot be entirely ruled out; however, it is considered unlikely.

Readings were then recorded with a GM probe on September 12, 1972 at 5K cpm at 34-ft BGS and radiation levels slowly declined at this depth. On June 29, 1974 peak readings were recorded using new monitoring equipment at 263K cpm at 35-ft BGS and 53K cpm at 52-ft BGS. Readings slowly decreased and were reported as less than 5K cpm by July 1979 through June 1987.

The following is an excerpt in GJ-HAN-16 from SGLS logging in 1996:

“A review of gross gamma log profiles collected from this borehole from 1973 to 1994 indicated elevated gamma activity in 1973 at about 35 ft, and at 52 ft in 1974; the intensity of the upper peak was a factor of 7 greater than the lower peak. By 1981, the upper peak was almost nonexistent and the source of activity causing the lower peak had apparently migrated downward or decayed away. From 1981 to 1987, peaks of about the same intensity (60 counts per second [cps]) were shown at lower depths within the borehole in each succeeding year, suggesting the possibility of vertical migration of contamination through the sediment. For example, the peak in the lower zone (i.e., below 52 ft) with the highest intensity in 1986 was shown at 68 ft, rather than at 52 ft as shown in 1974. However, because the peak intensity was just above the instrument-detection limit in each measurement, the apparent changes in depth from year to year may be the result of statistical variations in the count rate and not the migration of contaminants.”

Figure 10-9 shows the depths of radioactivity from 1975 to 1995 (HNF-3136). Note: Figure 10-9 x-axis reads later years to earlier years which are the opposite of the other figures.

Figure 10-9. Tank SX-114 Drywell 41-14-06 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

10.5.2.5 Drywell 41-14-08 (S48°W)

Drywell 41-14-08 was drilled March 3, 1962 and radiation readings are all reported as less than values starting with the first recoverable reading on March 20, 1969 through June 24, 1987 (see Appendix E7). No data were recovered for February 1972 to September 1973.

In January 1996, Cs-137 was the only man-made radionuclide detected in drywell 41-14-08 at concentrations measuring less than 1 pCi/g at a few locations near the ground surface and at 66-ft BGS (GJ-HAN-16). Document GJ-HAN-16 states, “*The slightly elevated concentration shown at 66 ft may be the result of a statistical anomaly*”...and, “*Log data indicate no evidence of a subsurface source of contamination near this borehole.*” Since historical records report little radioactivity in this drywell, drywell 41-14-08 is not included as part of the leak location for tank SX-114. Figure 10-10 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 10-10. Tank SX-114 Drywell 41-14-08 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

10.5.2.6 Drywell 41-14-09 (N82°W)

Drywell 41-14-09 was drilled March 6, 1962 with the first recoverable radioactivity reported on May 26, 1965 at a peak of 238K cpm at 62-ft BGS (see Appendix E7). No other readings were recovered until March 26, 1969, four years later, when a peak of 48K cpm at 63-ft BGS was recorded. Readings gradually decreased and were recorded at < 50K cpm by July 1969 possibly due to short lived radioisotopes. No readings were reported from February 1972 until September 1973. Readings were reported at 35K cpm in September 1973 and gradually decreased to 5K cpm five years later.

The following is an excerpt in GJ-HAN-16 from SGLS logging in 1996:

“Historical gross gamma log data collected from this borehole from 1973 to 1994 have been reviewed. Log data collected from 1973 to 1974 indicate elevated gamma readings at varying depths from about 60 to 64 ft. The differences in depth are apparently the result of depth initialization or data collection inconsistencies, and not the result of contaminant migration. The peak intensity in 1974 had decreased by about a factor of 2 from the levels shown in 1973. This decrease in intensity may be the result of a radionuclide with a relatively short half-life. However, the latest available gross gamma log data collected in 1994 show the intensity of the readings has only decreased by about 25 percent (from 110 to 75 cps) since 1977. Because of the low count rates, it is not known if these decreases are attributable to a mixture of radionuclides with different half-lives or the result of instrumentation variations.

Cs-137 was the only man-made contaminant detected in this borehole (1994). Contamination was measured from ground surface to about 17 ft, from 62 to 65.5 ft, and from 71 to 75 ft (TD).”

There may be an indication of two events that both involved Ru-106 that decayed away, 1965 and 1973. The 1965 event could be associated with the tank SX-115 test wells 45B and 17A and leak (see Tank SX-115 Segment). Test wells 45B and 17A were considered to be at the edge of the tank SX-115 leak plume towards tank SX-114 which could have also affected drywell 41-14-09. The radiation gradually decayed away in drywell 41-14-09.

The 1973 radiation peaks in drywell 41-14-09 described in GJ-HAN-16 above was likely Ru-106 which gradually decayed away and the very low levels of gamma radiation remaining were Cs-137 which fit the Cs-137 decay curve (HNF-3136). This second event may be associated with tank SX-114 as there was no radiation reported in nearby tank SX-115 drywells. Figure 10-11 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 10-11. Tank SX-114 Drywell 41-14-09 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

10.5.2.7 Drywell 41-14-11 (N37°W)

Drywell 41-14-11 was drilled March 6, 1962 and radiation readings are all reported as less than values starting with the first recoverable reading on March 20, 1969 through June 24, 1987 (see Appendix E7). No data were recovered for February 1972 to September 1973.

In January 1996, Cs-137 was the only man-made radionuclide detected in drywell 41-14-11 (GJ-HAN-16). Cs-137 was detected from the ground surface to 10-ft BGS, from 70 to 75-ft BGS, and at low concentrations throughout the remainder of the drywell. Measured Cs-137 concentrations were typically 1 pCi/g or less throughout the drywell except for near-surface contamination. The subsurface Cs-137 contamination was likely the result of surface spill that migrated down the drywell (GJ-HAN-16). Since historical records report little radioactivity in this drywell, drywell 41-14-11 is not included as part of the leak location for tank SX-114. Figure 10-12 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 10-12. Tank SX-114 Drywell 41-14-11 (HNF-3136)

Note: Bottom of the tank footing is ~53-ft BGS

10.5.3 Tank SX-114 Drywell Summary

Radioactivity in tank SX-114 drywell 41-14-06 first appeared before July 10, 1972 at 34-ft BGS. Tank SX-114 was suspected of leaking in August 1972 due to increased radioactivity in drywell 41-14-06. One month later radioactivity at a lower level peaked at 51-ft BGS in drywell 41-14-06. Three months later radiation was detected in drywell 41-14-04. Low levels of radiation were also detected in lateral 44-14-03 and drywell 41-14-09.

The drywell information indicates that a tank SX-114 leak was first detected at ~16-ft above the tank bottom, lowest point of the dished bottom (Internal letter LET-083172, "TK-114-SX Leak Status and Recommendations"). The first three keyed sidewall construction joints are at 7-ft 10-in, 15-ft 5½-in and 22-ft 4½-in above the lowest point of the tanks dished bottom (see Figure 10-13). It is possible these construction joints in the sidewall as well as possible cracks could be leak locations which were later detected in the drywells. It was postulated that tank SX-114 had developed a leak above the 16-ft waste height (i.e. 508,600 gal) and the waste level in tank SX-114 was lowered to ~15.1-ft (i.e., 480,000 gal) in August and September 1972 to prevent further waste loss (PPD-493-8-DEL, *Monthly Status and Progress Report August 1972*, page AIV-17; PPD-493-9-DEL). On August 21, 1972 a second peak appeared in drywell 41-14-06 and all remaining supernatant was transferred from tank SX-114 to tanks T-101 and T-102 lowering the waste height to that of the sludge (~6.8-ft above tank bottom). However, no daily liquid level readings were recovered for tank SX-114 during this time.

Drywell 41-14-04 radiation began rising October 20, 1972 at 57-ft BGS two months after the peak at 51-ft BGS in drywell 41-14-06 (see Section 10.5.2). Radiation levels began rising 19 months later on May 14, 1974 at the end of lateral 44-14-03 positioned between drywell 41-14-04 and 41-14-06 after having been reported at zero since a reading in 1964 (see Section 10.5.1). These may be unrelated separate events or they may be connected.

Drywell 41-14-09 radiation seems to be a separate event from the above. There could be two drywell 41-14-09 periods of radioactivity, the first of which coincides with the 1965 tank SX-115 leak and the associated test wells 45B and 17A (see Tank SX-115 Segment). Test wells 45B and 17A were considered to be at the edge of the tank SX-115 leak plume towards tank SX-114 which could have also affected drywell 41-14-09. The radiation gradually decayed away in drywell 41-14-09. The second drywell 41-14-09 period of radioactivity starting in September 1973 may be associated with tank SX-114 as there was no radiation reported in nearby tank SX-115 drywells.

Figure 10-13. Tank SX-114 Sidewall Features and Leak Detection Elevations

Referenced from H-2-39512, 75 FT. Tank Base Footing & Sidewall Reinforcing Waste Disposal Facility 241-SX

10.6 INLET LINES – PIPELINES – VENT LINES

Radioactivity was observed in the tank SX-114 drywells beginning in August 1972 and at the end of a nearby lateral 44-14-03 about two years later. Drywell 41-14-06 is located 6.9-ft to the south of tank SX-114 footing and drywell 41-14-04 is located 12.5-ft from the southeast side of tank SX-114 towards the tank footing below the auxiliary fill line inlet. These two drywells along with the end of lateral 44-14-03 are located on the south side of the SX Farm (Figure 10-14). No other tanks are adjacent to drywells 41-14-04 and 41-14-06. Radiation in drywell 41-14-09 was reported in September 1973 but seems unrelated to the above as this drywell is located ~11-ft from the west side of tank SX-114, near tank SX-115. Given the location of drywell 41-14-04 it is possible tank SX-114 piping could be a radioactivity source. However, there are no known historical leaks associated with pipelines in the vicinity of tank SX-114 (7G410-MEJ-07-004-Memorandum), therefore a review of pipe and vent lines was conducted to identify any potential leak sources other than the tank.

Figure 10-14. SX-114 Drywells 41-14-04, 41-14-06, and Lateral 44-14-03
Potential Leak Site Spatial Dimensions

Two 3 1/2-in pipelines (V-590 and V-591) that traverse nearby drywell 41-14-04 are the fill lines to tanks SX-115 and SX-114, respectively. Pipelines V-590 and V-591 are encased in a 3/8-in asphaltic waterproofing membrane. It is unlikely that waste could have leaked from these encased lines. However, pipeline V-591 enters tank SX-114 through the auxiliary fill line inlet nozzle assembly – 213 (see Figure 10-15). The 3 1/2-in O.D. H Ga. Stainless Steel tubing, pipeline V-591, enters the inlet assembly through a 4-in sch. 80 pipe that is located in the tank wall through a 6-in sch. 40 pipe that extends 6-in outside the tank wall. Asbestos is packed between the V-591 3 1/2-in tubing and the 4-in pipe. Oakum is packed between the outer end of the 3 1/2-in tubing and the 6-in pipe which is wrapped with 3/8-in waterproofing. It is possible the tank SX-114 pressurization event in August 1958 could have affected the packing material in the nozzle causing a potential leak site for any collection of condensate in the assembly. This nozzle is located near drywell 41-14-04 for which radioactivity was reported approximately three months after the initial leak was detected in drywell 41-14-06. Nozzle 213 is located approximately 20-ft 7-in BGS and radiation was detected in drywell 41-14-04 at 57-ft BGS. It is possible waste leaked from nozzle 213 and seeped down the tank wall and was detected at a lower BGS level in the drywell.

Figure 10-15. Auxiliary Fill Line Inlet Nozzle Details for Pipeline V-591 into Tank SX-114

Referenced from H-2-39517, 75 Ft. Dia. Tank Nozzle Assemblies & DTLs. Waste Disposal Facility 241- SX

Pipeline L114 was used to remove REDOX HLW supernatant from tank SX-114. Pipeline L114 originates in the centrally located tank SX-114 pump pit and traverses northeast (2 o'clock position) across the top of the tank, eventually terminating in diversion box 241-SX-152 (H-2-3412, *Transfer lines from Tanks to 241-SX-152*). The one spare inlet nozzle (H-2-39510, *Plan 75 FT. Tanks Waste Disposal Facility 241-SX TKs 101-115*; H-2-39517, 75 FT. Dia. Tank Nozzle Assemblies & Dtls. Waste Disposal Facility 241-SX, detail 216) is also located at the 2 o'clock position and is capped with a 3/8-in waterproofing over the slip cap on the outer 8-in sch. 80 pipe. Pipeline L114 and nozzle 216 are not located near any of the drywells where radioactivity was detected; therefore, they do not appear to be possible leak sources.

A buried 24-in vapor header atop tank SX-114 contained condensate as well as non-condensable vapors. This vapor header was welded, but included a butterfly valve to regulate airflow (located

at 8 o'clock position approximately 4-ft BGS on top of tank SX-114) (H-2-39901, *Tanks 107-115 Manifold Facilities General Layout*; H-2-39909, *Tanks 107-115 Manifold Facilities Vapor Manifold Support Details*). A small leak from this vapor header could possibly have gone unnoticed by tank farms personnel, since a material balance was difficult to perform for the boiling waste tanks. However, since no radioactivity was observed in the nearby drywell, 41-14-08, the vapor header does not appear to be a possible leak source.

A 3-in steel pipeline with a gate valve attached to riser R-7 atop tank SX-114 (located at the 9 o'clock position) was used to transfer condensate from tank SX-106 to tank SX-114. In November 1959, an estimated 25 kgal leak of condensate was reported to have occurred in the valve box atop tank SX-112 (RPP-RPT-29191, page 153). It is possible a leak could have occurred at this location and was detected at a lower BGS level in drywell 41-14-09. However, condensate was last added to tank SX-114 in 1965 and the drywell radioactivity was detected in 1972.

10.7 POSSIBLE TANK SX-114 LINER LEAK LOCATION(S)

There are possibly three tank SX-114 leak locations with one lateral indication of possible convergence of one or two of the drywell leak indications.

Beginning in the first quarter 1972 tank SX-114 contained approximately 95% RIX (Cs-137 denude HLW supernatant) with 5% REDOX HLW solution on top of 200 kgal of sludge. This would result in a disproportionately high concentration of Ru-106 to Cs-137 compared with REDOX HLW supernatant. Condensate from this mixture would be at an even higher ratio of Ru-106 to Cs-137. This could play into the relative radiation levels seen in the drywells and laterals as well as the decay profiles and mobility.

10.7.1 Leak Detected In July 1972, Site A

The first indication of a leak from tank SX-114 was detected in drywell 41-14-06 on July 10, 1972 when radioactivity levels of >1,000K cpm at 34-ft BGS (~16-ft waste level) (see site A in Figure 10-16). No liquid level decreases were reported during this time. One month later a second much lower radiation level peak developed in drywell 41-14-06 at 51-ft BGS likely due to the migration of the initial leak (see Section 10.5.2.4). Tank SX-114 was classified as a potentially leaking tank in August 1972. The initial leak is a possible sidewall leak above the 16-ft waste level.

Figure 10-16. Tank SX-114 Possible Leak Location (July 1972)
Tank inner ring is steel liner, outer ring is outer edge of tank footing

Leak first detected July 1972 in drywell 41-14-06 at 34-ft BGS and August 1972 in drywell 41-14-06 at 51-ft BGS

10.7.2 Leak Detected In October 1972, Site B

Drywell 41-14-04 radiation was first detected at 57-ft BGS on October 20, 1972. Possible leak sources include the tank liner and the auxiliary fill inlet line with a remote possibility of migration from leak site A (see Figure 10-16). The latter seems unlikely as the intervening lateral 44-14-03 did not indicate any radioactivity until May 1974 at a very low radiation level (see site B in Figure 10-17). The closest path to drywell 41-14-04 would be a tank leak location at or near the bottom of the tank. The other path would be from the failure of the auxiliary fill inlet line packed seals coupled with formation of condensate in the auxiliary fill line inlet assembly. The decay curve could possibly indicate condensate from the auxiliary fill line inlet assembly; however, a tank leak cannot be ruled out.

Figure 10-17. Tank SX-114 Possible Leak Location (July 1972)

Tank inner ring is steel liner, outer ring is outer edge of tank footing

Leak first detected July 1972 in drywell 41-14-06 at 34-ft BGS and August 1972 in drywell 41-14-06 at 51-ft BGS

10.7.3 Leak Detected in May 1974, Site C

Radioactivity was first detected in lateral 44-14-03 in May 1974, with a peak at the end of the lateral, outside the tank shadow, at 0.1K cpm (see site C in Figure 10-18). However, one early reading in 1964 indicated some radioactivity in this lateral which was not confirmed by two subsequent readings to 1974. Radioactivity reported in lateral 44-14-03 could be migration from either leak site A or B or both. However, a separate tank leak site cannot be ruled out.

Figure 10-18. Tank SX-114 Possible Leak Location (May 1974)

Tank inner ring is steel liner, outer ring is outer edge of tank footing

Leak first detected July 1972 in drywell 41-14-06 at 34-ft BGS and August 1972 in drywell 41-14-06 at 51-ft BGS

10.7.4 Leak Detected In September 1973, Site D

Radiation in drywell 41-14-09 appeared in 1965 at 62-ft BGS but may have been migration from the 1965 tank SX-115 leak which then decayed away. Readings from July 1969 through February 1972 were recorded as < 50K cpm. No drywell data were recovered from February 1972 until September 1973 when low level radiation peak was found at 60-ft BGS. The source of this radioactivity is unclear but since the location was below the tank it seems there could be either residual or migration of radiation from the 1965 tank SX-115 leak or a leak from tank SX-114 (see site D in Figure 10-19). Pipelines and the vent system do not seem to be credible sources.

Figure 10-19. Tank SX-114 Possible Leak Location (September 1973)

Tank inner ring is steel liner, outer ring is outer edge of tank footing

Leak first detected July 1972 in drywell 41-14-06 at 34-ft BGS and August 1972 in drywell 41-14-06 at 51-ft BGS

10.7.5 Leak Location Summary

The tank SX-114 leak first occurred in July 1972 based on increased radioactivity in drywell 41-14-06. Radioactivity was first recorded in March 1965 for the drywells, and there was no indication of a leak from tank SX-114 prior to 1972. The leak was found to have started in the southern portion of the tank as shown by site A on the sidewall of the tank (see Figure 10-20). One month later, an additional peak developed in drywell 41-14-06 at 51-ft BGS at much lower radiation levels likely due to the migration of the initial leak (see Section 10.5.2.4). Drywell 41-14-04 radiation began rising at 57-ft BGS in October 1972 and may have indicated a separate tank leak or a leak from the auxiliary fill line inlet assembly. In May 1974, radioactivity was initially detected at the end of the lateral 44-14-03, outside the tank shadow (site C). Radioactivity levels were low relative to those detected in drywells 41-14-04 and 41-14-06 indicating radioactivity reported in lateral 44-14-03 was possible spreading of radioactivity detected in 1972. Radioactivity in drywell 41-14-09 at 60-ft BGS in September 1973 appears to be either residual or migrating tank SX-115 leak or a tank SX-114 leak.

There is a possibility of a liner bulge which has been indicated by ALC #4 guy rod hanging free (see Section 10.4.5); however, there is no direct evidence and the possible location remains inconclusive.

Leak locations in Figure 10-20 are based on peak readings and are a representation of possible initial boundaries of radioactivity.

Figure 10-20. Tank SX-114 Possible Radial Leak Locations
 Tank inner ring is steel liner, outer ring is outer edge of tank footing

10.8 POSSIBLE TANK SX-114 LINER LEAK CAUSE(S)

Tank SX-114 was exposed to five conditions that could contribute to a failed liner. Some or all of the factors can act together to contribute to tank liner failure.

10.8.1 Tank Design

The design of the SX Farm tanks was the first that diverged from the round bottom knuckle design used in the earlier waste tanks; the tank bottom liner intersects the sidewall liner orthogonally. A fillet weld was used to close the seam where the sidewall and the tank bottom liners meet. Several other SSTs with fillet welds failed during service (RPP-RPT-45921). Weld inspections were less rigorous. Additionally, the design discontinued the use of the three-ply asphaltic membrane waterproofing between the liner sidewall and the concrete shell. These features were inferior to others and could possibly increase the likelihood of failure of the tank liner from induced stresses (see Section 10.3.1).

10.8.2 Thermal Conditions

Temperature requirements in HW-59919 (*Limitations for Existing Storage Tanks for Radioactive Wastes from Separations Plants*) issued October 22, 1959 indicated that the self-boiling waste operating temperature should be maintained between 50°F and 220°F. The HW-59919 document recommended a uniform rate of temperature increase of 2°F per day and the maximum sludge temperature should not exceed 300°F.

The tank SX-114 bulb (sludge) temperatures are shown in Appendix B7 and Appendix C7. The maximum temperature of 357°F was reported in August 1968. Tank SX-114 temperatures exceeded the maximum sludge temperature on several occasions as discussed in Section 10.4.2.

Assuming a conservative 55°F initial temperature of the tank liner when waste was first received on November 5, 1956 (HW-1991-DEL) and increased to ~120°F nine days later (see Appendix B7), the temperature rate of rise was therefore ~7.2°F per day. Tank SX-113 temperature recorded February 26, 1958 before receiving waste was 42°F, therefore 55°F may not be the worst case for ambient temperature for tank SX-114 in November 1956. No recording of tank SX-114 temperature was found before receiving waste.

On August 13, 1958 waste temperatures were ~269°F and increased to ~357°F by August 22, 1958 resulting in a pressurization event (WHC-MR-0135). Therefore, there was a temperature increase of 88°F over a 9 day period, and the average rate of rise was ~9.8°F per day, which was greater than the initial rate of rise from the first filling of waste into tank SX-114.

Note that the operating temperature limitations specified in HW-59919 were exceeded both before and after issuing the document. Thermal shock creates stress both from rapid temperature rise as well as waste-induced high temperatures.

10.8.3 Chemistry-Corrosion

Tank SX-114 was first filled with REDOX HLW (November 1956) which was stored in the tank for a total of 13 years. Tank SX-114 also stored RIX waste (~8 months) and nitrate leachate

waste (~3 years). Storage of RIX waste should not have resulted in pitting or SCC. The REDOX HLW consisting of low concentrations of nitrite and hydroxide would have created an environment conducive to pitting and/or SCC.

Supernatant and sludge samples taken in 1961 (supernatant would have been REDOX HLW and sludge samples were obtained during the nitrate leaching) indicated the waste chemistry would not have met the current DST specification (see Section 10.4.4). Under these conditions, there would be a high propensity for corrosion.

Sodium nitrate leaching of tank SX-114 waste started with transfer of supernatant out of the tank and subsequent addition of condensate from tank SX-106 in September 1961. The remaining nitrate-rich sludge was leached. Additional nitrate leachate waste was transferred into tank SX-114 from tanks SX-107 and SX-108. The nitrate leachate waste was transferred from tank SX-114 in May 1963 down to ~16 kgal heel. REDOX HLW was transferred to the tank on April 30, 1964 approximately one year later. Leaching was started in September 1961 and REDOX HLW was reintroduced into the tank in April 1964 for a total leachate period of approximately 2 years 7 months. Tank SX-114 was first suspected of leaking based on radioactivity detected in drywell 41-14-06 in August 1972, approximately nine years after transfer of most of the leachate waste. Loss of the protective nitrite and hydroxide ions would have created an environment conducive to SCC and/or pitting of the tank liner at the temperatures tank SX-114 experienced.

10.8.4 Liner Observations

The table in RHO-R-39 (see Table A7) indicated there was no inspection for a bulge in tank SX-114. The evidence of a liner bulge is possible in tank SX-114, but not conclusive. Liner bulging coupled with other tank conditions could affect tank liner integrity; however, by itself bulging can induce stresses that could result in locations that are more susceptible to corrosion.

10.8.5 Tank Construction Temperature

Winter temperatures as low as -6°F occurred during the period when the SX Farm tank liners were being constructed and leak tested (see Figure 3-4). The low temperatures experienced during construction were less than the current 18°F allowable temperature where impact loading had the potential for creating micro-fissures. Impact occurrences could have occurred during cold temperatures that may have triggered fissures in the steel liner.

10.9 TANK SX-114 CONCLUSIONS

Evidence indicates that the tank SX-114 liner possibly leaked in the sidewall above the 16-ft waste level and near the bottom of the tank at possibly two locations. Based on engineering judgment and available information the following conditions listed in the order of importance lead to the tank SX-114 failed liner:

1. Thermal conditions – rate of temperature rise and maximum temperature
2. Tank design – expansion limiting design changes
3. Waste storage chemistry and nitrate leaching – corrosion – SCC and/or pitting
4. Construction conditions – ductile-to-brittle transition temperature

There are several liner leak cause conditions that were examined, but the primary cause of the leak is thermal conditions experienced during the rapid addition of high temperature waste to a cold tank as well as waste storage temperatures. Also, the unique tank design did not allow for expansion of the bottom liner as the tank heated creating stresses. Storage of REDOX HLW at elevated temperatures, nitrate leachate waste (leachate remained in the tank or ~20 months, the longest period compared to the other leaking SX Farm tanks), and subsequent nitrate leaching created a chemical environment susceptible to nitrate-induced SCC and/or pitting attack on an already stressed metal liner. Tank construction occurred in winter under cold temperature conditions which could have affected the ductile-to-brittle steel transition temperature where metal loses its ability to absorb forces such as induced loads or the impact of falling objects creating micro-fissures or hairline cracks. In addition, a bulged bottom imparts stresses in the liner that could have predisposed it to SCC. Some or all of the factors can act serially or together to contribute to tank liner failure.

APPENDIX A7

TANK SX-114 BOILING WASTE OPERATIONAL HISTORY

Table A7-1. RHO-R-39 Boiling Waste Tank Operating Data Table

Tank No.	First Waste	Tank Pre-Heated	Pre-Heat Start	Liquid Heel Used	First Waste Rec'd From	Tank Failed	Inspected For Bulge	Bulge Present	Did Tank Boil on 1st Loading	Tank Started Boiling	Tank Emptied & Reused*	NaNO ₃ Leached from Sludge
101-SX	19 May 54	No	-	No	Redox	No	No	-	Yes	Nov 54	No	No
102-SX	Sep 54	No	-	No	101-SX, Cascade	No	No	-	No	-	No	No
103-SX	Nov 54	No	-	No	102-SX, Cascade	No	No	-	No	-	No	No
104-SX	2 Feb 55	No	-	No	Redox	No	No	-	Yes	Jun 55	No	No
105-SX	11 May 55	No	-	No	104-SX, Cascade	No	No	-	No	-	Yes	No
106-SX	Jun 54	No	-	No	Tank Farm Condensate	No	No	-	No	-	-	-
107-SX	3 Mar 56	No	-	Yes	Redox	Yes, 1964	Yes	Yes	Yes	Jun 56	Yes	Yes
108-SX	8 Nov 55	No	-	No	Redox	Yes, 1962	Yes	Yes	Yes	Jun 56	Yes	Yes
109-SX	20 Sep 55	No	-	Yes	Redox	Yes, 1965	Yes	No	Yes	Dec 55	Yes	No
110-SX	Nov 60	Yes	Apr 60	No	Redox	-	No	-	No	Between 1/61-6/61	Yes	No
111-SX	9 Jun 56	No	-	No	Redox	-	No	-	Yes	Nov 56	Yes	No
112-SX	13 Feb 56	No	-	No	Redox	Yes, 1969	Yes	Yes	Yes	Mar 56	Yes	No
113-SX	20 Feb 58	No	-	No	Redox	Yes, 1958	Yes	Yes	Yes	Apr 58	No	No
114-SX	Nov 56	No	-	No	Redox	-	No	-	Yes	Jun 57	Yes	Yes
115-SX	4 Nov 59	Yes	Sep 58	Yes	Redox	Yes, 1965	No	-	Yes	Nov 59	No	Yes
101-A	20 Jan 56	No	-	6" H ₂ O	Purex	No	Yes	No	Yes	Jul 57	Yes	No
102-A	20 Mar 56	No	-	6" H ₂ O	Purex	No	No	-	Yes	Jul 58	Yes	No
103-A	15 May 56	No	-	6" H ₂ O	Purex	No	No	-	Yes	Jul 56	Yes	No
104-A	30 Jun 59	No	-	6" H ₂ O	Purex	No	Yes	No	Yes	Aug 59	Yes	No
105-A	31 Jan 63	Yes	Jan 63	Yes	Purex	Yes, 1963	Yes	Yes	No***	Mar 63	No	No
106-A	31 Dec 60**	Yes	23 Feb 61	Yes	Purex	No	No	-	Yes	Aug 61	Yes	No
101-AX	1 Jun 65**	Yes	23 Nov 66	Yes	TK-103-A and TK-112-B	No	No	-	No***	Dec 66	Yes	No
102-AX	30 Sep 66**	Yes	2 Mar 69	Yes	TK-101-AX and TK-103-A	No	No	-	No***	Apr 69	No	No
103-AX	10 Feb 65	Yes	Nov 64	Yes	Purex	No	No	-	Yes	Apr 65	No	No
104-AX	9 Sep 66	Yes	Jun 66	Yes	Purex	No	No	-	Yes	Oct 66	No	No

* Emptied indicates supernatant was pumped out but sludge remained.

** Tanks used for temporary waste storage prior to the receipt of LW or HLW.

*** Did not boil until LW was routed to the tank.

Note: SX-111 was found to have been NaNO₃ Leached

APPENDIX B7

TANK SX-114 TEMPERATURES AUGUST 1956 – JUNE 1957

Figure B7-1. Tank SX-114 Temperature November and December 1956

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure B7-2. Tank SX-114 Temperature January through June 1957

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

APPENDIX C7

TANK SX-114 TEMPERATURE JANUARY 1957 – JUNE 1968

Figure C7-1. RHO-CD-1172 Tank SX-114 Temperature January 1957 through July 1958

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C7-2. RHO-CD-1172 Tank SX-114 Temperature August 1958 through February 1960

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C7-3. RHO-CD-1172 Tank SX-114 Temperature March 1960 through September 1961

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C7-4. RHO-CD-1172 Tank SX-114 Temperature October 1961 through April 1963

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C7-5. RHO-CD-1172 Tank SX-114 Temperature May 1963 through November 1964

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C7-6. RHO-CD-1172 Tank SX-114 Temperature December 1964 through June 1966

Figure C7-7. RHO-CD-1172 Tank SX-114 Temperature July 1966 through January 1968

Figure C7-8. RHO-CD-1172 Tank SX-114 Temperature February 1968 through June 1968

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

APPENDIX D7

TANK SX-114 LATERAL ACTIVITY

**Table D7-1. Tank SX-114 Lateral Radioactivity (counts per minute)
(June 1973 through June 1987)
(SD-WM-TI-356)¹**

44-14-01		44-14-02		44-14-03		
Date	Peak (K cpm)	Date	Peak (K cpm)	Date	Peak (K cpm)	Distance (ft)
N/A ²		N/A ²		3/3/64	0.6 ³	N/A ²
6/15/73	0	6/15/73	0	6/15/73	0	N/A ²
4/30/74	0	4/30/74	0	4/30/74	0	N/A ²
N/A ²		N/A ²		5/14/74	0.1	end
9/15/74	0	9/5/74	0	9/24/74	0.1	N/A ¹
N/A ²		N/A ²		10/11/74	1.1	end
2/3/75	0	2/3/75	0	2/3/75	1.0	end
7/8/75	< 0.1	7/8/75	0.1	7/15/75	0.8	end
10/1/75	< 0.1	10/1/75	< 0.1	10/1/75	0.7	end
3/2/76	< 0.1	3/2/76	< 0.1	3/2/76	0.8	end
5/4/77	< 0.1	5/4/77	< 0.1	5/4/77	0.5	end
7/11/78	< 0.1	7/11/78	< 0.1	7/11/78	0.4	end
7/18/79	< 0.1	7/18/79	< 0.1	7/18/79	0.2	end
7/8/80	< 0.1	7/8/80	< 0.1	7/8/80	0.1	end
6/22/81	< 0.1	6/22/81	< 0.1	6/22/81	< 0.1	N/A ¹
7/26/82	< 0.1	7/26/82	< 0.1	7/26/82	< 0.1	N/A ¹
6/14/83	< 0.1	6/14/83	< 0.1	6/14/83	< 0.1	N/A ¹
6/8/84	< 0.1	6/8/84	< 0.1	6/8/84	< 0.1	N/A ¹
6/19/85	< 0.1	6/19/85	< 0.1	6/19/85	< 0.1	N/A ¹
6/13/86	< 0.1	6/12/86	< 0.1	6/12/86	0.1	N/A ¹
6/19/87	< 0.1	6/19/87	< 0.1	6/30/87	< 0.1	N/A ¹

Note: ¹If Depths were not available, the column was omitted from the table

²N/A: Data not available

³Referenced from Monthly Report Chemical Processing Department February 1964

APPENDIX E7

TANK SX-114 GROSS GAMMA DRYWELL DATA

Table E7-1. Tank SX-114 Drywell Radioactivity (K counts per minute) (May 1965 to June 1987)
(Drywell Data Sheets Retrieved March 23, 2011 and SD-WM-TI-356) (1 of 3 sheets)¹

41-14-02 ⁸		41-14-03 ⁸		41-14-04 ⁶			41-14-06 ⁷			41-14-08 ⁸		41-14-09 ⁵			41-14-11 ⁸	
Drilled 3/9/1962		Drilled 3/1/1962		Drilled 3/20/1956			Drilled 3/2/1962			Drilled 3/3/1962		Drilled 3/6/1962			Drilled 3/6/1962	
Date	Peak (K cpm)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)
N/A ³		N/A ³		N/A ³			N/A ³			N/A ³		5/26/65	238 ⁹	62	N/A ³	
3/20/69	< 50	3/19/69	< 50	N/A ³			3/20/69	< 50	N/A ³	3/20/69	< 50	3/26/69	48	63	3/20/69	< 50
4/3/69	< 50	4/3/69	< 50	N/A ³			4/3/69	< 50	N/A ³	4/3/69	< 50	4/8/69	50	63	4/3/69	< 50
5/8/69	< 50	5/8/69	< 50	N/A ³			5/8/69	< 50	N/A ³	5/8/69	< 50	5/5/69	32	63	5/8/69	< 50
N/A ³		N/A ³		N/A ³			N/A ³			N/A ³		6/18/69	27	63	N/A ³	
7/17/69	< 50	7/17/69	< 50	N/A ³			7/17/69	< 50	N/A ³	7/17/69	< 50	7/17/69	< 50	N/A ³	7/17/69	< 50
8/20/69	< 50	8/20/69	< 50	N/A ³			8/20/69	< 50	N/A ³	8/20/69	< 50	8/20/69	< 50	N/A ³	8/20/69	< 50
9/22/69	< 50	9/22/69	< 50	N/A ³			9/22/69	< 50	N/A ³	9/22/69	< 50	9/22/69	< 50	N/A ³	9/22/69	< 50
10/17/69	< 50	10/17/69	< 50	N/A ³			10/17/69	< 50	N/A ³	10/17/69	< 50	10/17/69	< 50	N/A ³	10/17/69	< 50
11/20/69	< 50	11/20/69	< 50	N/A ³			11/20/69	< 50	N/A ³	11/20/69	< 50	11/20/69	< 50	N/A ³	11/20/69	< 50
12/18/69	< 50	12/18/69	< 50	N/A ³			12/18/69	< 50	N/A ³	12/18/69	< 50	12/18/69	< 50	N/A ³	12/18/69	< 50
1/22/70	< 50	1/22/70	< 50	N/A ³			1/22/70	< 50	N/A ³	1/22/70	< 50	1/22/70	< 50	N/A ³	1/22/69	< 50
2/24/70	< 50	2/24/70	< 50	N/A ³			2/24/70	< 50	N/A ³	2/24/70	< 50	2/24/70	< 50	N/A ³	2/24/70	< 50
3/24/70	< 50	3/23/70	< 50	N/A ³			3/23/70	< 50	N/A ³	3/23/70	< 50	3/24/70	< 50	N/A ³	3/24/70	< 50
4/21/70	< 50	4/21/70	< 50	N/A ³			4/21/70	< 50	N/A ³	4/21/70	< 50	4/21/70	< 50	N/A ³	4/21/70	< 50
5/19/70	< 50	5/19/70	< 50	N/A ³			5/19/70	< 50	N/A ³	5/19/70	< 50	5/19/70	< 50	N/A ³	5/19/70	< 50
6/29/70	< 50	6/26/70	< 50	N/A ³			6/29/70	< 50	N/A ³	6/29/70	< 50	6/29/70	< 50	N/A ³	6/29/70	< 50
8/24/70	< 50	8/21/70	< 50	N/A ³			8/21/70	< 50	N/A ³	8/21/70	< 50	8/24/70	< 50	N/A ³	8/24/70	< 50
9/28/70	< 50	9/28/70	< 50	N/A ³			9/28/70	< 50	N/A ³	9/28/70	< 50	9/28/70	< 50	N/A ³	9/28/70	< 50
10/20/70	< 50	10/20/70	< 50	N/A ³			10/20/70	< 50	N/A ³	10/20/70	< 50	10/20/70	< 50	N/A ³	10/20/70	< 50
12/29/70	< 50	12/29/70	< 50	N/A ³			12/29/70	< 50	N/A ³	12/29/70	< 50	12/29/70	< 50	N/A ³	12/29/70	< 50
1/18/71	< 50	1/18/71	< 50	N/A ³			1/18/71	< 50	N/A ³	1/18/71	< 50	1/18/71	< 50	N/A ³	1/18/71	< 50
3/29/71	< 50	3/29/71	< 50	N/A ³			3/29/71	< 50	N/A ³	3/29/71	< 50	3/29/71	< 50	N/A ³	3/29/71	< 50
5/3/71	< 50	5/3/71	< 50	N/A ³			5/3/71	< 50	N/A ³	5/3/71	< 50	5/3/71	< 50	N/A ³	5/3/71	< 50

Table E7-1. Tank SX-114 Drywell Radioactivity (K counts per minute) (May 1965 to June 1987)
(Drywell Data Sheets Retrieved March 23, 2011 and SD-WM-TI-356) (2 of 3 sheets)¹

41-14-02 ⁸		41-14-03 ⁸		41-14-04 ⁶			41-14-06 ⁷			41-14-08 ⁸		41-14-09 ⁵			41-14-11 ⁸	
Date	Peak (K cpm)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)
5/26/71	< 50	5/26/71	< 50	N/A ³			5/26/71	< 50	N/A ³	5/26/71	< 50	5/26/71	< 50	N/A ³	5/26/71	< 50
7/15/71	< 50	7/15/71	< 50	N/A ³			7/15/71	< 50	N/A ³	7/15/71	< 50	7/15/71	< 50	N/A ³	7/15/71	< 50
8/18/71	< 50	8/18/71	< 50	N/A ³			8/18/71	< 50	N/A ³	8/18/71	< 50	8/18/71	< 50	N/A ³	8/18/71	< 50
9/24/71	< 50	9/24/71	< 50	N/A ³			9/24/71	< 50	N/A ³	9/24/71	< 50	9/24/71	< 50	N/A ³	9/24/71	< 50
10/22/71	< 50	10/21/71	< 50	N/A ³			10/21/71	< 50	N/A ³	10/21/71	< 50	10/21/71	< 50	N/A ³	10/21/71	< 50
11/15/71	< 50	11/15/71	< 50	N/A ³			11/15/71	< 50	N/A ³	11/15/71	< 50	11/15/71	< 50	N/A ³	11/15/71	< 50
12/15/71	< 50	12/15/71	< 50	N/A ³			12/15/71	< 50	N/A ³	12/15/71	< 50	12/15/71	< 50	N/A ³	12/15/71	< 50
2/14/72	< 50	2/14/72	< 50	N/A ³			2/14/72	< 50	N/A ³	2/14/72	< 50	2/14/72	< 50	N/A ³	2/14/72	< 50
N/A ³		N/A ³		N/A ³			5/1/72	6 ⁴	34	N/A ³		N/A ³			N/A ³	
N/A ³		N/A ³		N/A ³			7/10/72	> 1000 ⁴	34	N/A ³		N/A ³			N/A ³	
N/A ³		N/A ³		N/A ³			8/15/72	> 950 ⁴	34	N/A ³		N/A ³			N/A ³	
								72 ⁴	51							
N/A ³		N/A ³		9/25/72	< 50	N/A ³	9/12/72	6 ¹⁰	29	N/A ³		N/A ³			N/A ³	
								5	34							
N/A ³		N/A ³		10/20/72	195	57	10/2/72	0.2	32	N/A ³		N/A ³			N/A ³	
N/A ³		N/A ³		11/6/72	355	56	11/6/72	0.1	34	N/A ³		N/A ³			N/A ³	
N/A ³		N/A ³		12/7/72	338	57	N/A ³			N/A ³		N/A ³			N/A ³	
N/A ³		N/A ³		1/2/73	285	57	N/A ³			N/A ³		N/A ³			N/A ³	
N/A ³		N/A ³		2/5/73	218	57	2/5/73	0.1	31	N/A ³		N/A ³			N/A ³	
N/A ³		N/A ³		3/1/73	500	57	3/12/73	0.1	31	N/A ³		N/A ³			N/A ³	
N/A ³		N/A ³		4/2/73	290	59	4/10/73	0.1	31	N/A ³		N/A ³			N/A ³	
N/A ³		N/A ³		5/2/73	250	59	5/7/73	0.1	51	N/A ³		N/A ³			N/A ³	
N/A ³		N/A ³		6/5/73	108	59	6/18/73	0.2	31	N/A ³		N/A ³			N/A ³	
N/A ³		N/A ³		7/2/73	150	56	7/2/73	0.3	31	N/A ³		N/A ³			N/A ³	

Table E7-1. Tank SX-114 Drywell Radioactivity (K counts per minute) (May 1965 to June 1987)
(Drywell Data Sheets Retrieved March 23, 2011 and SD-WM-TI-356) (3 of 3 sheets)¹

41-14-02 ⁸		41-14-03 ⁸		41-14-04 ⁶			41-14-06 ⁷			41-14-08 ⁸		41-14-09 ⁵			41-14-11 ⁸	
Date	Peak (K cpm)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)
N/A ³		N/A ³		8/8/73	100	56	8/6/73	0.2	32	N/A ³		N/A ³			N/A ³	
9/13/73	< 15	9/13/73	< 12	9/18/73	115	55	9/13/73	0.2	32	9/13/73	< 12	9/13/73	35	60	9/13/73	< 12
N/A ³		N/A ³		N/A ³			12/6/73	0.2	32	N/A ³		N/A ³			N/A ³	
N/A ³		N/A ³		1/1/74	90	59	1/24/74	0.1	34	N/A ³		N/A ³			N/A ³	
5/13/74	< 12	4/10/74	< 12	4/16/74	105	59	5/17/74	0.1	34	4/10/74	< 12	4/10/74	32	61	4/10/74	< 12
7/31/74	< 3 ²	7/31/74	< 3 ²	6/26/74	60	60	6/25/74	0.1	32	N/A ³		7/17/74	16	64	7/31/74	< 3 ²
N/A ³		N/A ³		6/29/74	15 ²	60	6/29/74	263 ²	35	N/A ³		7/31/74	6 ²	64	N/A ³	
							53 ⁴	52								
1/22/75	< 3	1/22/75	< 3	1/28/75	9	59	1/22/75	200	39	1/22/75	< 3 ²	1/23/75	7	64	2/6/75	< 3
							35	56								
7/22/75	< 3	7/22/75	< 3	7/22/75	6	59	7/22/75	96	34	7/22/75	< 3	7/22/75	7	63	7/22/75	< 3
4/6/76	< 3	4/6/76	< 3	4/6/76	4	57	4/6/76	53	34	4/6/76	< 3	4/7/76	6	61	4/7/76	< 3
8/3/77	< 3	8/8/77	< 3	6/7/77	3	57	8/3/77	13	35	8/3/77	< 3	8/3/77	6	60	8/3/77	< 3
7/4/78	< 3	7/4/78	< 3	7/4/78	< 3	N/A ³	7/4/78	9	37	7/4/78	< 3	7/4/78	5	61	7/4/78	< 3
							4	51								
7/17/79	< 3	7/17/79	< 3	7/17/79	< 3	N/A ³	7/17/79	5	38	7/17/79	< 3	7/3/79	5	60	7/17/79	< 3
7/14/80	< 3	7/14/80	< 3	7/14/80	< 3	N/A ³	7/14/80	3	32	7/14/80	< 3	7/14/80	5	60	7/14/80	< 3
6/15/81	< 3	6/15/81	< 3	6/15/81	< 3	N/A ³	6/15/81	4	52	6/15/81	< 3	6/15/81	5	61	6/15/81	< 3
7/27/82	< 3	7/27/82	< 3	7/27/82	< 3	N/A ³	7/27/82	3	57	7/28/82	< 3	7/28/82	5	62	7/28/82	< 3
6/23/83	< 3	6/23/83	< 3	6/23/83	< 3	N/A ³	6/24/83	4	64	6/23/83	< 3	6/23/83	5	62	6/23/83	< 3
6/12/84	< 3	6/12/84	< 3	6/12/84	< 3	N/A ³	6/13/84	3	66	6/12/84	< 3	6/12/84	5	63	6/12/84	< 3
6/12/85	< 3	6/12/85	< 3	6/12/85	< 3	N/A ³	6/12/85	3	67	6/12/85	< 3	6/12/85	5	64	6/12/85	3
6/9/86	< 3	6/9/86	< 3	6/9/86	< 3	N/A ³	6/9/86	3	68	6/9/86	< 3	6/10/86	4	64	6/10/86	< 3
6/24/87	< 3	6/24/87	< 3	6/24/87	< 3	N/A ³	6/24/87	2	59	6/24/87	< 3	6/24/87	5	64	6/24/87	< 3

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Note: ¹If Depths were not available, the column was omitted from the table

²New Monitoring Equipment

³N/A: Data not available

⁴Sctinillation Probe (SP) used.

⁵Readings were recorded using the SP from March 1969 to February 1972

⁶Readings were recorded using the SP from September 1972 to September 1973. GM Probe used starting September 13, 1973.

⁷Readings were recorded using the SP until August 1972. GM Probe used starting September 1972.

⁸Readings were recorded using the SP until February 1972. The probe used after this time was not stated.

⁹Referenced from RL-SEP-297, page 99

¹⁰GM Probe used

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11.1 TANK SX-115 BACKGROUND HISTORY

This section provides information on the historical waste loss event associated with SST 241-SX-115 (SX-115). Tank SX-115 has three laterals installed in 1962 about 10-ft under the tank (see Figure 11-1). There are seven drywells located around tank SX-115: 41-15-07 installed in 1956 and 41-15-02, 41-15-03, 41-15-05, 41-15-09, 41-15-10, and 41-14-09 installed in 1962. Ten additional test wells were drilled around tank SX-115 in August 1965 (17A, 41A, 41B, 45A, 45B, 47A, 48A, 48B, 48C, and 49A).

The bottom of the tank footing is ~53-ft 1-in BGS with ~6-ft 6-in soil cover over the dome (WHC-SD-WM-TI-665). Inside tank SX-115 are four ALCs 18-in above the tank bottom and equally spaced on a 40-ft diameter circle as shown in Figure 11-1 (H-2-39951). Two ALCs are designated low ALCs (8-ft 6-in tall) and two are high ALCs (13-ft 6-in tall) (H-2-9950).

Figure 11-1. Tank SX-115 Associated Drywells and Laterals
Tank inner ring is steel liner, outer ring is outer edge of tank footing

11.2 TANK SX-115 OPERATIONS SUMMARY

Tank SX-115 was constructed from 1953 to 1954 and was first put into service in August 1958, when a year-long preheating period was started (HW-57550, *Chemical Processing Department Waste Status Summary August 1, 1958-August 31, 1958*, page 8; HW-83906-C-RD, *Chemical Processing Department 200 West Area Tank Farm Inventory and Waste Reports January 1957 Through December 1958*, page 174; WHC-MR-0302, *Tank SX-115 Leak Assessment*). The first filling of the liquid heel began on August 31, 1958, tank SX-115 received ~18.2 kgal of raw water, 33 kgal of condensate from tank SX-106, and 6.3 kgal of REDOX HLW from tank D-8 along with a flush of the transfer pipeline. These additions were used as a liquid heel to minimize temperature increases when initially added with waste. Tanks in SX Farm were not fitted with steam coils; tank SX-115 was one of two tanks in SX Farm that was preheated prior to use (RHO-R-39). Tank SX-115 began to boil in October 1958 and waste temperatures rose from an assumed conservative ambient temperature of 55°F on September 1, 1958 to ~185°F by October 1, 1958 (see Table B8-1).

No additional transfers were made until REDOX HLW was transferred to tank SX-115 from November 1959 through June 1960, along with aged REDOX HLW supernatant from tank SX-109 from July through September 1960. Condensate from tank SX-106 and water were periodically added to tank SX-115 from November 1960 through July 1963 to maintain waste temperature below 300°F and prevent further concentration of the waste. In June 1964, all of the pumpable REDOX HLW supernatant was transferred from tank SX-115 to tank SX-102 to prepare for leaching the sludge within tank SX-115. Tank SX-115 contained ~192 kgal of waste as of June 30, 1964 (HW-83308, *Chemical Processing Department Waste Status Summary January 1, 1964 Through June 30, 1964*, page 8).

Condensate from tank SX-106 was transferred into tank SX-115 in June and July 1964 to leach sodium nitrate from the REDOX HLW sludge. The leached sodium nitrate solution (~215.6 kgal) was transferred to tank SX-105 in September 1964 and then to the REDOX Plant for use in suppressing hydrogen gas evolution during dissolution of irradiated nuclear fuel.

Tank SX-115 was determined to be leaking sodium nitrate waste (leachate) to the ground between February 24 and March 2, 1965 based on an observed liquid level decrease of about 16-in (see Appendix H8) and subsequent radioactivity detected in the laterals (BNWL-CC-701, *Characterization of Subsurface Contamination in the SX Tank Farm*, page 3). Tank SX-115 contained ~111 kgal (~47.7-in) of waste at the time the leak was discovered. Tank SX-115 was immediately declared a confirmed leaker, and the remaining pumpable waste was transferred to tank SX-105 on March 9, 1965 (see Appendix H8) leaving an 8 ⁵/₈-in heel in tank SX-115 (~10.3 kgal).

In April 1965, air purging began in tank SX-115 through one of the ALCs presumably to provide an air sweep as ALCs terminate ~18-in above the bottom and waste mixing was not possible. Temperatures then dropped from 180°F on March 10, 1965 to 159°F on April 28, 1965 (WHC-MR-0300, Supplement 1). Tank SX-115 remained inactive from 1965 to 1978 and the tank was declared interim stabilized in October 1978 based on photograph evaluations (HNF-SD-RE-TI-178, *Single-Shell Tank Interim Stabilization Record*, page 280). The operational history of tank SX-115 leak related details including temperature and liquid level is charted in Figure 11-2.

Figure 11-2. Operational Leak History of Tank SX-115

11.3 TANK DESIGN/CONSTRUCTION

11.3.1 Tank Design

The SX Farm tanks had multiple design features that could contribute to stresses or possible leak paths when the tank was being operated including:

- Orthogonal intersection between the steel bottom and the sidewall
- Fillet weld used between the bottom and sidewall intersection
- Less rigorous weld inspection testing
- Partial asphaltic membrane waterproofing
- Keyed construction joints in the sidewall

These features are common to all SX Farm tanks and additional details are discussed in Section 3.1.1.

11.3.2 Tank Construction Conditions

The outside temperature between January 16, 1954 and January 30, 1954 ranged from an average high of 24°F to an average low of 9°F. A picture of the SX Farm under construction (see Figure 3-4) taken January 20, 1954 (high 11°F low -6°F), shows several of the tanks full of water either undergoing leak testing or for concrete wall pouring. During this cold period snow covered ice is seen in the water filled tanks.

As described in Section 3.1.2, cold weather affects the ductile-to-brittle steel transition temperature, with 18°F being the assumed unrestricted low temperature construction limitation for the carbon steel liner, which could result in a fracture upon impact. Low temperatures experienced during construction at or less than the 18°F allowable temperature could cause impact loading (e.g. a dropped tool or piece of equipment from scaffolding) and result in the potential for creating micro-fissures weakening the steel liner.

11.4 TANK SX-115 IN-TANK DATA

11.4.1 Liquid Level

Tank SX-106 condensate was transferred to tank SX-115 in June-July 1964 for nitrate leaching. In September 1964, ~215.6 kgal of leachate was transferred from tank SX-115 to tank SX-105 (see Section 11.4.4) leaving a leachate heel of ~48 ½-in. No waste was transferred to or from tank SX-115 after September 1964 as liquid levels were reported at ~48-in (117.2-gal) through February 24, 1965 as shown in Figure 11-3 (see Appendix H8). The next reported reading was on March 2, 1965 when liquid levels were reported to be 31 ¾-in indicating a leak must have developed to allow this rapid drop in liquid level, approximately 16-in (RL-SEP-297, *REDOX Weekly Process Reports January through December*, No. 675). The liquid level continued to decrease to 30-in five days later and the remaining waste was pumped from tank SX-115 to tank SX-105 on March 9, 1965 leaving an 8 ½-in heel (RL-SEP-297, No. 676). Subsequent increases in radioactivity were detected in the laterals confirming the leak. Over the entire period of 12 days, the liquid level dropped ~18-in (49,500 gal). Document HWN-1991-DEL states the leak

being as large as 50,976 gal. The 50,976 gal volume has been used by several subsequent documents.

If the rate of decrease (0.6-gal/min) was extrapolated one day to the transfer of leachate on March 9, 1965 this would add 864 gal to the 18-in decrease of 495,500 gal for a total of 50,364 gal and possibly larger if the tank continued to leak while being pumped. The remaining leachate was transferred to tank SX-105 from tank SX-115 beginning March 9, 1965 (RL-SEP-297, No. 676) leaving a heel of $8\frac{5}{8}$ -in by March 17, 1965. After pumping, the liquid level decreased slightly to ~7-in by May 1965 indicating further possible leakage. However, air purging began in tank SX-115 in April 1965 so it is likely the latter decrease in liquid level were due to evaporation. Liquid levels remained steady at ~7-in through August 1965.

An analysis was performed shortly after tank SX-115 was confirmed to be leaking and reported in 1966 (BNWL-CC-701). This analysis was only able to account for 60% of the estimated leak volume of 50 kgal (a leak volume of approximately 30 kgal) (see Section 11.6).

**Figure 11-3. Tank SX-115 Surface Level
January 13, 1965 to May 19, 1965**

This is assumed to be referenced from the center tank bottom.

Reference: RL-SEP-297, *REDOX Weekly Reports* (see Appendix H8).

It is unclear why there was a change in the liquid level rate of decrease from March 2 to March 8, 1965 as shown in Figure 11-3. A fairly large single or series of openings to the soil had occurred through the tank liner and concrete assuming the initial leak rate of 5.2 gal/min. For unknown reasons the opening(s) may have partially closed resulting in a slower rate of leakage (0.6 gal/min). It is interesting to note the similar rates of the initial leak and the pumping shown in Figure 11-3. There was, however, radioactivity detected in the laterals subsequent to the liquid level decreases confirming the presence of a leak in tank SX-115 and not an inadvertent pumping scenario.

The agitation of the waste within the boiling tank, the recycle of cool condensate, and evaporation made it very difficult to detect small leaks with liquid level measurements (ARH-R-43, Rev. 2). However, at the time the leachate leak occurred in tank SX-115, temperatures were below boiling at approximately 180°F. The liquid level analysis from the earliest available data indicates a leak site could be no higher on the sidewall than ~32-in. However, lateral and drywell data indicate that the tank SX-115 leak was at or near the bottom of the tank (see Section 11.6).

The liquid level plot in Figure 11-4 indicates the transfer activity into and out of tank SX-115. The liquid levels are end of quarter levels so this figure may not reflect all transfers into and out of the tank that occurred during the operational history of the tank. See Figure 11-2 for historical monthly liquid level readings.

Figure 11-4. Tank SX-115 End of Quarter Surface Level

WHC-SD-WM-ER-352, Rev. 0, *Historical Tank Content Estimate for the Southwest Quadrant of the Hanford 200 West Area*

11.4.2 Temperature

Tank SX-115 was preheated using a liquid heel received on August 31, 1958, prior to the initial filling of waste (HW-57550). Temperatures quickly rose to ~100°F two days later from a conservative assumed ambient ground temperature of 55°F and continued to increase to ~210°F by October 1958 (see Appendix B8). After reaching ~210°F by October 15, 1958, the waste temperature gradually declined to ~173°F by November 1959. In November 1959 through June 1960, REDOX HLW was added again to tank SX-115 causing waste temperatures to rapidly increase to ~240°F by March 1960 (see Appendix C8). Waste temperatures were relatively stable at ~260°F until December 1961. Temperatures gradually decreased from December 1961 to January 1965, where temperatures were reported at ~175°F.

The first indication of a leak in tank SX-115 was detected between February 24, 1965 and March 2, 1965 due to a 16-in liquid level decrease and further decrease of ~2-in for a total of ~18-in decrease with subsequent increased lateral activity. The thermal history for tank SX-115 starts in August 1958 through 1969 (RHO-CD-1172, pages B-73 to B-114). See Figure 11-2 for the combined available thermal history for tank SX-115.

11.4.3 Liner Observations

Documents RHO-R-39 and ARH-R-43, Rev. 2, contain tables that do not list a bulge in the tank SX-115 liner (see Appendix A8). However, a tank SX-115 bulge was reported to be present October 1958 which was stated in document HW-58051 (*Chemical Processing Department Research and Engineering Operation Monthly Report* page J-8):

“When minor variations in liquid level were observed on October 13, a sounding of the tank (SX-115) bottom was made which indicated the liner to be raised three inches above its original elevation which had been confirmed by soundings made as late as October 2. The injection of approximately 90,000 gallons of water into the tank reduced the average solution temperature 38 F but lowered the sludge temperature only 10 F, despite the agitation provided by two circulators. Concurrently the tank liner returned to within a half-inch of its original position and remained there throughout the report period in spite of a 30 F increase in the average solution temperature.”

This 3-in bulge was detected in October 1958, shortly after the liquid heel was added to tank SX-115 for preheating (see Section 11.2). It is possible the liner bulged upwards greater than the 3-in that was measured as the liner returned to approximately its original position shortly afterwards.

No other documentation was found for the occurrence of additional liner bulges in tank SX-115. After reviewing photographs of tank SX-115, it is possible a bulge was present at one time due to the presence of failed ALCs (see Section 11.4.5); however, the earliest photographs available are from December 1969.

11.4.4 Chemistry-Corrosion

Waste Chemistry

Tank SX-115 first received a liquid heel for preheating the tank in August 1958 which was stored for about one year. The tank was then filled with REDOX HLW (R) in November 1959 and stored mostly this waste type throughout operation (see Table 11-1). The typical concentrations for nitrite, nitrate, and hydroxide for these waste types are shown in Table 11-2. Nitrite and hydroxide are known as nitrate-induced SCC inhibitors. One key characteristic for inhibiting SCC is to maintain a high nitrite concentration to nitrate concentration ratio (see Section 3.2.4).

Table 11-1. Tank SX-115 Waste Storage Chronology

Date	Waste Type	Length of Storage
August 1958 to November 1959	Raw water, condensate, REDOX HLW	~ 1 year
November 1959 to June 1964	REDOX HLW and aged REDOX HLW	~ 4 ½ years
June 1964 to March 1965	Nitrate Leachate heel	~ 1 year

Table 11-2. Waste Chemistries for Waste Types Stored in Tank SX-115

Waste Type	[NO ₃] ¹	[NO ₂] ¹	[OH] ¹	Meets Current DST Specification ²
R ³	4.83		0.74	No ⁴

1. Reference WHC-EP-0449, 1991, *The Sort on Radioactive Waste Type Model: A Method to Sort Single-Shell Tanks into Characteristic Groups*.
2. Reference OSD-T-151-00007, Rev. 12, (2013), *Operating Specifications for the Double-Shell Storage Tanks*.
3. Reference WHC-EP-0772, 1994, *Characterization of the Corrosion Behavior of the Carbon Steel Liner in Hanford Site Single-Shell Tanks*.
4. Does not meet the current DST specification since the hydroxide and nitrite concentrations are not greater than or equal to 1.2M.

Tank SX-115 stored mostly REDOX HLW throughout operation for about 5 ½ years total including the preheating period where the liquid heel consisted of REDOX HLW, condensate, and raw water. REDOX HLW does not meet the current DST specification for waste chemistry due to low concentrations of the nitrate-induced SCC inhibitors, nitrite and hydroxide. Thus, these conditions of the REDOX HLW would likely create an environment conducive to SCC and/or pitting (see Section 3.2.4).

Nitrate Leaching

Tank SX-115 was listed as one of the tanks that underwent sodium nitrate sludge leaching with waste analysis shown in Table 11-3. Supernatant was transferred out of the tank and condensate from tank SX-106 was added June to July 1964 for sodium nitrate leaching of the remaining nitrate-rich sludge (see Table 11-4). The sodium nitrate solution (leachate) remained in the tank for ~3 months with temperatures ranging from 170°F to 220°F. Approximately 215.6 kgal of

leachate was transferred from tank SX-115 to tank SX-105 between September 17, 1964 and October 1, 1964.

Table 11-3. Tank SX-115 Sodium Nitrate Waste Analysis (September 16, 1964)

Component	Concentration	Units
NaOH	1.28	M
Cr ⁺⁶	1.42	g/L
Cs-137	0.763	Ci/gal
Cs-134	0.0092	Ci/gal

Referenced from BNWL-CC-701, page 10

No further waste transactions occurred following transferring leachate out of tank SX-115 until the end of February 1965 when the leak was first detected. The first indication of a leak in tank SX-115 was based on liquid level decreases and confirmed by subsequent radioactivity detected in the laterals, approximately five months after the tank was nitrate leached.

Table 11-4. Tank SX-115 Nitrate Leaching Chronology

Date	Transfers/Comments	Duration	Reference
6/11/64 – 6/18/64	Transferred 573,797 gal supernatant from tank SX-115 to tank SX-102	N/A	See Appendix H
6/25/64 – 7/16/64	Added 77,837 gal condensate from tank SX-106 to tank SX-115 Added 137,766 gal condensate from tank SX-106 to tank SX-115 (215,603 gal total)	N/A	See Appendix H
9/17/64 – 10/1/64	Transferred 215,603 gal leachate from tank SX-115 to tank SX-105	Leached for ~ 3 months	See Appendix H
10/1/64 – 2/24/65	Leachate heel at ~4-ft or 117,200 gal	~ 5 months	See Appendix H
2/24/65 – 3/8/65	Liquid level drop of ~18-in (49,500 gal). Tank SX-115 first declared a confirmed leaker. The leak could be as large as 50,976 gal.	8 months from start of leaching	RL-SEP-297; HWN-1991-DEL
3/9/65	Transferred 52,349 gal of leachate from tank SX-115 to tank SX-105 after leak detected leaving a heel at ~ 8 5/8-in (8,919 gal) by March 17, 1965. The heel was at ~7-in (4,450 gal) by May 1965.	N/A	See Appendix H; RL-SEP-297

Note: Liquid level measurements are assumed to be referenced to the center tank bottom

Sodium nitrate leaching reduces nitrite and hydroxide concentrations which would increase the propensity for corrosion especially at the elevated temperatures experienced in tank SX-115.

11.4.5 Photographs

Photographs taken February 15, 1972 were reviewed and indicated one ALC with a missing turnbuckle guy rod and one ALC with bent piping and a turnbuckle guy rod hanging free (see Figure 11-5 and Figure 11-6, respectively). Earliest available photographs taken December 22, 1969 indicated the same ALC problems as the later February 15, 1972 photographs. No photographs that were taken before 1969 were available and therefore it is uncertain if the 1958 liner bulge of 3-in (see Section 11.4.3) caused the problems with the two ALCs. Figure 11-5 shows ALC #2 with a missing turnbuckle guy rod in the northwest quadrant of the tank and Figure 11-6 shows ALC #4 with bent piping and a turnbuckle guy rod hanging free in the southeast quadrant of the tank.

**Figure 11-5. Tank SX-115 ALC #2 Photograph 720766-16CN
February 15, 1972**

**Figure 11-6. Tank SX-115 ALC #4 Photograph 720766-32CN
February 15, 1972**

The locations of all ALCs in tank SX-115 are shown in Figure 11-7 with the two ALCs (#2 and #4) located in the tank possibly showing evidence of a liner bulge. These are the only ALCs that have visible detached turnbuckle guy rods during this time. This may be evidence of a liner bulge that could have resulted in failure of the turnbuckle guy rod bottom liner attachment. However, detachment of the ½-in diameter turnbuckle guy rod as well as bent piping could also be the result of mixing the waste when the ALCs were operating with the resulting forces on internal equipment.

Figure 11-7. Tank SX-115 Air Lift Circulator (ALC) Locations

11.5 TANK SX-115 EX-TANK DATA

11.5.1 Laterals

A leak from tank SX-115 may have occurred as early as 1963 based on a scan of lateral 44-15-02 taken on December 12, 1963. The December 12, 1963 scan of lateral 44-15-02 indicated “... background readings between 40 and 60 c/m and radiation peaks between 60 and 98 c/m. These readings were taken by a probe that is no longer used, and they [i.e., these readings] cannot be compared with readings cited elsewhere in this report [i.e., BNWL-CC-701]. Insufficient data are available to estimate the amount leaked, but it was minor compared with the 1965 leak. Using the same probe, the 1965 leak generated readings exceeding 2,000,000 c/m (off scale)” (WHC-MR-0302, page 9). There was no reported liquid level decline associated with the radioactivity detected in lateral 44-15-02 in 1963; therefore, no estimate of the waste loss can be made. Given the low levels of gamma activity detected, any waste loss in 1963 was likely to have been small.

After an 18-in liquid level decrease from February 24, 1965 to March 8, 1965, radioactivity was reported in tank SX-115 laterals shortly afterwards confirming a tank leak (ARH-R-43, page 42). Actual lateral data was not found for this time frame. The first lateral information found was for lateral 44-15-02 at 2K cpm from 14.2 to 26.2-ft from the northeast edge of the tank on June 13, 1966 (BNWL-CC-701). The level and location of radioactive peaks were not mentioned for the other laterals in this document; however, Figure 11-8, taken from BNWL-CC-701, indicated radioactivity was present in all laterals. It is unclear why other lateral data was not included in the document or other sources including available data sheets. This was the only lateral reporting radioactivity that was recovered until 1973 (see Appendix D8).

Figure 11-8. Tank SX-115 Subsurface Cs-137 Concentration Contour Estimates (Contour value $\times 10^6$, pCi/g) (modified from BNWL-CC-701 1966) (RPP-ENV-39658)

Note: Groundwater Monitoring Wells are drywells and Characterization Boreholes are Test Wells; the latter are used in the present document to estimate the contours. The units were converted to pCi/g for comparison purposes to the 2005 lateral data in Figure 8-14.

Lateral 44-15-01 activity before November 1973 was reported as “erratic” data (SD-WM-TI-356) and it remains unclear what was meant by erratic data as previous data before 1973 were not recovered. The first available data for lateral 44-15-01 was recorded on November 24, 1973 with a peak reported at 93K cpm at 2.7-ft from the northeast edge of the tank. Radioactivity remained relatively stable until February 10, 1975 when the peak reading was reported at 5K cpm at 12.7-ft from the northeast edge of the tank. Activity then remained relatively stable through June 1987 (see Appendix D8).

The first recoverable lateral 44-15-02 data were first reported on June 13, 1966, with radioactivity levels at 2K cpm from 14.2 to 26.2-ft from the northeast edge of the tank. The next three available readings, January 1973 to September 1974, reported zero values. On October 15, 1974 a peak was recorded at 1.6K cpm at 45.2-ft from the northeast edge of the tank.

Readings remained relatively stable until April 1977 and then gradually decreased to 0.1K cpm between 45.2-ft and 41.2-ft underneath the tank by July 1982. Radioactivity remained at this level through June 1987 with two peaks at 0.1K cpm at 40.2-ft and 76.2-ft from the northeast edge of the tank (see Appendix D8).

The first available radioactivity was reported in lateral 44-15-03 on January 2, 1973 at 2,914K cpm at 7.6-ft from the northeast edge of the tank. Activity in this lateral was much higher compared to laterals 44-15-01 and 44-15-02 over the course of the data available. Radioactivity remained relatively stable until February 1975 when a peak was reported at 460K cpm at 12.6-ft underneath the tank. An increase in radiation in lateral 44-15-03 was reported on June 25, 1975 (OR 75-69) likely due to changes in soil conditions. Readings remained relatively stable through June 1987 (see Appendix D8).

It is likely an increase in activity in all the laterals occurred when the leak from tank SX-115 was first detected in March 1965 with the first recoverable data from June 1966. Compared to the other laterals, lateral 44-15-02 recorded the least amount of radioactivity and lateral 44-15-03 contained the highest levels of radiation. It is possible radiation was detected in all of the laterals under tank SX-115 following the observed liquid level drop of more than 16-in; however, additional data were not recovered for any of the laterals until the 1973 period. Peak lateral activity from 1966, 1973, and 1974 are shown in Figure 11-9. The peak readings shown in Figure 11-9 do not show all of the corresponding radioactive locations of the Cs-137 contour plot shown in Figure 11-8 from BNWL-CC-701 (June 1966) indicating the possibility of the missing data between 1966 and 1973.

Figure 11-9. SX-115 Peak Lateral Radioactivity (cpm) in 1966, 1973, and 1974
 Location indicated in green with date and level of radioactivity

Note: A leak was first reported February 24 to March 8, 1965 due to a liquid level decrease of ~18-in with subsequent increase in activity in the laterals; however, no actual lateral data were found until June 1966 and 1973.

2005 Lateral Data

Later lateral profiles with peak readings from May 2005 (RPP-RPT-27605) are shown in Figure 11-10 (see Appendix F8). The 2005 profiles around the earlier (1966 through 1987) radioactive locations appear to be fairly stable and separate from each other, e.g. multiple leak indications from the tank concrete shell. The earlier radioactivity detected in lateral 44-15-02 between 45.2-ft and 40.2-ft (see Appendix D8) was not detected in the 2005 lateral scan. Three additional distinct peak profiles of low level radioactivity near the south and west edge of the tank show up in May 2005 underneath the tank shadow, one each in laterals 44-15-01 and 44-15-03. The Cs-137 concentrations shown in Figure 11-8 were recorded at 1×10^8 pCi/g for each lateral in

discrete locations; however, data from May 2005 show large differences in gamma radiation levels among the three laterals. Maximum concentrations of 3×10^7 , 2×10^2 , and 2×10^5 pCi/g in laterals 44-15-03, 44-15-02, and 44-15-01, respectively. Some of these differences may be attributed to improved detection capabilities as well as possible decay of short lived radionuclides since the earlier data. These could be separate leak sites associated with the tank steel liner (lower sidewall or footing) or possible seepage of tank waste pooled on the asphaltic membrane passing through or around the water stop and potential cracks in the footing. Cracks were found in the tank SX-108 footing associated with heat stress and are probably present in most of the high heat SX Farm tanks (see Tank SX-108 Segment). The sidewall core drilling of tank SX-115 also detected radioactivity near the tank footing (see Section 11.5.4).

The three locations identified in Figure 11-9 were also identified in 2005, especially the radioactivity in the northeast portion of the tank (see Figure 11-10) as well as the possibility of some migration.

Figure 11-10. SX-115 Peak Lateral Radioactivity May 2005 (pCi/g)

11.5.2 Drywells

There are seven drywells located around tank SX-115: 41-15-07 installed in 1956 and 41-15-02, 41-15-03, 41-15-05, 41-15-09, 41-15-10, and 41-14-09 installed in 1962. Ten additional test wells were drilled around tank SX-115 in August 1965 (17A, 41A, 41B, 45A, 45B, 47A, 48A, 48B, 48C, and 49A). All of the radiation readings in drywells are assumed to be maximum values or peak readings unless otherwise noted and are from the Red-GM probe unless otherwise indicated (see Section 3.3.2). The bottom of the tank footing is ~53-ft 1-in BGS. The following subsections report the available drywell information and the drywell summary section provides the analyses of the associated drywells with tank SX-115.

11.5.2.1 Drywell 41-15-02 (N60°E)

Drywell 41-15-02 was drilled March 29, 1962 with the first recoverable radiation reading on March 31, 1965 at 690K cpm at 63-ft BGS approximately one month after the liquid level decrease and pumping the tank March 17, 1965 (see Appendix E8). Radiation levels slowly declined to 242K cpm at 63-ft BGS by May 26, 1965. No data were recovered for May 1965 to March 1969. Radiation levels were reported as less than values in March 1969 through June 1987 indicating earlier readings were probably due to short lived radioisotopes. This is one of five drywells that indicated radiation in 1965 that apparently decayed away and did not show up later.

In January 1996, Cs-137 was the only man-made radionuclide detected in drywell 41-15-02 from the ground surface to about 6-ft BGS and at two other isolated depths at concentrations near minimum detection limit (GJ-HAN-17). The highest Cs-137 concentration was measured at 4.5-ft BGS at 2 pCi/g. Document GJ-HAN-17 states, "*No evidence of a subsurface source of contamination exists for this borehole.*" Since historical records are indeterminate after 1965, drywell 41-15-02 is not included as part of the leak location for tank SX-115. Figure 11-11 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 11-11. Tank SX-115 Drywell 41-15-02 (HNF-3136)

Note: Bottom of the tank footing ~53-ft 1-in BGS

11.5.2.2 Drywell 41-15-03 (S68°E)

Drywell 41-15-03 was drilled April 2, 1962 with the first recoverable reading reported on March 31, 1965 at 140K cpm at 64-ft BGS, approximately one month after the liquid level decrease (see Appendix E8). Radiation levels gradually increased three days later and was reported as 140K cpm and 240K cpm at 59-ft and 64-ft BGS, respectively. Readings gradually declined to 100K cpm at 60 to 65-ft BGS by May 26, 1965. No data were recovered for May 1965 to March 1969. Radiation levels were reported as less than values in March 1969 through June 1987 indicating earlier readings were probably due to short lived radioisotopes. This is one of five drywells that indicated radiation in 1965 that apparently decayed away and did not show up later.

In January 1996, Cs-137 was the only man-made radionuclide detected in drywell 41-15-03 near the ground surface and at isolated locations throughout the drywell (GJ-HAN-17). The highest Cs-137 concentration of about 2 pCi/g was measured at the bottom of the drywell (75-ft BGS). Document GJ-HAN-17 states, “*No evidence exists for any Cs-137 contamination from a subsurface source.*” Since historical records are indeterminate after 1965, drywell 41-15-03 is not included as part of the leak location for tank SX-115. Figure 11-12 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 11-12. Tank SX-115 Drywell 41-15-03 (HNF-3136)

Note: Bottom of the tank footing ~53-ft 1-in BGS

11.5.2.3 Drywell 41-15-05 (S18°E)

Drywell 41-15-05 was drilled March 30, 1962 with the first recoverable reading reported on March 31, 1965 at 85K cpm at 59-ft BGS, approximately one month after the liquid level decrease (see Appendix E8). Radiation levels increased one month later to 120K cpm at 59-ft BGS. No data were recovered for May 1965 to March 1969. Radiation levels were reported as less than values in March 1969 through June 1987 indicating earlier readings were probably due to short lived radioisotopes. This is one of five drywells that indicated radiation in 1965 that apparently decayed away and did not show up later.

In January 1996, Cs-137 was the only man-made radionuclide detected in drywell 41-15-05 near the ground surface and at a few isolated depths at concentrations less than 0.5 pCi/g (GJ-HAN-17). Document GJ-HAN-17 states, “*No evidence for a subsurface source of contamination exists.*” Since historical records are indeterminate after 1965, drywell 41-15-05 is not included as part of the leak location for tank SX-115. Figure 11-13 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 11-13. Tank SX-115 Drywell 41-15-05 (HNF-3136)

Note: Bottom of the tank footing ~53-ft 1-in BGS

11.5.2.4 Drywell 41-15-07 (S29°W)

Drywell 41-15-07 was drilled March 27, 1956 with the first recoverable reading reported on March 26, 1969 at 160K cpm at 59-ft BGS, approximately four years after the liquid level decrease (see Appendix E8). Radiation levels remained relatively stable and were reported as 100K cpm by March 1971 at 57-ft BGS. On February 2, 1973, an additional peak developed at 5K cpm at 100-ft BGS that decayed away. Radiation levels remained relatively stable until July 31, 1974 when the peak radiation dropped to 30K cpm at 58-ft BGS and remained at this level through June 1987.

In January 1996, Cs-137 was the only man-made radionuclide detected in drywell 41-15-07 (GJ-HAN-17). Cs-137 was detected from 55.5 to 60-ft BGS with the maximum concentration of about 7 pCi/g. Document GJ-HAN-17 states, "*Leakage from tank SX-115 is the source of the subsurface contamination at this borehole.*" Figure 11-14 shows the depths of radioactivity from 1975 to 1995 (HNF-3136). This was the only tank SX-115 drywell reporting significant Cs-137 radioactivity.

Figure 11-14. Tank SX-115 Drywell 41-15-07 (HNF-3136)

Note: Bottom of the tank footing ~53-ft 1-in BGS

11.5.2.5 Drywell 41-15-09 (S78°W)

Drywell 41-15-09 was drilled April 3, 1962 with the first recoverable reading reported on March 31, 1965 at 440K cpm at 55-ft BGS, approximately one month after the liquid level decrease (see Appendix E8). Radiation levels slowly decreased to 250K cpm at 55-ft BGS two months later. No data were recovered for May 1965 to March 1969. Radiation levels were reported as less than values in March 1969 through June 1987 indicating earlier readings were probably due to short lived radioisotopes. This is one of five drywells that indicated radiation in 1965 that apparently decayed away and did not show up later.

In January 1996, Cs-137 was the only man-made radionuclide detected in drywell 41-15-09 throughout the entire length of the drywell at concentrations near the minimum detection limit (GJ-HAN-17). Document GJ-HAN-17 states, “*No evidence exists for a subsurface source of the Cs-137 contamination.*” Since historical records are indeterminate after 1965, drywell 41-15-09 is not included as part of the leak location for tank SX-115. Figure 11-15 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 11-15. Tank SX-115 Drywell 41-15-09 (HNF-3136)

Note: Bottom of the tank footing ~53-ft 1-in BGS

11.5.2.6 Drywell 41-15-10 (N47°W)

Drywell 41-15-10 was drilled April 30, 1962, was deepened to 125-ft BGS in 1973, and the first recoverable reading reported on May 26, 1965 at 95K cpm at 65-ft BGS, approximately two months after the liquid level decrease (see Appendix E8). No data were recovered from May 1965 to March 1969. Radiation levels were reported as less than values by March 1969 through June 1987 indicating earlier readings were probably due to short lived radioisotopes. This is one of five drywells that indicated radiation in 1965 that apparently decayed away and did not show up later.

In January 1996, Cs-137 was the only man-made radionuclide detected in drywell 41-15-10 from the ground surface to 23-ft BGS with the highest concentration of 18 pCi/g measured at 5.5-ft BGS (GJ-HAN-17). Document GJ-HAN-17 states, *“The concentrations of Cs-137 above 23 ft apparently originated from the surface, although the nonuniformity of the contamination distribution is somewhat unusual and might indicate a subsurface pipe source”*...*“No evidence exists for a subsurface source of Cs-137 contamination below 23 ft.”* Since historical records are indeterminate after 1965, drywell 41-15-10 is not included as part of the leak location for tank SX-115. Figure 11-16 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 11-16. Tank SX-115 Drywell 41-15-10 (HNF-3136)

Note: Bottom of the tank footing ~53-ft 1-in BGS

Drywell 41-14-09 (N82°W)

Drywell 41-14-09 was drilled March 6, 1962 with the first recoverable radioactivity reported on May 26, 1965 at a peak of 238K cpm at 62-ft BGS (see Appendix E7). No other readings were recovered until March 26, 1969, four years later, when a peak of 48K cpm at 63-ft BGS was recorded. Readings gradually decreased and were recorded at < 50K cpm by July 1969 possibly due to short lived radioisotopes. No readings were reported from February 1972 until September 1973. Readings were reported at 35K cpm in September 1973 and gradually decreased to 5K cpm five years later.

The following is an excerpt in GJ-HAN-16 from SGLS logging in 1996:

“Historical gross gamma log data collected from this borehole from 1973 to 1994 have been reviewed. Log data collected from 1973 to 1974 indicate elevated gamma readings at varying depths from about 60 to 64 ft. The differences in depth are apparently the result of depth initialization or data collection inconsistencies, and not the result of contaminant migration. The peak intensity in 1974 had decreased by about a factor of 2 from the levels shown in 1973. This decrease in intensity may be the result of a radionuclide with a relatively short half-life. However, the latest available gross gamma log data collected in 1994 show the intensity of the readings has only decreased by about 25 percent (from 110 to 75 cps) since 1977. Because of the low count rates, it is not known if these decreases are attributable to a mixture of radionuclides with different half-lives or the result of instrumentation variations.

Cs-137 was the only man-made contaminant detected in this borehole (1994). Contamination was measured from ground surface to about 17 ft, from 62 to 65.5 ft, and from 71 to 75 ft (TD).”

There may be an indication of two events that both involved Ru-106 that decayed away, 1965 and 1973. The 1965 event could be associated with the tank SX-115 test wells 45B and 17A and leak (see Section 11.5.2.7). Test wells 45B and 17A were considered to be at the edge of the tank SX-115 leak plume towards tank SX-114 which could have also affected drywell 41-14-09. The radiation gradually decayed away in drywell 41-14-09.

The 1973 radiation peaks in drywell 41-14-09 described in GJ-HAN-16 above was likely Ru-106 which gradually decayed away and the very low levels of gamma radiation remaining were Cs-137 which fit the Cs-137 decay curve (HNF-3136). This second event may be associated with tank SX-114 as there was no radiation reported in nearby tank SX-115 drywells (see Tank SX-114 Segment). Figure 11-17 shows the depths of radioactivity from 1975 to 1995 (HNF-3136).

Figure 11-17. Tank SX-115 Drywell 41-14-09 (HNF-3136)

Note: Bottom of the tank footing ~53-ft 1-in BGS

11.5.2.7 1966 Additional Test Wells

In August 1965, ten additional test wells (17A, 41A, 41B, 45A, 45B, 47A, 48A, 48B, 48C, and 49A) were drilled around tank SX-115 and are shown in Figure 11-8. Available test well construction, depth, and sampling details can be found in BNWL-CC-701. Sediment samples were taken at 1-ft depth intervals and samples were analyzed in the laboratory by “quantitative gamma analysis” (BNWL-CC-701). The only long lived radioisotope detected by the laboratory analyses was Cs-137. In 1966, only two of these wells, 48B and 48C, showed Cs-137 concentrations $>1 \times 10^7$ pCi/g (BNWL-CC-701, page 13). The largest concentration of Cs-137 was detected in drywell 48B, located near lateral 44-15-02, with concentrations between 50 and 1.1×10^8 pCi/g from 58 to 62-ft BGS. Maximum Cs-137 concentrations ($\sim 3 \times 10^3$ pCi/g) were significantly less in drywell 48C (10-ft southwest of drywell 48B) at a depth between 60 and 65-ft BGS. In drywells 45B and 17A, maximum Cs-137 concentrations were $\sim 1 \times 10^7$ pCi/g from 60 to 65-ft BGS. These four were the only drywells that showed elevated Cs-137 concentrations during this time. See Appendix G8 for the Cs-137 concentration profiles for drywells 48B, 48C, 45B, and 17A. No additional data for these four test wells or any of the data from the other six test wells are available except for the indication of test wells 48A, 49A, and 41B being at or within the last radioactivity contour line on Figure 11-8 (see Table 11-5 for a compilation of the available information on the test wells). This indicated there was at least some radioactivity detected in these three test wells at lower elevations from the continuation of known drywell and test well at the lower elevations associated with the outer radioactivity contour line.

Table 11-5. Test Well Soil Sample Results 1966 (BNWL-CC-701)

Test Well	Description ¹	Peak Soil Sample Cs-137 pCi/g ²	Comments Cs-137
17A	Standard 5-in drive sampler ²	1x10 ⁵ to 1x10 ⁷	Medium
41A	Standard 5-in drive sampler ²	N/A	Assumed ² No detectable
41B	Standard 5-in drive sampler ²	N/A	Trace
45A	2¼-in split tube driver sampler	N/A	No detectable
45B	Standard 5-in drive sampler ²	1x10 ⁶ to 1x10 ⁷	Medium
47A	Standard 5-in drive sampler ²	N/A	Assumed ² No detectable
48A	2¼-in split tube driver sampler	N/A	No detectable
48B	Standard 5-in drive sampler ²	~1x10 ⁸	N/A
48C	Standard 5-in drive sampler ²	1x10 ³	Very low
49A	Standard 5-in drive sampler ²	N/A	Assumed ³ Trace

1. Six inch diameter surface casing to prevent cave in
2. Both solid and split tube sampler types were used
3. Converted from original µCi/g (see Figure G8-1 and Figure G8-2)
4. Assumption based on similar contour line placement

11.5.3 Tank SX-115 Drywell/Test Well Summary

Tank SX-115 was first suspected of leaking at the end of February and March 1965 due to an initial liquid level decrease of 16-in which increased to ~18-in before pumping with subsequent radioactivity detected in the laterals. Radioactivity in drywell 41-15-07 first appeared before March 26, 1969 at 59-ft BGS. Drywell 41-15-07 is the only tank SX-115 drywell that seems to be associated with the tank SX-115 leak. The GJ-HAN-17 document concluded, “*Some surface-derived contamination was found in the boreholes surrounding tank SX-115. This contamination migrated downward into the vadose zone sediment to varying degrees. Only borehole 41-15-07 showed subsurface contamination that could be readily correlated and attributed to a subsurface contamination source.*” There is also the possibility that earlier radioactivity detected in drywell 41-14-09 in 1965 could be the result of the tank SX-115 leak; however, later indications of radioactivity detected in this drywell could be associated with nearby tank SX-114. Therefore, drywell 41-14-09 could be associated with either tanks SX-114 or SX-115, or both.

Tank SX-115 drywells 41-15-02, 41-15-03, 41-15-05, 41-15-09, and 41-15-10 may indicate radioactivity associated with a tank SX-115 leak, but with the short decay period and extensive coverage around the tank are not a good indicator of leak location. The outermost contour isobars in Figure 11-8 near the edge of the tank show the extent of Cs-137 radioactivity found in the test well soil samples and radiation in the drywells in 1966. This indicates that the early radioactivity in the drywells was probably due to shorter lived radioisotopes that decayed away. This was probably due to the nitrate leached waste present in the tank when the leak occurred. The nitrate leached waste was depleted in Cs-137 as the cesium-rich supernatant had been

previously transferred from the tank. The radiation levels in all five drywells were reported as less than values beginning in March 1969 through June 1987.

Ten test wells were drilled around the perimeter of tank SX-115 in 1965 and sediments were collected between 50 and 80-ft BGS, analyzed for gamma emitting radionuclides, and reported in BNWL-CC-701. Two test wells (48C and 48B) on the southwest side of the tank and two test wells (45B and 17A) on the northeast side of the tank indicated high levels of radioactivity. Three other test wells indicated an undefined low level of radioactivity on the northwest side of the tank as indicated by the outer radioactivity contour line (see Figure 11-8).

11.5.4 Tank SX-115 Footing and Sidewall Condition

In early July 1981, a concrete core drilled to a depth of 38-ft 8-in and 2.7-in diameter was removed from the haunch (transition from the wall to the dome), wall, and the footing of tank SX-115 (RHO-CD-1538, *Waste Tank 241-SX-115 Core Drilling Results*). The location of where the core was drilled is shown in the subsequent figures in Section 11.6. Drilling was reported to have stopped 8-in short of the bottom of the tank footing when radioactivity was encountered; however, no radioactivity was detected in the sidewall or haunch. The last 6-ft of concrete core segment removed during drilling had a beta radiation reading of 1,600-mR at the bottom of the segment. Also, the drilling water was slightly contaminated with a reading of 3,800 cpm when drilling this last segment. The location where the core was extracted is located in a possible leak site (see Figure 11-23) and confirms the leak site was at or near the tank bottom. The core was extracted in support of SST structural integrity evaluations and was tested to determine elasticity and strength properties.

Four core pieces taken from tank SX-115 were found to have cracks ranging from 2 to 10-in in length and internal cracks in large aggregate pieces were observed in one core. The cores may have cracked or were damaged during either coring or core extraction; therefore, the cores may not necessarily be reflective of the tank wall condition. A pattern of possible decreasing strength with depth was observed, but all samples were above the design values (RHO-RE-CR-2, *Strength and Elastic Properties Tests of Hanford Concrete Cores- 241-SX-115 Tank and 202-A Purex Canyon Building*). A photograph of the concrete cores drilled from 0-ft to 8-ft in tank SX-115 is shown in Figure 11-18.

**Figure 11-18. Tank SX-115 Concrete Cores 0-ft to 8-ft
Photograph 096997-6, July 1981**

11.6 POSSIBLE TANK SX-115 LINER LEAK LOCATION(S)

The lateral radioactivity when first detected could be an indication of the location of liner leak. However, the liner leak may have penetrated the waterproof membrane at any location or pooled on the waterproof membrane and followed concrete cracks or breaks to a different location including the top of the tank footing.

It is likely that the tank SX-115 leak occurred at or near the bottom of the tank because all of the leak indicators, three laterals and one drywell, were located at or near the tank bottom. There is a possibility of a sidewall leak below the 4-ft waste level due to the initial 16-in liquid level decrease but is unlikely since lateral and drywell data indicate the leak was at or near the tank bottom.

The volume of the tank SX-115 leak (~50 kgal) coupled with the rate of leakage indicates that a fairly large crack or multiple cracks developed in the tank liner in possibly two quadrants around the tank at or near the tank bottom. The location was indicated by the lateral radioactivity and test wells specifically drilled in 1965 after the leak. The test wells provided data for an analysis of the leak size. The analysis at that time accounted for ~60% of the volume of the liquid level decrease. One drywell, 41-15-07, indicated migration in 1973. The sidewall core drill of the sidewall in 1981 detected radioactivity in the last core at the bottom of the sidewall. Cracking under similar thermal conditions was seen in the cores of the tank SX-108 footing which was probably the case in most of the SX Farm tanks. Therefore, seepage through the lower sidewall

and footing is easily understood and could be at many locations around the lower portion of the tank. Depending on the integrity of the asphaltic waterproofing membrane there could be leakage through the concrete footing at any location under the tank. It is unknown why there was such an apparently large volume leak over such a short period of time. The GJ-HAN-17 report offered several possibilities as to the alleged discrepancy between the liquid level decrease volume and the radioactivity volumetric analysis as follows:

“One or more of the following conditions could account for detection of a smaller than anticipated volume of contamination at the tank SX-115 location: (1) the tank leak volume was significantly less than 50,000 gal, (2) the liquid that leaked contained a much lower radionuclide content than other tank leaks in the SX Tank Farm, (3) the chemical nature of the liquid that leaked from the tank retarded the migration of radionuclide contaminants, or (4) the leak volumes from other tanks within the SX Farm have been significantly underestimated.”

A conceptual model in RPP-ENV-39658, Rev. 0, indicated that Cs-137 accounted for a volume of approximately 60%. The volume at ~60% of the ~50 kgal liquid level decrease results in a leak of ~30 kgal which is still a sizeable leak. It is unclear what caused the steel liner to fail with an apparent much larger opening than was experienced in any of the other SX Farm leaking tanks. Some possibilities include variations in the quality of the liner steel, quality of the liner fabrication, and the fit of the bottom steel liner and sidewall steel orthogonal joint as it integrates with the concrete/grout. Other possibilities include the grout alignment to the liner bottom, asphaltic waterproofing membrane, and concrete footing underlayment as well as other possible factors.

11.6.1 Leak Detection Reported June 1966, Site A

Tank SX-115 leak was first detected due to a liquid level decrease of ~16-in over a period of six days in February-March 1965. Radioactivity was first detected in lateral 44-15-02 and reported June 1966 at 14.2 to 26.2-ft from the northeast edge of the tank (see Figure 11-19). Radioactivity at much higher levels was first detected in January 1973 in lateral 44-15-03 at 7.6-ft from the northeast edge. It is likely radioactivity reported in lateral 44-15-03 was present in 1966 as indicated by BNWL-CC-701; however, earlier data were not recovered.

Figure 11-19. Tank SX-115 Possible Leak Location (Reported June 1966)

Tank inner ring is steel liner, outer ring is outer edge of tank footing

Leak first detected Feb-March 1965 due to an initial liquid level decrease of more than 16-in and confirmed by later radioactivity increases in laterals, test wells, and a drywell. The green dot on lateral 44-15-02 and the green bar on lateral 44-15-03 indicate the location of reported radioactivity.

11.6.2 Leak Detection Reported 1966 and in November 1973, Site B

Radioactivity was detected in samples from test wells 45B and 17B and reported in June 1966 from 60 to 65-ft BGS (BNWL-CC-701) (see Figure 11-20). The first recoverable reading for drywell 41-14-09 reported radioactivity in May 1965 at 62-ft BGS. This is likely associated with the tank SX-115 leak due to timing; however, an indication of the tank SX-114 leak cannot be ruled out. The first recoverable data reported radioactivity in lateral 44-15-01 in November 1973 at 2.7-ft from the northeast edge of the tank. It appears this is a separate leak site from Site A (see Figure 11-19) as radiation levels were high in both laterals 44-15-01 and 44-15-03 and much lower in the intervening lateral 44-15-02, indicating little if any communication between the sites.

Figure 11-20. Tank SX-115 Possible Leak Location (Reported June 1966)

Tank inner ring is steel liner, outer ring is outer edge of tank footing

Leak first detected Feb-March 1965 due to an initial liquid level decrease of more than 16-in and confirmed by later radioactivity increases in laterals, test well, and a drywell.

11.6.3 Leak Detection Reported June 1966, Site C

Radioactivity detected in test well 48B from 58 to 62-ft BGS and test well 48C from 60 to 65-ft BGS were reported in June 1966 (BNWL-CC-701) (see Figure 11-21). Radioactivity levels were greater than those detected in the test wells northwest of the tank (see site B in Figure 11-20). It was assumed radioactivity was also present towards the end of lateral 44-15-02 but was not recorded since radioactivity levels were likely lower and peaks were only recorded in the laterals during this time. This appears to be the detection of a separate leak site from Sites A and B although, as mentioned above, the detection of radioactivity in the soil can be at a location dissociated from the actual tank liner leaks location.

Figure 11-21. Tank SX-115 Possible Leak Location (1983)
Tank inner ring is steel liner, outer ring is outer edge of tank footing

Leak first detected Feb-March 1965 due to an initial liquid level decrease of more than 16-in and confirmed by later radioactivity increases in laterals, test wells, and a drywell.

11.6.5 Leak Location Summary

Tank SX-115 leak was first detected based on liquid level decreases (~18-in) from February 24, 1965 to March 8, 1965. One data point of increased radioactivity in one of the laterals was detected shortly afterwards confirming the tank leak; however, no further lateral data was recovered for the laterals until January 1973. Ten test wells were drilled after the leak and a report (BNWL-CC-701) in 1966 indicated two sets of two test wells showing radioactivity below the tank. Three distinct locations were identified as possible leak site locations as shown in Figure 11-23. Radioactivity was reported in drywell 41-14-09 in 1965 which could be an indication of a tank SX-115 leak and/or tank SX-114 leak; however, it seems likely associated with tank SX-115 versus SX-114. Drywell, 41-15-07 indicated radioactivity in 1969, which was probably due to migration from one of the previous leak sites. Several of the drywells around tank SX-115 indicate radioactivity in 1965 that decayed away and therefore are not included in the leak location discussion.

Figure 11-23 shows a composite of the leak location sites. It is likely the leak occurred at or near the bottom of the tank since all of the leak indicators (laterals, drywells, and test wells) were located at or near the tank bottom. Leak locations in Figure 11-23 are based on peak readings and are a representation of possible initial boundaries of radioactivity.

A liner bulge of 3-in was detected in 1958 which subsided. Two ALCs, #2 and #4, indicated disconnected turnbuckles and ALC #4 with bent piping from photographs taken in 1969 and 1972 (see Section 11.4.5). It is interesting to note that if the bulge was on a line between these two ALCs that this may have resulted in pulling the liner away from the sidewall resulting in stress that when subjected to nitrate leachate could have resulted in two opposing locations such as Site A-B and Site C-D. However, there is no direct evidence and the possible location remains inconclusive.

Figure 11-23. Tank SX-115 Possible Radial Leak Locations
Tank inner ring is steel liner, outer ring is outer edge of tank footing

11.7 POSSIBLE TANK SX-115 LINER LEAK CAUSE(S)

Tank SX-115 was exposed to five conditions that could contribute to a failed liner. Some or all of the factors can act together to contribute to tank liner failure.

11.7.1 Tank Design

The design of the SX Farm tanks was the first that diverged from the round bottom knuckle design used in the earlier waste tanks; the tank bottom liner intersects the sidewall liner orthogonally. A fillet weld was used to close the seam where the sidewall and the tank bottom liner meet. Several other SSTs with fillet welds failed during service (RPP-RPT-45921). Weld inspections were less rigorous. Additionally, the design discontinued the use of the three-ply asphaltic membrane waterproofing between the liner sidewall and the concrete shell. These features were inferior to others and could possibly increase the likelihood of failure of the tank liner from induced stresses (see Section 11.3.1).

11.7.2 Thermal Conditions

Temperature requirements in HW-59919 issued October 22, 1959 indicated that the self-boiling waste operating temperature should be maintained between 50°F and 220°F. The HW-59919 document recommended a uniform rate of temperature increase of 2°F per day and the maximum sludge temperature should not exceed 300°F.

The tank SX-115 bulb (sludge) temperatures are shown in Appendix B8 and Appendix C8. The maximum temperature of 266°F was reported on September 16, 1960 which did not exceed the maximum temperature limit (see Appendix C8).

Assuming a 55°F initial temperature of the tank liner when waste was first received on August 31, 1958 (HW-57550) and increased to ~148°F by September 17, 1958 18 days later (see Table B8). Tank SX-113 temperature recorded February 26, 1958 before receiving waste was 42°F, therefore 55°F may not be the worst case for ambient temperature for tank SX-115 in August 1958. No recording of tank SX-115 temperature was found before receiving waste. Over this 18 day period there was a temperature increase of 93°F, and the average rate of rise was ~5.2°F per day which is above the recommended rate of 2°F per day. There were no other increases in temperatures that exceeded the initial average rate of rise of 5.2°F per day during the operation of tank SX-115.

Note that the operating temperature limitations specified in HW-59919 were exceeded before issuing the document. Thermal shock creates stress both from rapid temperature rise as well as waste-induced high temperatures.

11.7.3 Chemistry-Corrosion

Tank SX-115 first received a liquid heel for preheating the tank in August 1958 which was stored for about one year. The tank was then filled with REDOX HLW in November 1959 and stored mostly this waste type throughout operation. During this period, the tank stored REDOX

HLW for about 5 ½ years total. The REDOX HLW consisting of low concentrations of nitrite and hydroxide would have created an environment conducive to pitting and/or SCC.

Sodium nitrate leaching of tank SX-115 started with the transfer of supernatant out of the tank and subsequent addition of condensate from tank SX-106 in June to July 1964. The nitrate leachate waste was transferred from tank SX-115 to tank SX-105 in September 1964; however, additional nitrate leachate waste from other SX Farm tanks were added to tank SX-115 and stored in the tank until March 1965. Thus, tank SX-115 stored nitrate leachate waste for about one year before the tank was first suspected of leaking. Loss of the protective nitrite and hydroxide ions would have created an environment conducive to SCC and/or pitting of the tank liner (see Section 11.4.4).

11.7.4 Liner Observations

The tank SX-115 liner was reported to have bulged 3-in in 1958 (HW-58051). A review of photographic evidence seems to indicate a possible liner bulge as reported in HW-58051 at least from an observation of bent piping and failures of the turnbuckle guy rods. The evidence of a liner bulge is possible in tank SX-115, but the location of the bulge is uncertain (see Figure 11-23). Liner bulging coupled with other tank conditions could affect tank liner integrity; however, by itself bulging can induce stresses that could result in locations that are more susceptible to corrosion (see Section 11.4.3).

11.7.5 Tank Construction Temperature

Winter temperatures as low as -6°F occurred during the period when the SX Farm tank liners were being constructed and leak tested (see Figure 3-4). The low temperatures experienced during construction were less than the current 18°F allowable temperature where impact loading had the potential for creating micro-fissures. Impact occurrences could have occurred during cold temperatures that may have triggered fissures in the steel liner.

11.8 TANK SX-115 CONCLUSIONS

Evidence indicates that the tank SX-115 liner leaked at or near the bottom of the tank at possibly three locations. Based on engineering judgment and available information the following conditions listed in the order of importance lead to the tank SX-115 failed liner:

1. Thermal conditions – rate of temperature rise
2. Tank design –expansion limiting design changes
3. Waste storage chemistry and nitrate leaching – SCC and/or pitting
4. Construction conditions – ductile-to-brittle transition temperature
5. Bulging liner – an effect of primarily thermal conditions along with tank design and potentially nitrate leaching

There were several liner leak cause conditions that were examined, but the primary cause is the tank SX-115 thermal conditions experienced during the rapid addition of high temperature waste to a cold tank despite the use of a liquid heel for preheating the tank. Also, the unique tank design did not allow for expansion of the bottom liner as the tank heated creating stresses.

Storage of REDOX HLW at elevated temperatures, nitrate leaching, and subsequent storage of nitrate leachate waste created a chemical environment susceptible to nitrate-induced SCC and/or pitting attack on an already stressed metal liner. Tank construction occurred in winter under cold temperature conditions which could have affected the ductile-to-brittle steel transition temperature where metal loses its ability to absorb forces such as induced loads or the impact of falling objects creating micro-fissures or hairline cracks. In addition, a bulged bottom imparts stresses in the liner that could have predisposed it to SCC. Some or all of the factors can act serially or together to contribute to tank liner failure.

The volume of waste that leaked from tank SX-115 was the largest volume of any of the leaking SX Farm tanks and begs the question of what caused the steel liner to fail with such a large apparent opening. Some possibilities include variations in the quality of the liner steel, liner fabrication, the grout alignment to the liner bottom to the asphaltic waterproofing membrane to the concrete footing underlayment, and the fit of the bottom steel liner and sidewall steel orthogonal joint as it integrated with the concrete/grout. Other possibilities may exist that are unknown as well as a combination of any of the above; however, it can only be speculated what factors attributed to the large leak volume from tank SX-115.

APPENDIX A8

TANK SX-115 BOILING WASTE OPERATIONAL HISTORY

Table A8-1. RHO-R-39 Boiling Waste Tank Operating Data Table

Tank No.	First Waste	Tank Pre-Heated	Pre-Heat Start	Liquid Heel Used	First Waste Rec'd From	Tank Failed	Inspected For Bulge	Bulge Present	Did Tank Boil on 1st Loading	Tank Started Boiling	Tank Emptied & Reused*	NaNO ₃ Leached from Sludge
101-SX	19 May 54	No	-	No	Redox	No	No	-	Yes	Nov 54	No	No
102-SX	Sep 54	No	-	No	101-SX, Cascade	No	No	-	No	-	No	No
103-SX	Nov 54	No	-	No	102-SX, Cascade	No	No	-	No	-	No	No
104-SX	2 Feb 55	No	-	No	Redox	No	No	-	Yes	Jun 55	No	No
105-SX	11 May 55	No	-	No	104-SX, Cascade	No	No	-	No	-	Yes	No
106-SX	Jun 54	No	-	No	Tank Farm Condensate	No	No	-	No	-	-	-
107-SX	3 Mar 56	No	-	Yes	Redox	Yes, 1964	Yes	Yes	Yes	Jun 56	Yes	Yes
108-SX	8 Nov 55	No	-	No	Redox	Yes, 1962	Yes	Yes	Yes	Jun 56	Yes	Yes
109-SX	20 Sep 55	No	-	Yes	Redox	Yes, 1965	Yes	No	Yes	Dec 55	Yes	No
110-SX	Nov 60	Yes	Apr 60	No	Redox	-	No	-	No	Between 1/61-6/61	Yes	No
111-SX	9 Jun 56	No	-	No	Redox	-	No	-	Yes	Nov 56	Yes	No
112-SX	13 Feb 56	No	-	No	Redox	Yes, 1969	Yes	Yes	Yes	Mar 56	Yes	No
113-SX	20 Feb 58	No	-	No	Redox	Yes, 1958	Yes	Yes	Yes	Apr 58	No	No
114-SX	Nov 56	No	-	No	Redox	-	No	-	Yes	Jun 57	Yes	Yes
115-SX	4 Nov 59	Yes	Sep 58	Yes	Redox	Yes, 1965	No	-	Yes	Nov 59	No	Yes
101-A	20 Jan 56	No	-	6" H ₂ O	Purex	No	Yes	No	Yes	Jul 57	Yes	No
102-A	20 Mar 56	No	-	6" H ₂ O	Purex	No	No	-	Yes	Jul 58	Yes	No
103-A	15 May 56	No	-	6" H ₂ O	Purex	No	No	-	Yes	Jul 56	Yes	No
104-A	30 Jun 59	No	-	6" H ₂ O	Purex	No	Yes	No	Yes	Aug 59	Yes	No
105-A	31 Jan 63	Yes	Jan 63	Yes	Purex	Yes, 1963	Yes	Yes	No***	Mar 63	No	No
106-A	31 Dec 60**	Yes	23 Feb 61	Yes	Purex	No	No	-	Yes	Aug 61	Yes	No
101-AX	1 Jun 65**	Yes	23 Nov 66	Yes	TK-103-A and TK-112-B	No	No	-	No***	Dec 66	Yes	No
102-AX	30 Sep 66**	Yes	2 Mar 69	Yes	TK-101-AX and TK-103-A	No	No	-	No***	Apr 69	No	No
103-AX	10 Feb 65	Yes	Nov 64	Yes	Purex	No	No	-	Yes	Apr 65	No	No
104-AX	9 Sep 66	Yes	Jun 66	Yes	Purex	No	No	-	Yes	Oct 66	No	No

* Emptied indicates supernatant was pumped out but sludge remained.

** Tanks used for temporary waste storage prior to the receipt of LWW or HLW.

*** Did not boil until LWW was routed to the tank.

Note: SX-111 was found to have been NaNO₃ Leached

Table A8-2. ARH-R-43 Waste Tank Leak Experience Table

TABLE 3. Underground Waste Storage Tank Leak Experience

<u>Tank</u>	<u>Built</u>	<u>First Used</u>	<u>Type of Waste Stored</u>	<u>Service</u>	<u>Leak First Suspected</u>	<u>Reason for Suspicion</u>	<u>Leak Confirmed by</u>	<u>Bulge Found</u>	<u>Estimated Volume of Leak, gal</u>	<u>Associated Cs-137, kCi</u>
104-U	1943-44	1947	Bismuth phosphate waste Uranium recovery waste	Nonboiling	1956	Bulged liner	Refill with water (1961)	Yes	55,000*	0.09
113-SX	1953-54	1958	Redox waste	Boiling	1958	Bulged liner	Refill with salt solution (1962)	Yes	15,000**	8
106-TV	1951-52	1953	TBP waste	Nonboiling	1959	Liquid level measurements	Soil radiation readings (1959)		20,000	2
101-U	1943-44	1946	Bismuth phosphate waste Uranium recovery waste Redox waste	Nonboiling	1959	Liquid level measurements	Liquid level measurements		30,000	23
105-TV	1951-52	1953	TBP waste	Nonboiling	1960	Liquid level measurements	Liquid level measurements		35,000	4
108-SX	1953-54	1955	Redox waste	Boiling	1962	Soil radi- ation readings	Liquid level measurements	Yes	3,400	17
105-A	1954-55	1963	Purex waste	Boiling	1963	Soil radi- ation readings	Soil radiation readings	Yes	Small	
107-SX	1953-54	1956	Redox waste	Boiling	1964	Soil radi- ation readings	Soil radiation readings	Yes	Small	
109-SX	1953-54	1955	Redox waste	Boiling	1965	Soil radi- ation readings	No further evidence	No	Small	
115-SX	1953-54	1958	Redox waste	Boiling	1965	Liquid level measurements	Soil radiation readings		50,000***	40
112-SX	1953-54	1956	Redox waste	Boiling	1969	Liquid level measurements	Soil radiation readings	Yes	30,000	45

* Contained water at time of leak.
 ** Contained NaNO_3 solution at time of leak, also some residual supernatant solution.
 *** Contained NaNO_3 solution at time of leak.

Note: See tank farm segments for information on individual specific tanks

APPENDIX B8

TANK SX-115 TEMPERATURES JULY 1958 – OCTOBER 1958

Table B8-1. REDOX Weekly Tank Farm Readings July 1958 to October 1958

REDOX TANK FARM READINGS - 1958 (cont.)

(Build temp. thermometer 119)

	7-16-58	7-23-58	7-30-58	8-6-58	8-13-58	8-20-58	8-27-58	9-3-58	9-10-58	9-17-58	9-24-58	10-1-58	10-8-58	10-15-58	10-22-58	10-29-58				
TANK NO.	Fe ²⁺ /In. Temp	Fe ²⁺ /In. Temp	Fe ²⁺ /In. Temp	Fe ²⁺ /In. Temp	Fe ²⁺ /In. Temp	Fe ²⁺ /In. Temp	Fe ²⁺ /In. Temp	Fe ²⁺ /In. Temp	Fe ²⁺ /In. Temp	Fe ²⁺ /In. Temp	Fe ²⁺ /In. Temp	Fe ²⁺ /In. Temp	Fe ²⁺ /In. Temp	Fe ²⁺ /In. Temp	Fe ²⁺ /In. Temp	Fe ²⁺ /In. Temp				
101-5	23'10 1/4 155	23'10 1/4 155			23'10 1/4 155	23'9 1/2 155	23'9 1/2 155	23'9 1/2 155	23'9 1/2 155	23'9 1/2 155	23'9 1/2 155	23'9 1/2 155	23'9 1/2 155	23'9 1/2 155	23'9 1/2 155	23'9 1/2 155	23'9 1/2 155			
102-5	23'0" 82	23'0" 82			23'0" 82	23'0" 82	23'0" 82	23'0" 82	23'0" 82	23'0" 82	23'0" 82	23'0" 82	23'0" 82	23'0" 82	23'0" 82	23'0" 82	23'0" 82			
103-5	23'3 3/4 82	23'3 3/4 82			23'3 3/4 82	23'3 3/4 82	23'3 3/4 82	23'3 3/4 82	23'3 3/4 82	23'3 3/4 82	23'3 3/4 82	23'3 3/4 82	23'3 3/4 82	23'3 3/4 82	23'3 3/4 82	23'3 3/4 82	23'3 3/4 82			
104-5	22'7" 200	22'7" 200			22'7" 200	22'7" 200	22'7" 200	22'7" 200	22'7" 200	22'7" 200	22'7" 200	22'7" 200	22'7" 200	22'7" 200	22'7" 200	22'7" 200	22'7" 200			
105-5	22'5" 92	22'4 3/4 91			22'4 3/4 92	22'4 3/4 92	22'4 3/4 92	22'4 3/4 92	22'5" 92	22'5" 92	22'5" 92	22'5" 92	22'5" 92	22'5" 92	22'5" 92	22'5" 92	22'5" 92			
106-5	23'3" 80	23'3" 80			23'3" 80	23'3" 80	23'3" 80	23'3" 80	23'3" 80	23'3" 80	23'3" 80	23'3" 80	23'3" 80	23'3" 80	23'3" 80	23'3" 80	23'3" 80			
107-5	17'4" 148	17'6 3/4 148			18'3" 149	18'4 1/2 149	18'7 1/2 149	19'0" 149	19'4" 149	19'4" 149	19'4" 149	19'4" 149	19'4" 149	19'4" 149	19'4" 149	19'4" 149	19'4" 149			
108-5	23'8" 92	23'8" 92			23'8" 92	23'8" 92	23'8" 92	23'8" 92	23'8" 92	23'8" 92	23'8" 92	23'8" 92	23'8" 92	23'8" 92	23'8" 92	23'8" 92	23'8" 92			
109-5	23'8 1/2 75	23'8 1/2 73			23'8 1/2 75	23'8 1/2 75	23'8 1/2 75	23'8 1/2 75	23'8 1/2 75	23'8 1/2 75	23'8 1/2 75	23'8 1/2 75	23'8 1/2 75	23'8 1/2 75	23'8 1/2 75	23'8 1/2 75	23'8 1/2 75			
110-5	24'2 1/2 118	24'2 1/2 85			24'2 1/2 118	24'2 1/2 116	24'2 1/2 116	24'2 1/2 116	24'2 1/2 116	24'2 1/2 116	24'2 1/2 116	24'2 1/2 116	24'2 1/2 116	24'2 1/2 116	24'2 1/2 116	24'2 1/2 116	24'2 1/2 116			
111-5	23'7 1/2 86	23'7 1/2 85			23'7 1/2 86	23'7 1/2 87	23'7 1/2 87	23'7 1/2 87	23'7 1/2 87	23'7 1/2 87	23'7 1/2 87	23'7 1/2 87	23'7 1/2 87	23'7 1/2 87	23'7 1/2 87	23'7 1/2 87	23'7 1/2 87			
112-5	24'2 1/2 85	24'2 1/2 116			24'2 1/2 85	24'2 1/2 85	24'2 1/2 85	24'2 1/2 85	24'2 1/2 85	24'2 1/2 85	24'2 1/2 85	24'2 1/2 85	24'2 1/2 85	24'2 1/2 85	24'2 1/2 85	24'2 1/2 85	24'2 1/2 85			
16																				
101-SX	14'4" 282	14'4" 293			14'4" 300	14'3 3/4 300	14'4 1/2 304	14'5" 300	14'4 3/4 303	14'3 3/4 306	14'3 3/4 306	14'3 3/4 306	14'3 3/4 306	14'3 3/4 306	14'3 3/4 306	14'3 3/4 306	14'3 3/4 306			
102-SX	30'6" 118	30'6" 120			30'5 1/2 119	30'5 1/2 119	30'5 1/2 122	30'5 1/2 123	30'5 1/2 119	30'4 3/4 122	30'4 3/4 123	30'4 3/4 123	30'4 3/4 123	30'4 3/4 123	30'4 3/4 123	30'4 3/4 123	30'4 3/4 123			
103-SX	13'9 3/4 98	13'9 3/4 99			23'7" 170	23'7 1/2 177	23'7 1/2 185	23'7 1/2 190	23'7 1/2 192	23'5 1/2 196	23'4 1/2 200	23'3 1/2 200	23'3 1/2 200	23'3 1/2 200	23'3 1/2 200	23'3 1/2 200	23'3 1/2 200			
104-SX	23'3" 237	23'3" 235			23'3 1/2 237	23'3 1/2 232	23'3 1/2 240	23'3 1/2 240	23'3 1/2 236	23'3 1/2 235	23'3 1/2 232	23'3 1/2 232	23'3 1/2 232	23'3 1/2 232	23'3 1/2 232	23'3 1/2 232	23'3 1/2 232			
105-SX	28'5 1/2 124	28'5 1/2 128			28'4 3/4 128	28'4 3/4 121	28'4 3/4 129	28'4 3/4 125	28'4 3/4 124	28'4 3/4 127	28'4 3/4 129	28'4 3/4 127	28'4 3/4 127	28'4 3/4 127	28'4 3/4 127	28'4 3/4 127	28'4 3/4 127			
106-SX	6'10 1/2 186	Plug 186			7'11" 183	7'5 1/2 185	6'5 1/2 184	6'8 1/2 188	6'10" 187	4'8 1/2 190	3'5" 190	3'3 1/2 188	3'7" 187	4'2 1/2 187	3'7 1/2 187	3'9 1/2 187	3'9 1/2 187			
107-SX	21'10 1/2 310	21'8 1/2 309			23' 1/2 298	21'10 1/2 300	21'8" 294	22'5" 293	22'2" 291	22'1 1/2 290	22'3 1/2 289	22'1" 289	21'11 1/2 289	21'9 1/2 288	21'7 1/2 288	21'6 1/2 288	21'6 1/2 288			
108-SX	18'5 1/2 290	18'4 1/2 291			18'1 1/2 292	18'1 1/2 283	17'10" 283	17'8 1/2 283	17'7" 282	17'9 1/2 307	18'1 1/2 317	18'5 1/2 317	18'8 1/2 309	19'6" 306	19'1 1/2 294	19'9" 299	19'9" 306			
109-SX	29'9 1/2 210	29'10" 210			29'9 1/2 208	29'9 1/2 206	29'9 1/2 205	29'9 1/2 205	29'9 1/2 204	29'8 1/2 205	29'8 1/2 202	29'8 1/2 203	29'8 1/2 202	29'8 1/2 202	29'8 1/2 202	29'8 1/2 202	29'8 1/2 202			
110-SX	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-			
111-SX	20'6" 224	19'11 1/2 223			19'10 1/2 221	19'10 1/2 220	19'9 1/2 218	19'9 1/2 218	19'8 1/2 217	19'7 1/2 215	19'7 1/2 219	19'7 1/2 219	19'7 1/2 219	19'7 1/2 219	19'7 1/2 219	19'7 1/2 219	19'7 1/2 219			
112-SX	26'5 1/2 201	26'4 3/4 200			26'4 1/2 199	26'4 1/2 196	26'4 1/2 196	26'4 1/2 195	26'4 1/2 195	26'4 1/2 195	26'4 1/2 195	26'4 1/2 195	26'4 1/2 194	26'4 1/2 194	26'4 1/2 194	26'4 1/2 193	26'4 1/2 193			
113-SX	9'8 1/2 252	9'4 1/2 253			0'8 1/2 226	2'10 1/2 223	3'2 1/2 210	0'2 1/2 215	0'1 1/2 202	0'1" 202	0'1" 202	0'1" 202	0'1" 200	0'1 1/2 200	0'1 1/2 200	0'1 1/2 200	0'1 1/2 199			
114-SX	19'7 1/2 268	20'4 1/2 269			21'0" 269	20'9 1/2 331	21'6" 250	20'6 1/2 267	21'10" 302	22'3 1/2 283	22'3 1/2 262	22'3 1/2 257	22'4 1/2 251	22'6" 251	22'7 1/2 251	22'7 1/2 249	22'7 1/2 251			
115-SX	-	-			-	8'24" 0'5"	-	2'7" 100	4'3 1/2 126	5'5 1/2 148	6'3 1/2 169	6'5 1/2 185	6'6" 200	7'5 1/2 209	9'2" 186	9'2" 205	9'2" 205			
* Circ on 112-SX forced condenser to 109-SX																				
7-23 to 7-25 Pumped 113-SX to 103-SX																				
*** DIAL SHOWS 200°F BUT TEMP IS 125°F AS THERE ARE 2 200°F POINTS ON DIAL - BEEH.																				
** 112-SX TANK BULGED - NO LIQUID ABOVE BULGE																				
* 106-SX to 114-SX, - 37,000 8/21 5'8/22																				
D-8 waste routed to 115-SX 9-1-58, 53,976 gals. H ₂ O added prior to SW addition.																				
9-4-58 114-SX electrode replaced - 21'9" wire to 20'6"																				
9-25-58 work - 20'6" to 115-SX																				

APPENDIX C8

TANK SX-115 TEMPERATURE AUGUST 1958 – JANUARY 1968

Figure C8-1. RHO-CD-1172 Tank SX-115 Temperature August 1958 through February 1960

Figure C8-2. RHO-CD-1172 Tank SX-115 Temperature March 1960 through September 1961

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C8-3. RHO-CD-1172 Tank SX-115 Temperature October 1961 through April 1963

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C8-4. RHO-CD-1172 Tank SX-115 Temperature May 1963 through November 1964

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C8-5. RHO-CD-1172 Tank SX-115 Temperature December 1964 through June 1966

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

Figure C8-6. RHO-CD-1172 Tank SX-115 Temperature July 1967 through January 1968

Note: Sludge temperature 2-in to 3-in off the tank bottom (see Section 3.2.2)

APPENDIX D8

TANK SX-115 LATERAL ACTIVITY

**Table D8-1. Tank SX-115 Lateral Radioactivity (K counts per minute)
(1973 to 1987) (SD-WM-TI-356)**

44-15-01			44-15-02			44-15-03		
Date	Peak (K cpm)	Distance (ft) ¹	Date	Peak (K cpm)	Distance (ft) ¹	Date	Peak (K cpm)	Distance (ft) ¹
N/A ²			6/66	2	14.2-26.2	N/A ²		
11/24/73	93	2.7	1/2/73	0	N/A ²	1/2/73	2914 ⁴	7.6
12/19/73	90	7.7	N/A ²			8/24/73	2700	12.6
12/31/73	115	12.7	N/A ²			12/31/73	2100	12.6
4/29/74	72	12.7	4/16/74	0	N/A ²	4/29/74	1950	12.6
5/6/74	84	12.7	N/A ²			7/10/74	1950	12.6
8/26/74	84	12.7	9/3/74	0	N/A ²	9/20/74	2070	12.6
10/10/74	285	12.7	10/15/74	1.6	45.2	N/A ²		
2/10/75	5 ³	12.7	1/6/75	1.4	45.2	2/18/75	460 ³	12.6
N/A ²			4/28/75	1.7	45.2	N/A ²		
7/21/75	3	12.7	7/8/75	1.6	45.2	7/8/75	270	12.6
10/21/75	3	12.7	10/21/75	1.2	45.2	10/21/75	285	12.6
4/6/76	4	12.7	4/6/76	1.2	45.2	4/6/76	285	12.6
4/5/77	6	12.7	4/5/77	1.1	45.2	1/3/77	680	14.6
7/10/78	4	12.7	7/11/78	0.8	45.2	1/12/78	567	14.6
N/A ²			N/A ²			7/10/78	554	14.6
7/2/79	5	12.7	7/2/79	0.6	45.2	7/2/79	590	14.6
7/10/80	5	12.7	7/8/80	0.5	45.2	7/10/80	360	14.6
6/15/81	5	12.7	6/15/81	0.4	46.2	6/16/81	635	14.6
7/26/82	4	12.7	7/26/82	0.1	41.2	7/26/82	585	17.6
6/15/83	4	12.7	6/14/83	0.2	44.2	6/15/83	647	18.6
6/8/84	4	13.7	6/8/84	0.1	44.2	6/8/84	625	18.6
6/19/85	4	13.7	6/19/85	0.1	46.2	6/19/85	532	16.6
6/13/86	4	10.7	6/12/86	0.1	40.2	6/16/86	530	16.6
6/19/87	5	11.7	6/19/87	0.1	40.2	6/19/87	615	15.6
				0.1	76.2			

Note: ¹Under the tank from northeast edge

²N/A: Data not available

³Red Probe

⁴Green Probe

APPENDIX E8

TANK SX-115 GROSS GAMMA DRYWELL DATA

Table E8-1. Tank SX-115 Drywell Radioactivity (K counts per minute) (March 1969 to June 1987)
(Drywell Data Sheets Retrieved March 24, 2011 and SD-WM-TI-356) (1 of 4 sheets)¹

41-15-02 ⁴			41-15-03 ⁴			41-15-05 ⁴			41-15-07 ⁵			41-15-09 ⁴			41-15-10 ⁴		
Drilled 3/29/1962			Drilled 4/2/1962			Drilled 3/30/1962			Drilled 3/27/1956			Drilled 4/3/1962			Drilled 4/30/1962		
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)
3/31/65	690 ⁶	63	3/31/65	140 ⁶	64	3/31/65	85 ⁶	59	N/A ³			3/31/65	440 ⁶	55	N/A ³		
4/3/65	690 ⁶	63	4/3/65	140 ⁶	59	4/3/65	85 ⁶	59	N/A ³			4/3/65	440 ⁶	55	N/A ³		
				240 ⁶	64												
4/28/65	340 ⁶	63	4/28/65	120 ⁶	60-65	4/28/65	120 ⁶	59	N/A ³			4/28/65	310 ⁶	55	N/A ³		
5/26/65	242 ⁶	63	5/26/65	100 ⁶	60-65	5/26/65	120 ⁶	59	N/A ³			5/26/65	250 ⁶	55	5/26/65	95 ⁶	65
3/24/69	< 50	N/A ³	3/24/69	< 50	N/A ³	3/24/69	< 50	N/A ³	3/26/69	160	59	3/24/69	< 50	N/A ³	3/24/69	< 50	N/A ³
4/3/69	< 50	N/A ³	4/3/69	< 50	N/A ³	4/3/69	< 50	N/A ³	4/8/69	175	59	4/3/69	< 50	N/A ³	4/3/69	< 50	N/A ³
5/8/69	< 50	N/A ³	5/8/69	< 50	N/A ³	5/8/69	< 50	N/A ³	5/5/69	113	59	5/8/69	< 50	N/A ³	5/8/69	< 50	N/A ³
N/A ³			N/A ³			N/A ³			6/12/69	70	59	N/A ³			N/A ³		
7/31/69	< 50	N/A ³	7/31/69	< 50	N/A ³	7/31/69	< 50	N/A ³	7/8/69	115	57	7/31/69	< 50	N/A ³	7/31/69	< 50	N/A ³
8/21/69	< 50	N/A ³	8/21/69	< 50	N/A ³	8/21/69	< 50	N/A ³	8/5/69	128	56	8/21/69	< 50	N/A ³	8/21/69	< 50	N/A ³
9/22/69	< 50	N/A ³	9/22/69	< 50	N/A ³	9/22/69	< 50	N/A ³	9/5/69	135	59	9/22/69	< 50	N/A ³	9/22/69	< 50	N/A ³
10/20/69	< 50	N/A ³	10/20/69	< 50	N/A ³	10/20/69	< 50	N/A ³	10/2/69	125	59	10/20/69	< 50	N/A ³	10/20/69	< 50	N/A ³
11/20/69	< 50	N/A ³	11/20/69	< 50	N/A ³	11/20/69	< 50	N/A ³	11/3/69	115	59	11/20/69	< 50	N/A ³	11/20/69	< 50	N/A ³
12/22/69	< 50	N/A ³	12/22/69	< 50	N/A ³	12/22/69	< 50	N/A ³	12/3/69	130	59	12/22/69	< 50	N/A ³	12/22/69	< 50	N/A ³
N/A ³			N/A ³			N/A ³			1/6/70	148	59	N/A ³			N/A ³		
2/24/70	< 50	N/A ³	2/24/70	< 50	N/A ³	2/24/70	< 50	N/A ³	2/2/70	130	59	2/24/70	< 50	N/A ³	2/24/70	< 50	N/A ³
3/24/70	< 50	N/A ³	3/24/70	< 50	N/A ³	3/24/70	< 50	N/A ³	3/4/70	135	59	3/24/70	< 50	N/A ³	3/24/70	< 50	N/A ³
4/27/70	< 50	N/A ³	4/27/70	< 50	N/A ³	4/27/70	< 50	N/A ³	4/8/70	138	59	4/27/70	< 50	N/A ³	4/27/70	< 50	N/A ³
5/19/70	< 50	N/A ³	5/19/70	< 50	N/A ³	5/19/70	< 50	N/A ³	5/3/70	140	59	5/19/70	< 50	N/A ³	5/19/70	< 50	N/A ³
6/29/70	< 50	N/A ³	6/29/70	< 50	N/A ³	6/29/70	< 50	N/A ³	6/4/70	150	57	6/29/70	< 50	N/A ³	6/29/70	< 50	N/A ³
7/27/70	< 50	N/A ³	7/27/70	< 50	N/A ³	7/27/70	< 50	N/A ³	7/1/70	123	57	7/27/70	< 50	N/A ³	7/27/70	< 50	N/A ³
8/24/70	< 50	N/A ³	8/24/70	< 50	N/A ³	8/24/70	< 50	N/A ³	8/4/70	125	57	8/24/70	< 50	N/A ³	8/24/70	< 50	N/A ³
9/30/70	< 50	N/A ³	9/30/70	< 50	N/A ³	9/30/70	< 50	N/A ³	9/3/70	123	56	9/30/70	< 50	N/A ³	9/30/70	< 50	N/A ³
10/20/70	< 50	N/A ³	10/20/70	< 50	N/A ³	10/20/70	< 50	N/A ³	10/1/70	118	56	10/20/70	< 50	N/A ³	10/20/70	< 50	N/A ³

Table E8-1. Tank SX-115 Drywell Radioactivity (K counts per minute) (March 1969 to June 1987)
(Drywell Data Sheets Retrieved March 24, 2011 and SD-WM-TI-356) (2 of 4 sheets)¹

41-15-02 ⁴			41-15-03 ⁴			41-15-05 ⁴			41-15-07 ⁵			41-15-09 ⁴			41-15-10 ⁴		
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)
N/A ³			N/A ³			N/A ³			11/4/70	110	56	N/A ³			N/A ³		
12/29/70	< 50	N/A ³	12/29/70	< 50	N/A ³	12/29/70	< 50	N/A ³	12/10/70	126	57	12/29/70	< 50	N/A ³	12/29/70	< 50	N/A ³
1/18/71	< 50	N/A ³	1/18/71	< 50	N/A ³	1/18/71	< 50	N/A ³	1/6/71	120	57	1/18/71	< 50	N/A ³	1/18/71	< 50	N/A ³
N/A ³			N/A ³			N/A ³			2/5/71	130	57	N/A ³			N/A ³		
3/29/71	< 50	N/A ³	3/29/71	< 50	N/A ³	3/29/71	< 50	N/A ³	3/4/71	100	57	3/29/71	< 50	N/A ³	3/29/71	< 50	N/A ³
N/A ³			N/A ³			N/A ³			4/13/71	90	57	N/A ³			N/A ³		
5/3/71	< 50	N/A ³	5/3/71	< 50	N/A ³	5/3/71	< 50	N/A ³	5/5/71	75	57	5/3/71	< 50	N/A ³	5/3/71	< 50	N/A ³
5/26/71	< 50	N/A ³	5/26/71	< 50	N/A ³	5/26/71	< 50	N/A ³	6/3/71	85	57	5/26/71	< 50	N/A ³	5/26/71	< 50	N/A ³
7/29/71	< 50	N/A ³	7/29/71	< 50	N/A ³	7/29/71	< 50	N/A ³	7/9/71	100	57	7/29/71	< 50	N/A ³	7/29/71	< 50	N/A ³
8/18/71	< 50	N/A ³	8/18/71	< 50	N/A ³	8/18/71	< 50	N/A ³	8/2/71	90	57	8/18/71	< 50	N/A ³	8/18/71	< 50	N/A ³
9/28/71	< 50	N/A ³	9/28/71	< 50	N/A ³	9/28/71	< 50	N/A ³	9/8/71	85	57	9/28/71	< 50	N/A ³	9/28/71	< 50	N/A ³
10/25/71	< 50	N/A ³	10/25/71	< 50	N/A ³	10/25/71	< 50	N/A ³	10/4/71	90	57	10/25/71	< 50	N/A ³	10/25/71	< 50	N/A ³
11/17/71	< 50	N/A ³	11/17/71	< 50	N/A ³	11/17/71	< 50	N/A ³	11/2/71	93	57	11/17/71	< 50	N/A ³	11/17/71	< 50	N/A ³
12/15/71	< 50	N/A ³	12/15/71	< 50	N/A ³	12/15/71	< 50	N/A ³	12/2/71	93	57	12/15/71	< 50	N/A ³	12/15/71	< 50	N/A ³
N/A ³			N/A ³			N/A ³			1/17/72	97	57	N/A ³			N/A ³		
2/15/71	< 50	N/A ³	2/15/71	< 50	N/A ³	2/15/71	< 50	N/A ³	2/7/72	98	57	2/15/71	< 50	N/A ³	2/15/71	< 50	N/A ³
N/A ³			N/A ³			N/A ³			3/13/72	100	57	N/A ³			N/A ³		
N/A ³			N/A ³			N/A ³			4/18/72	88	57	N/A ³			N/A ³		
N/A ³			N/A ³			N/A ³			5/4/72	85	57	N/A ³			N/A ³		
N/A ³			N/A ³			N/A ³			6/1/72	88	57	N/A ³			N/A ³		
N/A ³			N/A ³			N/A ³			7/3/72	80	57	N/A ³			N/A ³		
N/A ³			N/A ³			N/A ³			8/15/72	95	57	N/A ³			N/A ³		
N/A ³			N/A ³			N/A ³			9/7/72	68	57	N/A ³			N/A ³		
N/A ³			N/A ³			N/A ³			10/2/72	60	57	N/A ³			N/A ³		
N/A ³			N/A ³			N/A ³			11/6/72	60	56	N/A ³			N/A ³		

Table E8-1. Tank SX-115 Drywell Radioactivity (K counts per minute) (March 1969 to June 1987)
(Drywell Data Sheets Retrieved March 24, 2011 and SD-WM-TI-356) (3 of 4 sheets)¹

41-15-02 ⁴			41-15-03 ⁴			41-15-05 ⁴			41-15-07 ⁵			41-15-09 ⁴			41-15-10 ⁴		
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)
N/A ³			N/A ³			N/A ³			12/7/72	53	56	N/A ³			N/A ³		
N/A ³			N/A ³			N/A ³			1/8/73	68	56	N/A ³			N/A ³		
N/A ³			N/A ³			N/A ³			2/5/73	56	56	N/A ³			N/A ³		
										5	100						
N/A ³			N/A ³			N/A ³			3/7/73	115.0	56	N/A ³			N/A ³		
										10	100						
N/A ³			N/A ³			N/A ³			4/2/73	93.0	56	N/A ³			N/A ³		
										3.0	100						
N/A ³			N/A ³			N/A ³			5/22/73	115	52	N/A ³			N/A ³		
N/A ³			N/A ³			N/A ³			6/5/73	46	56	N/A ³			N/A ³		
										6	100						
N/A ³			N/A ³			N/A ³			7/2/73	84	53	N/A ³			N/A ³		
										7	122						
N/A ³			N/A ³			N/A ³			8/5/73	75	57	N/A ³			N/A ³		
9/13/73	< 12	N/A ³	9/13/73	< 12	N/A ³	9/13/73	< 12	N/A ³	9/4/73	105	52	9/13/73	< 12	N/A ³	9/13/73	< 12	N/A ³
4/10/74	< 12	N/A ³	4/10/74	< 12	N/A ³	4/10/74	< 12	N/A ³	4/9/74	115	56	4/10/74	< 12	N/A ³	4/10/74	< 12	N/A ³
7/31/74	< 3 ²	N/A ³	7/31/74	< 3 ²	N/A ³	6/29/74	< 3 ²	N/A ³	6/18/74	92	57	7/2/74	< 12	N/A ³	7/17/74	< 12	N/A ³
N/A ³			N/A ³			N/A ³			7/31/74	30 ²	58	7/31/74	< 3 ²	N/A ³	8/21/74	< 3 ²	N/A ³
2/6/75	< 3	N/A ³	1/28/75	< 3	N/A ³	1/23/75	< 3	N/A ³	1/23/75	25	57	1/23/75	< 3	N/A ³	1/28/75	< 3	N/A ³
7/22/75	< 3	N/A ³	7/15/75	< 3	N/A ³	7/22/75	< 3	N/A ³	7/15/75	23	57	7/22/75	< 3	N/A ³	7/22/75	< 3	N/A ³
4/7/76	< 3	N/A ³	4/6/76	< 3	N/A ³	4/6/76	< 3	N/A ³	4/6/76	22	55	4/7/76	< 3	N/A ³	4/7/76	< 3	N/A ³
7/13/77	< 3	N/A ³	7/13/77	< 3	N/A ³	7/13/77	< 3	N/A ³	7/13/77	21	56	7/13/77	< 3	N/A ³	7/13/77	< 3	N/A ³
7/4/78	< 3	N/A ³	7/4/78	< 3	N/A ³	7/4/78	< 3	N/A ³	7/4/78	21	55	7/4/78	< 3	N/A ³	7/4/78	< 3	N/A ³
7/3/79	< 3	N/A ³	7/3/79	< 3	N/A ³	7/3/79	< 3	N/A ³	1/3/79	21	55	7/3/79	< 3	N/A ³	7/3/79	< 3	N/A ³

Table E8-1. Tank SX-115 Drywell Radioactivity (K counts per minute) (March 1969 to June 1987)
(Drywell Data Sheets Retrieved March 24, 2011 and SD-WM-TI-356) (4 of 4 sheets)¹

41-15-02 ⁴			41-15-03 ⁴			41-15-05 ⁴			41-15-07 ⁵			41-15-09 ⁴			41-15-10 ⁴		
Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)	Date	Peak (K cpm)	Depth (ft BGS)
N/A ³			N/A ³			N/A ³			7/3/79	23	56	N/A ³			N/A ³		
7/14/80	< 3	N/A ³	7/14/80	< 3	N/A ³	7/14/80	< 3	N/A ³	7/14/80	22	55	7/14/80	< 3	N/A ³	7/14/80	< 3	N/A ³
6/15/81	< 3	N/A ³	6/15/81	< 3	N/A ³	6/15/81	< 3	N/A ³	6/15/81	22	56	6/15/81	< 3	N/A ³	6/15/81	< 3	N/A ³
7/28/82	< 3	N/A ³	7/28/82	< 3	N/A ³	7/28/82	< 3	N/A ³	7/28/82	16	57	7/28/82	< 3	N/A ³	7/28/82	< 3	N/A ³
6/23/83	< 3	N/A ³	6/23/83	< 3	N/A ³	6/23/83	< 3	N/A ³	6/23/83	23	57	6/23/83	< 3	N/A ³	6/23/83	< 3	N/A ³
6/12/84	< 3	N/A ³	6/12/84	< 3	N/A ³	6/12/84	< 3	N/A ³	6/12/84	17	57	6/12/84	< 3	N/A ³	6/12/84	< 3	N/A ³
6/12/85	< 3	N/A ³	6/12/85	< 3	N/A ³	6/12/85	< 3	N/A ³	6/12/85	17	58	6/12/85	< 3	N/A ³	6/12/85	< 3	N/A ³
6/10/86	< 3	N/A ³	6/10/86	< 3	N/A ³	6/10/86	< 3	N/A ³	6/10/86	23	59	6/10/86	< 3	N/A ³	6/10/86	< 3	N/A ³
6/24/87	< 3	N/A ³	6/24/87	< 3	N/A ³	6/24/87	< 3	N/A ³	6/24/87	21	59	6/24/87	< 3	N/A ³	6/24/87	< 3	N/A ³

Note: ¹If Depths were not available, the column was omitted from the table

²New Monitoring Equipment- S Probe

³N/A: Data not available

⁴Scintillation Probe (SP) used from March 1969 to February 1972. The probe used after this time was not stated.

⁵Readings were recorded using the SP from March 1969 to September 1973. The probe used after this time was not stated.

⁶Referenced from RL-SEP-297

APPENDIX F8

TANK SX-115 LATERAL GAMMA LOGGING

**Figure F8-1. Gamma Survey for Lateral 44-15-01 on Logarithmic Scale May 2005
(RPP-RPT-27605)**

**Figure F8-2. Gamma Survey for Lateral 44-15-02 on Logarithmic Scale May 2005
(RPP-RPT-27605)**

**Figure F8-3. Gamma Survey for Lateral 44-15-03 on Logarithmic Scale May 2005
(RPP-RPT-27605)**

APPENDIX G8

TANK SX-115 CESIUM-137 CONCENTRATION PROFILES IN DRYWELLS (1966)

**Figure G8-1. Cesium-137 Concentration Profile in Drywells 48B and 48C
(modified from BNWL-CC-701) (RPP-ENV-39658)**

**Figure G8-2. Cesium-137 Concentration Profile in Drywells 45B and 17A
(modified from BNWL-CC-701) (RPP-ENV-39658)**

APPENDIX H8

TANK SX-115 REDOX WEEKLY PROCESS REPORTS

H8.1 REDOX Weekly Readings for 1965

Liquid levels from January 13, 1965 to May 19, 1965 are shown in Table H8-1. Tank SX-115 REDOX weekly reports from February 21, 1965 to March 20, 1965 are shown in Figure H8-1 to Figure H8-4. Liquid level readings were assumed to be recorded on Wednesdays as indicated in later REDOX weekly reports for SX Farm. These weekly reports were the earliest available liquid level data and were used in the analysis in Section 11.4.1.

**Table H8-1. Tank SX-115 Liquid Level (LL)
January 13, 1965 to May 19, 1965
(RL-SEP-297)**

Date	SX115
	LL (in)
1/13/1965	48.5
1/20/1965	48.5
1/27/1965	48.5
2/3/1965	48.5
2/10/1965	48.5
2/16/1965	48
2/17/1965	48.5
2/24/1965	48
3/2/1965	31.75
3/8/1965	30
3/17/1965	8.625
3/24/1965	8.5
3/31/1965	8
4/7/1965	7.75
4/14/1965	7.5
4/21/1965	7.5
4/28/1965	7
5/5/1965	6.75
5/12/1965	6.75
5/19/1965	7

Figure H8-1. REDOX Weekly Report 2-21-65 to 2-27-65
(RL-SEP-297)

Liquid levels stable at ~48-in
through Feb. 24, 1965

Following are the waste storage tank data for the period 2-21-65 - 2-27-65.

	<u>105-SX</u>	<u>107-SX</u>	<u>108-SX</u>	<u>109-SX</u>	<u>110-SX</u>	<u>111-SX</u>	<u>112-SX</u>	<u>113-SX</u>	<u>114-SX**</u>	<u>115-SX</u>
Liquid Level	23'1"	15'5"	19'8-3/4"	21'1"	20'6-3/4"	12'3 1/2"	20'5 1/2"	0'7 1/2"	18'1"	4'0"
Bulb 1" Sludge Temp. F.	125	292	299	270	194	252	208	100	295	171
Scanner 1" Sludge Temp. F.	--	294	306	272	257	257	208	105	248	188
2-Ft. Supernatant Temp. F.	--	237	238	5'-218 2'-242	194	215	200	0	244	171
Supernatant Temp. Gradient* F	--	2	4	2	0	3	3	0	6	0
No. of Circulators Operating	--	1,2,&3	1,2,3,&4	1,3,&4	1&3	1&3	1,2,3,&4	--	1,2,3,&4	--
Specific Gravity	--	1.52	1.573	1.63	1.517	1.36	1.61	--	1.60	--
Apparent Sludge Depth	--	0'8"	0'11"	2'10"	2'0"	1'10 1/2"	3'2"	0'3 1/2"	1'2"	0'4 1/2"

* These are the temperature differences between the two-foot (5-foot for 109-SX) level and the highest liquid level in the tank.

** 114-SX is the current salt waste receiver tank.

113-SX liquid level rose from a static 0' 6 1/2" and 86-90°F temperature to an 0' 7 1/2" liquid level and a 100°F temperature. This rise in liquid level is believed to have been caused by a leaking valve in the condensate return line letting condensate leak into 113-SX.

113-SX has an apparent sludge depth of 0' 3 1/2".

108-SX soil sample at 18' depth read 5,000 c/m mostly ruthenium on scan analysis. FEO made a special shielded GM probe to monitor activity under the 108-SX tank. A maximum reading of 36 R was found in the S 77° 15' lateral just under the edge of 108-SX tank. The tank bottom 107-SX and 108-SX tested stable.

Well #29 @55' off scale on well probe; 24,000 c/m on caisson probe.

Well #30 @52' 120,000 c/m on well probe.

Well #33 @57' 885,000 c/m on well probe.

Well #38 @54' 130,000 c/m on well probe.

**Figure H8-2. REDOX Weekly Report 2-28-65 to 3-6-65
(RL-SEP-297)**

Following are the waste storage tank data for the period 2-28-65 - 3-6-65.

	<u>105-SX</u>	<u>107-SX</u>	<u>108-SX</u>	<u>109-SX</u>	<u>110-SX</u>	<u>111-SX</u>	<u>112-SX</u>	<u>113-SX</u>	<u>114-SX**</u>	<u>115-SX</u>
Liquid Level	23'½"	15'5"	19'9½"	21'5½"	20'6½"	11'9½"	20'4½"	0'7-3/4"	17'4½"	2'7-3/4"
Bulb 1" Sludge Temp. F	121	294	302	272	189	253	202	95	311	173
Scanner 1" Sludge Temp. F	--	290	308	271	255	252	202	101	290	182
2-Ft. Supernatant Temp. F	--	234	235	5'-215 2'-259	194	213	192	0	243	165
Supernatant Temp. Gradient F*	--	3	4	1	1	2	6	0	4	0
No. of Circulators Operating	--	1,2,&3	1,2,3,&4	1,3,&4	1&3	1&3	1,2,3,&4	--	1,2,3,&4	--
Specific Gravity	--	1.52	1.576	1.62	1.491	1.41	1.62	--	1.63	--
Apparent Sludge Depth	--	0'8½"	0'11"	3'0"	2'0"	1'10½"	3'2"	0'3½"	1'2"	0'4½"

* These are the temperature differences between the two-foot (5-foot for 109-SX) level and the highest liquid level in the tank.

**114-SX is the current salt waste receiver tank.

NOTE: 241-SX

On February 28, 1965, while flushing 107, 108, and 114-SX dip tubes simultaneously, a slight pressurization bump occurred which was severe enough to bring on the cooling water. The system quickly recovered to normal.

On March 2, 1965, the volume of the nearly empty 115-SX tank was recorded at 2' 7", three-fourth inches after remaining at a static level of about 4' ever since the first of the year. This reading was confirmed on the afternoon of March 5, 1965, by high radiation readings taken from under the 115-SX tank. Investigation revealed that since 115-SX was carried as an empty tank, it was not read routinely. The last reading before the leak was discovered was on February 16, 1965, when the recorded level was 4' 0". On March 2, 1965, the reported level was 2' 2-3/4". A large leak must have developed to allow this rapid a drop in liquid level.

Liquid level readings were last recorded Feb. 24, 1965 before the leak (see Figure H-1) not Feb. 16. as indicated above

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**Figure H8-3. REDOX Weekly Report 3-7-65 to 3-13-65
(RL-SEP-297)**

This reading was not included in the analysis as it conflicts with the statement below.

Following are the waste storage tank data for the period 3-7-65 - 3-13-65.

	105-SX	107-SX	108-SX	109-SX	110-SX	111-SX	112-SX	113-SX	114-SX**	115-SX
Liquid Level	24'6-3/4"	15'2 1/2"	19'10 1/2"	21'4 1/2"	20'6 1/2"	11'3 1/2"	20'4 1/2"	0'8 1/2"	17'10 1/2"	0'9"
Bulb 1" Sludge Temp. F	119	291	303	277	185	253	201	98	319	169
Scanner 1" Sludge Temp. F	--	290	310	274	255	256	209	105	275	182
2-Ft. Supernatant Temp. F	--	236	235	5'-216 2'-258	195	218	197	0	245	0
Supernatant Temp. Gradient F*	--	2	3	3	2	2	5	0	4	0
No. of Circulators Operating	--	1,2,&3	1,2,3,&4	1,3,&4	1&3	1&3	1,2,3,&4	--	1,2,3,&4	--
Specific Gravity	--	1.54	1.580	1.61	1.523	1.44	1.62	--	1.63	--
Apparent Sludge Depth	--	0'5"	1'0"	3'0"	2'0"	1'10 1/2"	3'0"	0'3 1/2"	1'6"	0'4"

* These are the temperature differences between the two-foot (5-foot for 109-SX) level and the highest liquid level in the tank.

** 114-SX is the current salt waste receiver tank.

NOTE: 241-SX Tank Farm

Tank solutions for suspected leaker tanks are being concentrated more than was formerly allowed in an effort to reduce the leakage and self-seal the tank.

A summary of 115-SX recent historical data appears below:

on 2-16-65 observed reading 4' 0 " = 117,349 gallons
on 3-02-65 next observed reading 2' 7-3/4"
on 3-08-65 next observed reading 2' 6 " = 67,751

Loss to ground from 115-SX tank leakage = 49,598 gallons

on 3-09-65, the 2' 6" observed reading contents were pumped from 115-SX to 105-SX leaving a recorded reading of 0' 8 1/2" heel in 115-SX or a 10,264 gallon heel. The total gallons pumped from 115-SX to 105-SX were 57,487 gallons.

The last date liquid levels were at 4-ft was on Feb. 24, 1965

**Figure H8-4. REDOX Weekly Report 3-14-65 to 3-20-65
(RL-SEP-297)**

Following are the waste storage tank data for the period 3-14-65 - 3-20-65.

	<u>105-SX</u>	<u>107-SX</u>	<u>108-SX</u>	<u>109-SX</u>	<u>110-SX</u>	<u>111-SX</u>	<u>112-SX</u>	<u>113-SX</u>	<u>114-SX**</u>	<u>115-SX</u>
Liquid Level	24'6-3/4"	15'5 1/2"	19'11-3/4"	21'3 1/2"	20'6 1/2"	10'11"	20'3-3/4"	0'8-5/8"	17'5 1/2"	0'8-5/8"
Bulb 1" Sludge Temp. F	124	295	304	274	182	253	199	098	319	160
Scanner 1" Sludge Temp. F	---	296	313	274	254	254	207	099	292	170
2-Ft. Supernatant Temp. F	---	235	235	5'=215 2'=254	194	216	189	0	244	0
Supernatant Temp. Gradient F*	---	2	3	1	2	3	9	0	5	0
No. of Circulators Operating	---	1,2,&3	1,2,3,&4	1,3,&4	1&3	1&3	1,2,3,&4	---	1,2,3,&4	---
Specific Gravity	---	1.55	1.576	1.61	1.513	1.46	1.62	---	1.63	---
Apparent Sludge Depth	---	0'6 1/2"	0'11"	3'0"	2'2"	1'9"	2'6"	0'3"	1'8 1/2"	0'4"

* These are the temperature differences between the two-foot (5-foot for 109-SX) level and the highest liquid level in the tank.

** 114-SX is the current salt waste receiver tank.

NOTE: 241-SX

A higher concentration of suspected leaker tanks continues in an effort to help seal the leaks. Pumped part of 103-SX to 101-TX; then while transferring 103-SX to ~~101-SX~~, the flush riser valve failed on 3-19-65. While pumping 103-SX to ~~101-SX~~, a leak was discovered outside the pump pit. Tried to replace the valve but found it so "hot" maintenance couldn't get to it, so a new line was installed from 102-SX pump pit into 103-SX pump pit. To pump into or out of 103-SX pump pit, the 102-SX routing must be used. Analysis of 110-SX freezing point curve was requested as 110-SX is scheduled to be pumped to 103-SX shortly.

108-SX - Contamination readings are static, no new report.

115-SX - No seam has been completed as yet under 115-SX.

Liquid levels gradually decreased to ~7-in by May 1965 and remained steady through August 1965

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12.0 CONCLUSIONS

Five conditions may have contributed to SX Farm tank liner failure including: tank design, thermal shock, chemistry-corrosion, liner behavior (bulging), and construction temperature. Tank design did not apparently change from tank to tank for the SX Farm tanks; however, there could be many unknown variables present in the quality of materials and quality of construction. Several significant SX Farm tank design changes occurred from previous successful tank farm designs including fillet welded orthogonal bottom-sidewall joint and waterproof membrane changes. Tank liner construction occurred in winter under cold weather conditions below the ductile-to-brittle transition temperature which may have resulted in latent damage in some steel liners from the impact of falling objects. The remaining three conditions varied from tank to tank and are discussed below (see Table 12-1 and Table 12-2).

The SX Farm tanks received high temperature boiling waste from REDOX which challenged the tank design with rapid heat up and high temperatures. The tanks should have been pre-heated to avoid rate of rise thermal shock and the possibility of releasing moisture from the grout under the bottom liner as well as the possibility of vaporizing some of the organic asphalt under the grout. The resulting buildup of trapped pressure caused by the orthogonal sidewall to bottom steel liner joint results in the possibility of a bulged bottom liner. Only tank SX-115 was reported to have been pre-heated but the resulting rate of temperature rise was more than 2.5 times the recommended rate and formed a measured 3-in bulge. However, there could have been larger bulges in tank SX-115 that were not measured. Bulging along with other factors such as SCC caused by nitrate leaching could have resulted in tank SX-115 leaking as well as other SX Farm tanks.

Supernatant removal with subsequent nitrate leaching was conducted in all but three of the eight leaking tanks and all of the nitrate leached tanks leaked. Nitrate leaching lowered nitrite and hydroxide concentrations which would increase the propensity for corrosion especially at the relatively high temperatures that were experienced. The effects of SCC increased with higher temperatures. One of the three tanks (tank SX-113) only stored nitrate leachate waste; however, the effect on nitrite and hydroxide concentrations was the same, as the supernatant had been removed. Tank SX-113 only stored nitrate leachate waste one month before leaking. Tanks SX-111 and SX-114 leaks were detected 10 and 11 years, respectively, from the start of nitrate leaching. This seems like an inordinately long period when compared to other leaking SX Farm tanks that were nitrate leached which indicates other unknown factors may influence the amount of time it takes for the leak to be detected.

A bulged tank bottom was present or possible in all of the eight leaking SX Farm tanks. A bulge of the tank bottom imparts stresses in the liner that could have predisposed it to SCC and/or pitting. A bulge of 4-ft developed when tank SX-113 was filled causing a temperature rate of rise at more than 4.5 times the recommended rate. Tank SX-113 could have experienced a weakened sidewall and bottom liner to such an extent that the liner failed. In addition, the added effect of storing nitrate leachate waste on an already stressed tank liner could have contributed to liner failure. The two SX Farm leaking tanks that were not nitrate leached or contained nitrate leached waste (tank SX-109 and SX-112) were reported to have bulged and they both sustained a temperature rate of rise more than 2.5 times the recommended rate. The bulging along with the

rate of temperature rise could have resulted in liner failure. Only one of the sound tanks (tank SX-105) stored nitrate leachate waste (see Table 12-2). The nitrate leachate waste was stored at the relatively low temperature of ~115°F, and tank SX-105 was not inspected for a bulge. Storage of the leachate waste in tank SX-105 should not have increased the propensity for SCC and/or pitting.

There may be a combination threshold relationship for leaking versus sound SX Farm tanks between the rate of rise in temperature and the maximum temperature. All eight of the leaking SX Farm tanks had relatively high rate of temperature rise; however, there were three of the five sound tanks that had similar rates of temperature rise but overall lower maximum temperatures.

Bumping (pressurization) was experienced in several of the leaking and one of the sound tanks. There doesn't seem to be a direct relationship with leaking tanks. In the most severe bumping incident with tank SX-114, the pressurization could have affected the piping seals into or out of the tank; however, it remains inconclusive. Therefore, bumping which is an effect of thermal conditions has not been considered in the overall factors that cause tank liner failure.

It is possible that no one characteristic of the SX Farm tanks could in isolation from the others have resulted in failure. However, the application of so many stressors – heat up rate, high temperature, loss of corrosion protection, and tank design – working jointly or serially on these eight tanks, resulted in their failure. Thermal shock coupled with the tank design, construction conditions, and chemistry-corrosion seems to be the overriding factors that can lead to tank liner failure. The distinction between leaking and sound SX Farm tanks seems to center on the waste types, thermal conditions, and nitrate leaching.

Table 12-1. SX Farm Leakers Leak Location and Causes

Leaking Tank	Initial Waste Details				Leak Status		Nitrate Leaching				Evidence of a Bulging Liner		Thermal Conditions				
	First Filled	First Boiling	Waste Type	Tank Pre-heated	Leak Detected	Indication of leak	Nitrate Leached	Months Leachate stored	Addition of waste after nitrate leached	Duration from start of leaching until leak detected	Bulge Present	Failed ALCs	Rate of Rise	Max Temp	Temp Duration	Bumping	Maximum pressurization
SX-107	4/13/1956	Jun-56	R, CW	No	Mar-64	Lateral	yes- Dec. 1962	~ 1 mo at 200-245°F	~ 1 week	~ 14 mo	Yes	Yes- #2 & #3	5.8°F/ day April 13 to May 2, 1956	390°F Feb. 1958	7 months > 300°F	Yes- Jan. and Feb. 1957	0.2 to 0.6 psig
SX-108	11/8/1955	Jan-56	R	No	Dec-62	Laterals	yes- May 1962	~ 3 mo at 180-260°F	~ 1 mo	~ 7 mo	Yes- Rodding 2.5-ft	Yes- #2	4.6°F/ day Nov. 8 to Dec. 1, 1955	320°F Sept. 1958	11 months > 300°F	Yes- Jan. and Feb. 1957	0.6 psig
SX-109	9/20/1955	12/12/1955	R	No	Jan-65	Laterals/ drywells	no	NA	NA	NA	Yes	Cannot be determined	5.7°F/ day Sept. 20 to Oct. 13, 1955	290°F Sept. 1962	22 months > 280°F	No	NA
SX-111	6/9/1956	Nov-56	R, RIX	No	Apr-74	Laterals	yes- Mar. 1964	~ 3 mo at 185-240°F	~ 6 mo	~ 10 yrs	Yes	Yes- #1 & #3	5.7°F/ day June 9 to June 27, 1956	320°F Jan. 1968	27 months > 300°F	No	NA
SX-112	2/13/1956	Mar-56	R	No	Jan-69	Laterals/LL decrease	no	NA	NA	NA	Yes	Yes- #3 & #4	5.8°F/ day Feb. 13 to Feb. 29, 1956	316°F Mar. 1962	1 month > 300°F	No	NA
SX-113	2/20/1958	4/20/1958	R	No	Nov-62	Lateral/LL decrease	no- but held leachate	~ 1 mo at 105-117°F	no waste added after leachate transferred	Leaked during leak test with leachate	Yes- Rodding 4-ft, applied vacuum before receiving waste	Yes - #2 & #3	9.7°F/ day Feb. 20 to Mar. 12, 1958	254°F July 1958	1 month > 250°F	No	NA
SX-114	11/5/1956	Jun-59	R, RIX	No	Aug-72	drywell	yes- Sept. 1961	~ 20 mo at ~175°F	~ 11 mo	~ 11 yrs	Possible	Yes- #4	4.7°F/ day Nov. 5 to 14, 1956; 9.8°F/ day Aug. 13 to 22, 1958	357°F Aug. 1958	41 months > 300°F	Yes- Aug. 1958	2.1 psig
SX-115	9/1/1958	Oct-58	R	Yes	Feb-Mar 65	LL decrease	yes- June 1964	~ 3 mo at 170-220°F	Leaked ~ 5 mo later, no waste added	~8 mo	Yes- Rodding 3-in	Yes- #2 & #4	5.2°F/ day Aug. 31 to Sept. 17, 1958	266°F Sept. 1960	3 months > 260°F	No	NA

Construction of SX Farm: June 1953 to May 1954
* Referenced from RHO-R-39
B: B Plant HLW
BL: B Plant Low Level
BNW: Battelle Northwest Laboratory Waste
CPLX: Complexant Concentrate
CW: Cladding Waste

DSSF: Dilute Double-Shell Slurry Feed
DW: Decontamination Waste
EB: Evaporator Bottoms
Evap: Evaporator Feed (post 1976)
IX: Ion Exchange Waste
LW: Laboratory Waste

N: N-Reactor Waste
OWW: Organic Wash Waste from PUREX
PNF: Partial Neutralization Feed
PSS: PUREX Sludge Supernatant
R: REDOX High Level Waste
Resid: Residual Evaporator Liquor

RIX: REDOX Ion Exchange
TBP: Tri-Butyl Phosphate-waste
TL: Terminal Liquor
Water: Flush water from miscellaneous sources
224: Lanthanum Fluoride Finishing Waste

Table 12-2. SX Farm Sound Tank Leak Location and Causes

Sound Tanks	Initial Waste Details				Leak Status		Nitrate Leaching				Evidence of a Bulging Liner		Thermal Conditions				
	First Filled	First Boiling	Waste Type	Tank Pre-heated	Leak Detected	Indication of leak	Nitrate Leached	Months Leachate stored	Addition of waste after nitrate leached	Duration from start of leaching until leak detected	Bulge Present	Failed ALCs	Rate of Rise	Max Temp	Temp Duration	Bumping	Maximum pressurization
SX-101	5/20/1954	1/13/55	R, EB, RIX, TL, PNF, CPLX, Resid	No	-	-	-	-	-	-	Tank not inspected for a bulge*	NA	1.3°F/ day	417°F	22 months >300°F	Yes- Feb. 1955	1.5 psig March 1, 1955
SX-102	9/9/1954	-	R, EB, RIX, PNF, Resid., DSSF	No	-	-	-	-	-	-	Tank not inspected for a bulge*	NA	5.2°F/ day	212°F	0 months >250°F	No	NA
SX-103	11/21/1954	-	R, CW, OWW, PNF, EB, Resid., DSSF	No	-	-	-	-	-	-	Tank not inspected for a bulge*	NA	7.2°F/ day	225°F	0 months >250°F	No	NA
SX-104	2/28/1955	7/21/55	R, EB, RIX, PNF, Resid., DSSF	No	-	-	-	-	-	-	Tank not inspected for a bulge*	NA	4.6°F/ day	300°F	13 months >300°F	Yes	Less than 1.5 psig
SX-105	6/2/1955	-	R, EB, RIX, PNF, Resid., DSSF	No	-	-	-	~ 48 mo at ~115°F	-	-	Tank not inspected for a bulge*	NA	3°F/ day	200°F	2 months >200°F	No	NA
SX-106	10/4/1954	-	R, EB, RIX, CPLX, BL, PNF, CW, IX, Resid., Evap., PL, B, Water, OWW, N, BNW, LW, TBP, DW, PSS	No	-	-	-	-	-	-	Tank not inspected for a bulge*	NA	2.7°F/ day	195°F	0 months >250°F	No	NA
SX-110	12/9/1960	4/19/1962	R, RIX, EB, IX, BL, 224, BNW	Yes	-	-	-	-	-	-	Tank not inspected for a bulge*	Yes- #1, #3, #4	1.2°F/ day	310°F	5 months >300°F	No	NA

Construction of SX Farm: June 1953 to May 1954
* Referenced from RHO-R-39
B: B Plant HLW
BL: B Plant Low Level
BNW: Battelle Northwest Laboratory Waste
CPLX: Complexant Concentrate
CW: Cladding Waste

DSSF: Dilute Double-Shell Slurry Feed
DW: Decontamination Waste
EB: Evaporator Bottoms
Evap: Evaporator Feed (post 1976)
IX: Ion Exchange Waste
LW: Laboratory Waste

N: N-Reactor Waste
OWW: Organic Wash Waste from PUREX
PNF: Partial Neutralization Feed
PSS: PUREX Sludge Supernatant
R: REDOX High Level Waste
Resid: Residual Evaporator Liquor

RIX: REDOX Ion Exchange
TBP: Tri-Butyl Phosphate-waste
TL: Terminal Liquor
Water: Flush water from miscellaneous sources
224: Lanthanum Fluoride Finishing Waste

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APPENDIX A

MEETING MINUTES

January 11, 2011

February 1, 2011

March 1, 2011

March 16, 2011

April 5, 2011

April 19, 2011

May 3, 2011

May 31, 2011

June 14, 2011

July 12, 2011

MEETING SUMMARY

From: J. G. Field
Phone: 376-3753
Location: Ecology Office,
Date: January 11, 2011
Subject: Tank Farm Leak Evaluation

To: Distribution/Attendees

Attendees: Jeff Lyon, ECOLOGY
Mike Barnes, ECOLOGY
Michelle Hendrickson, ECOLOGY
Bob Lober, ORP/DOE
Dennis Washenfelter, WRPS
Ted Venetz, WRPS
Don Harlow, WRPS
Les Fort, WRPS
Paul Henwood, S.M. Stoller
Marcus, Wood, CHPRC

PURPOSE:

To discuss expanding the tank leak assessment process to include tank integrity assessments as defined in the newly approved TPA Change # M-45-10-01.

Review of Previous Meeting Summaries:

The meeting summary for December 14, 2010 was reviewed and approved.

Enhanced Tank Leak and Integrity Assessment Process

Dennis Washenfelter presented for discussion the TPA M-45-91F-T04 proposed work organization and workflow. The identified target milestone objectives are to:

- Identify leak locations and leak causes for the 100-Series SSTs identified as leaking by the Tank Farm Leak Evaluation Group (as described in RPP-32681, *Process to Assess Tank Farm Leaks in Support of Retrieval and Closure Planning*, July 2007).
- Determine leak rate for tanks A-105 and U-104
- Determine need to update/revise existing RPP-32681 Tank Farm Leak Assessment reports with the leak information.
- Report results as Leak Locations and Leak Causes as a TPA secondary document.

Jeff Lyon stated that the change request was approved and Bob Lober agreed to provide copies of the approved change request to Jim Field and Dennis Washenfelter.

Ted Venetz distributed a diagram of the SSTIP Leak Integrity Milestones. After much discussion, it was concluded that a change request needs to be prepared and submitted to

sequence the milestones to improve the workscope logic and timing of deliverables. It was agreed that Michelle Hendrickson would draft such a change request for approval.

Don Harlow provided for discussion and review by the group a proposed outline for the individual tank leak location and causes assessment. The intent is to build the final document a “tank” chapter at a time to enable easy configuration of the final report. Don Harlow requested that the group review the draft proposed outline and provide comments. Michelle Hendrickson requested that a design and construction – physical description section may need to be added as appropriate.

The group agreed to follow the existing evaluation process as described in RPP-32681, essentially:

- The standing work group will continue with designated members from Ecology, ORP, and WRPS.
- The group will provide technical input for leak analysis, review of the analysis, and accepts final results.
- WRPS will prepare leak analysis for the group discussion.
- Meeting minutes will be used for documentation.

There was some discussion on how the work process will be performed and the approach taken to accomplish the intent in accordance with the established TPA milestones. It was agreed to add a new section (Section 8) to RPP-32681 to incorporate the work element to evaluate tank liner failure causes. It was agreed that RPP-32681, Rev. 0 will be revised to reflect this change in the next month.

It was suggested to begin with the leak assessments that have generally accepted causes and common operating history to perfect analysis techniques. It was proposed to start with evaluating tanks 241-SX-107 – 109 and 241-SX-111-115.

The proposed format for the Tank Leak Assessment meetings is to go to a two hour block of time to discuss the tank farm leak assessments for half of the meeting and specific tank leak locations and causes the other half of the meeting.

ACTIONS:

1. All: Review meeting summary.
2. J. Field/L. Fort: Prepare and distribute January 11, 2011 Meeting Summary
3. M. Wood: Ready to present the U farm groundwater information for discussion during the next meeting.
4. L. Fort: Evaluate the possibility and identify the process by which consolidation of the leak assessment findings will be documented.
5. B. Lober: Provide a signed copy of the TPA Change # M-45-10-1 to Dennis Washenfelter and Jim Field.
6. M. Hendrickson: Prepare the TPA Change Request to modify due dates of M-45-91F milestones.
7. Jim Field: Revise document RPP-32681, Rev. 0, to reflect the addition of the tank leak location and cause workscope.

8. All: Review the proposed individual tank leak location and causes outline.
9. D. Washenfelder: Prepare to discuss leak location and cause assessment for at least one SX Farm tank and distribute draft information prior to the next meeting.

NEXT MEETING:

Discuss groundwater information for WMA U and discuss the expanded leak investigation (assessing leak location and causes) for tank 241-SX-107 and possibly a second SX-Farm tank.

Date: February 1, 2011
Time: 9:00-11:00
Location: ECOLOGY Office

MEETING SUMMARY

From: J. G. Field
Phone: 376-3753
Location: Ecology Office,
Date: February 1, 2011
Subject: Tank Farm Leak Inventory and Tank Integrity Assessments

To: Distribution/Attendees

Attendees:

Mike Barnes, ECOLOGY
Joe Caggiano; ECOLOGY
Jim Field; WRPS
Jordan Follett; WRPS
Les Fort, WRPS
Crystal Girardot; WRPS

Don Harlow, WRPS
Michelle Hendrickson, ECOLOGY
Paul Henwood, S.M. Stoller
Ted Venetz, WRPS
Dennis Washenfelter, WRPS
Marcus, Wood, CHPRC

PURPOSE:

Discuss groundwater observations near U Farm (Part 1) and begin tank integrity waste leak location and cause assessments relative to tank 241-SX-107 (Part 2). Discussions as to Part 1 of the meeting will be included in the U farm leak assessment report. Discussions as to Part 2 of the meeting will be included in a roll up report of leak locations and causes in support of TPA-M-45-91F.

Review of Previous Meeting Summaries and Actions:

The meeting summary for January 11, 2011 was reviewed and approved.

- The BY and BX Tank Farm leak assessment reports were released and will be distributed to assessment team members. ORP will then send the reports to tribes and stakeholders. The reports will be revised as needed to incorporate comments.
- A draft S Tank Farm leak assessment report draft will be distributed later this week for review by the assessment team.
- A question was raised as to whether the rate of leaks for tanks A-105 and U-104 should be reviewed. It was noted that it may be difficult to determine the rate of any tank leak. It was recognized that quantifying tank leak rates would provide some technical insight into environmental risks (i.e., how much waste could leak) from tanks that have leaked in the past.
- A signed copy of the TPA Change # M-45-10-1 was provided to Dennis Washenfelter. Michelle Hendrickson reported that a revision to the TPA Change Request to modify due dates of M-45-91F milestones is in progress.
- A draft revision of RPP-32681 was prepared to reflect the addition of the tank leak location and cause workscope. The revision was accepted with no comments.

Part 1: U Farm Ground Water

Marc Wood led a discussion on groundwater characteristics and understanding in and near Waste Manage Area U (WMA U). Information presented was from the WMA U Field Investigation Report (FIR) (RPP-35485) and Annual Groundwater Monitoring Reports. This information will be included in the U Farm leak assessment report.

Key observations included:

- Samples from groundwater monitoring wells east of WMA U show high levels of ^{99}Tc and nitrate (NO_3).
- At least some of the ^{99}Tc and NO_3 appears to be related to leaks from tanks U-104 and or U-110.
- Normally ground water flows from West to East below WMA-U. Based on groundwater data, discharges of 500 million gal of waste to the 216-U-114 ditch apparently manifested first in 1991 causing the groundwater to flow from the East to West and to the North from 1991 through 1996. It also resulted in perched water zones above the Cold Creek formation.
- Gross beta (^{99}Tc) and NO_3 were detected in monitoring wells in the early 1980's and concentrations are continuing to increase in some wells.
- Although drywells show high concentrations of Uranium in the vadose zone due to U-104 and U-110 leaks, no uranium has been detected in the groundwater to date below WMA-U.
- A low permeability layer, the Cold Creek formation, about 100 ft below WMA-U apparently sorbed and slowed uranium migration compared to uranium migration in WMA BX which has reached groundwater.

Part 2. Tank Leak Location and Cause – Tank SX-107

Dennis Washenfelter led a discussion on leak location and possible waste leak causes around tank 241-SX-107 and a general discussion on the cause of leaks in SX farm and criteria to consider. Information presented will be included in a roll up report of leak locations and causes. A summary of information presented and discussed is included in Attachment A. Nitrate leaching was apparently a key factor in the SX farm tank leaks. It was noted that every tank that was nitrate leached during operations liner failed. Several other causes were discussed including: tank design, thermal shock, bulging and construction and cold weather impacts.

Three additional causes were discussed:

- The effect of operations (i.e., impact of sequence of waste operations)
- Common ion effect on tank liner integrity (i.e., possible suppression of nitrate leaching by high Na^+ in tank waste)
- Thermal destruction of the liners (e.g., high rate of temperature increase, high temperature waste storage)

It was recommended that the construction detail of the SX wall footing/joint be expanded to show the water stop and that an elaboration be made on caustic additions to the tank for pH/corrosion control.

A preliminary matrix of tank leak causes was presented. The matrix will be revisited for each tank assessed, a column will be added for operations as a separate cause and a subheading for each major cause will be further defined and added to the matrix. For example “design” may include several different construction design features, some of which contributed more to tank leaks than others. This matrix will be included in the common factors report (M-45-91F-T02). Ecology noted that the matrix would be strengthened by including information for not only the 23 tanks designated as leakers, but also characteristics of “sound” tanks.

Two key purposes were discussed for the leak location and cause assessments recommended by the expert panel. 1. To identify what we can fix to limit leaks in the future and 2. To help assess the need to move at-risk tanks forward in the tank retrieval sequence.

ACTIONS:

10. All: Review meeting summary for discussion in the next meeting.
11. J. Field/ D. Washenfelter: Prepare and distribute January 11, 2011 Meeting Summary
12. L. Fort: Prepare to present TX farm tank information for discussion during the next meeting.
13. M. Hendrickson: Prepare the TPA Change Request to modify due dates of M-45-91F milestones.
14. Jim Field: Release RPP-32681, Rev. 1, reflecting the addition of the tank leak location and cause workscope.
15. All: Review SX-107 information presented and provide feedback in the next meeting.
16. D. Washenfelter/ D. Harlow: Prepare to discuss leak location and cause assessment for tank SX 108 and distribute draft information prior to the next meeting.
17. D. Harlow: Add “operations” section to SX-107 and subsequent reports that considers possible impacts such as pH control, common ion effect, dynamics of tank filling and emptying, and control and uniformity of heating and temperature.

NEXT MEETING:

Part 1. Discuss TX-Farm tanks leaks. Part 2. Review tank SX-107 leak location and causes, and discuss leak location and causes for tank 241-SX-108.

Date: February 17, 2011 (Postponed to March 1, 2011)
Time: 9:00-11:00
Location: ECOLOGY Office

MEETING SUMMARY

From: J. G. Field *J. G. Field*
Phone: 376-3753
Location: Ecology Office,
Date: March 1, 2011
Subject: Tank Farm Leak Inventory and Tank Integrity Assessments

To: Distribution/Attendees

Attendees:

Mike Barnes, ECOLOGY	Michelle Hendrickson, ECOLOGY
Joe Caggiano; ECOLOGY	Paul Henwood, S.M. Stoller
Jim Field; WRPS	Bob Lober, ORP
Jordan Follett; WRPS	Pam McCann, ORP
Les Fort, WRPS	Ted Venetz, WRPS
Crystal Girardot; WRPS	Dennis Washenfelter, WRPS
Don Harlow, WRPS	Marcus, Wood, CHPRC

PURPOSE:

The purpose of this meeting was to:

- 1) Discuss a communication strategy on how the leak assessment reports and revisions will be relayed to the tribes and stakeholders, specifically revisions and response to alternate C Farm leak inventory estimates;
- 2) Discuss the approach undertaken to assess C farm sound tanks and unplanned release estimates (Part 1);
- 3) Begin tank integrity waste leak location and cause assessments relative to tank 241-SX-108 (Part 2).

Review of Previous Meeting Summaries and Actions:

The meeting summary for February 1, 2011 was reviewed and approved.

- this week A disk containing the draft S Farm leak assessment report was given to Ecology for review.
- Michelle Hendrickson reported that the TPA Change Request to modify due dates of M-45-91F milestones status remains as "in progress."
- The final draft page from the pending revision of document RPP-32681 incorporating additional details to reflect tank leak location and cause workscope was distributed for final sanction. The revision will be released this week.

Part 1: Tank Farm Leak Inventory Assessments

C Farm Leak Loss Communications

Participants discussed the current strategy and stake holder involvement as described in RPP-23681. ORP communications is preparing a fact sheet describing the current tank farm leak assessment process. The focus of the discussion was on approaches to discuss the process with

tribes and stakeholders. The timing to revisit C Farm was discussed relative to ongoing characterization efforts and the new information that lends itself to an update, of C farm inventory estimates. Participants agreed that it would be beneficial to discuss plans and approach to further assess C farm now, but estimates of releases in some locations (e.g. C-104 and C-101) should be deferred until the current slant push data underneath these tanks is available. An action was taken to look into when the C-104 and C-101 data will be available and if the data can be delivered and released in a timely manner to support assessments and a revised C Farm leak assessment report. Ecology also noted that issues with ^{99}Tc and ^{106}Ru laboratory interferences and implications to current soil analyses will need to be addressed. It was also noted that UPR-82 and UPR-86 release estimates should be reassessed based on direct push results to date.

C Farm Inventory Approach

An approach was presented, similar to the Nez Perce approach, fully considering the drywell data and visualizations in the Addendum to the C Tank Farm Report (GJO-98-39-TARA), but also considering different waste type compositions consistent with the data. One of the criticisms of the initial assessment and estimates in RPP-ENV-33418 was that they do not account for ^{60}Co releases. The current approach attempts to better quantify and account for these unplanned releases.

GJO-98-39-TARA estimated the total volume of contaminated soils and total activity based on spectral gamma and high rate logging drywell data for ^{137}Cs , ^{60}Co , and ^{154}Eu . Although these estimates are numerical interpretations, they help to understand the magnitude of the waste releases. Knowledge of different gamma contaminants in the soil, an idea of the type of waste released, and consideration of the maximum release that could occur based on soil water content allows for the consideration of alternative conceptual models to estimate a volume and mass of waste that may have been released. An example was presented and discussed. The approach and example will be described in the revised C farm assessment report.

Participants agreed that the approach presented should be pursued. Limitations of the approach and potential modifications will be discussed in the next meeting. While the approach results in greater release estimates, the estimates still do not explain measured ^{99}Tc in ground water wells; this will continue to be an issue and source of public criticism. The C farm work plan was designed largely to look for the ^{99}Tc plume source. ORP noted that investigations are continuing in C farm and investigation strategies will be modified, as needed, as additional information is obtained. A participant suggested sampling soils near the bottom of ^{60}Co plume visualizations shown in the addendum report. It was noted that this may be useful, but would be inconsistent with the location of boreholes where the highest ^{99}Tc was observed in ground water samples.

Part 2. Tank Leak Location and Cause

Tank SX-107 and Tank SX-108

The preliminary assessment associated with tank 241-SX-108 that will become part of the leak locations and possible waste leak causes report was reviewed. It was identified that nitrate leaching waste processing was a factor in causing some of the SX farm tanks to leak. Several other contributing causes to tank liner waste containment failure were discussed including tank design, thermal shock, bulging and construction, cold weather impacts, and the effect of high

waste temperatures (e.g., high rate of temperature increase, high temperatures during storing of waste).

It was recommended that the report include lateral and drywell installation dates as a means to correlate available drywell and lateral data. It was also suggested to investigate the duration the tank sat stagnant after nitrate leaching operations were concluded and before tanks were filled; and include a possible leak cause table reflecting the relative importance of each leak cause. The draft matrix tabulation of tank leak causes was presented showing the conclusions resulting from the SX-107 and SX-108 evaluations. The matrix will be revisited as each tank is assessed; the matrix will be included in the final report.

Two comments were made to discuss possible future actions. 1) Reorder the tank list to investigate the leak location and causes for C-farm after SX-farm is completed. 2) Consider how the leak cause might correlate with the leak loss volumes in the Common Factors report. The 241-SX-109 report will be discussed in the next meeting.

ACTIONS:

Part 1

- 18. All: Review meeting summary for discussion in the next meeting.
- 19. J. Field/ D. Harlow: Prepare and distribute March 1, 2011 Meeting Summary
- 20. L. Fort: Prepare to present C Farm tank information for discussion during the next meeting.
- 21. Jim Field: Distribute RPP-32681, Rev. 1 changes to Ecology for review.

Part 2

- 22. All: Review SX-108 information presented and provide feedback in the next meeting.
- 23. D. Washenfelder/ D. Harlow: Prepare to discuss leak location and cause assessment for tank SX 109 and distribute draft information prior to the next meeting.

NEXT MEETINGS:

Part 1. Revisit C Farm releases. Part 2. Review tank SX-107 and SX-108 leak location and causes, and discuss leak location and causes for tank 241-SX-109.

Date: March 9 (Part 1 only)
Time: 2:30-4:30
Location: ECOLOGY Office

Date: March 16 (Part 1 and Part 2)
Time: 2:00-4:00
Location: ECOLOGY Office

MEETING SUMMARY

From: J. G. Field *JG Field*
Phone: 376-3753
Location: Ecology Office,
Date: March 16, 2011
Subject: Tank Farm Leak Inventory and Tank Integrity Assessments

To: Distribution/Attendees

Attendees:

Mike Barnes, ECOLOGY
Joe Caggiano; ECOLOGY
Jim Field; WRPS
Les Fort, WRPS
Crystal Girardot; WRPS
Don Harlow, WRPS

Michelle Hendrickson, ECOLOGY
Paul Henwood, S.M. Stoller
Jeremy Johnson, ORP
Bob Lober, ORP
Ted Venetz, WRPS

PURPOSE:

The purpose of this meeting was to:

- 1) Continue discussing a new approach to assess C farm sound tanks and unplanned release estimates and assess releases near tanks 241-C-101 and 241-C-102 (Part 1);
- 2) Discuss tank leak location and cause of liner integrity issues at tank 241-SX-109 (Part 2).

Review Previous Meeting Summaries and Actions:

The meeting summary for March 1, 2011 was reviewed and approved.

Bob Lober discussed response to a Nez Perce letter regarding C farm contaminated soil inventory estimates and the leak loss process. Contents of the letter and initial responses were discussed on March 7, 2011 in a teleconference with the tribes. We will continue to provide leak loss assessment reports to the tribes for review and will brief the tribes quarterly on leak loss assessment results.

The 241-SX-107 final draft that will become part of the tank integrity report addressing leak locations and waste leak causes was distributed..

Part 1: Tank Farm Leak Inventory Assessments

C Farm Inventory Approach

Comments on the draft approach and write-up for C Farm were discussed. The following items will be included and discussed in the assessment report.

1. Waste process timelines for each of the tanks reviewed whether classified as sound or assumed leakers.
2. Clarify statements from Welty (SD-WM-TI-356) that drywells or tank liquid levels, "remained stable during the review period."
3. Further assess overfilled tanks and address conditions that may or may not have resulted in a release to the soil.

4. Ensure inventory reassessments address ^{60}Co plumes from SGLS data and visuals.
5. Discuss uncertainties in liquid level measurements presented and give examples as appropriate.
6. Be sure to decay radionuclide results presented to a common date.

Re-assessment of Tanks C-101 and C-102

Information was presented for tanks C-101 and C-102. This information will be incorporated in the revised C farm assessment. One suspect liquid level measurement suggests a change in the rate of decrease after the liquid level decreased below the spare inlet port in tank C-101.

However, if this level is incorrect, there may be no change in slope. This would indicate that all of the liquid level decrease observed in the 1960s could be attributed to evaporation. Although other sources indicate that evaporation does not account for liquid losses in C Farm, these sources assume that the tank condensate condenser equipment was operating efficiently and condensate was routed back into the tank. There is evidence that condensate may have been released from the condenser pit to the surrounding tank area.

It was suggested that cladding waste may have been released through the cascade or spare inlet lines during the time that tank C-101 cascaded to tank C-102 in 1962. The tank was overfilled from 1965 to 1967 with waste from the CR vault. Based on the volume of the ^{60}Co plume and a 5% increase in moisture content, a leak volume of 7,000 gal was estimated. Based on the low gamma activity measured by SGLS in drywells, it was determined that the waste released was likely PUREX cladding waste and not P1 supernate (PSS),

An informal assessment of tank C-101 concluded that the tank probably did not leak, and if it did leak the release point would have been high on the tank wall (see November 2, 2010 meeting summary). A formal tank integrity assessment (TFC-ENG-CHEM-D-42) is planned after reviewing results of slant hole logging and sampling near tank C-101. Preliminary sample results are currently scheduled to be completed in July 2011.

Tank C-102 was then discussed. It was noted that the historical narrative and waste process time line for tank C-102 should include the waste transfer to tank C-102 from tank C-103 in the fourth quarter of 1962; this will be added. Although photographs indicate that tank C-102 was filled above the cascade line, there was no evidence that waste was released from the cascade line or spare inlets of this tank. The ^{60}Co plumes below tank C-102 were attributed to releases from tanks C-104 and/or C-105 to be discussed in the next meeting. There is no external evidence of waste releases from tank C-102.

Part 2. Tank Leak Location and Cause

Tank SX-109

The draft tank 241-SX-109 integrity assessment that will become part of the leak locations and waste leak causes report was reviewed. Tank design was identified as a factor in causing some of the SX farm tanks to leak and was most likely a primary cause with tank SX-109. Several other contributing causes to SX-109 tank liner waste containment failure were: thermal shock, bulging, and impacts resulting from construction during cold weather. Tank SX-109 thermal shock failure was likely due to a moderately high rate of temperature increase and to a lesser extent high temperatures during storage of waste. Waste in tank SX-109 did not undergo the

nitrate leaching process as did some of the SX Farm tanks; therefore nitrate leaching did not contribute to liner failure for this tank.

It was suggested to investigate the rate of temperature rise during the second filling of REDOX HLW supernatant in the tank (SX-109) as well as the lateral drywell readings taken in June 1966. It was also suggested to investigate tanks SX-108 and SX-109 as potential sources for activity in drywell 41-09-03 and tank SX-112 as a potential source for activity in drywell 41-00-08. Decay plots were discussed as a means to determine whether the measured activity is from a nearby source or migrated from a distant source.

To add perspective to the differences in SX Farm design, historical failure rates for fillet welds versus full penetration butt welds and failure results for bubble versus x-ray weld testing were discussed.

A draft matrix showing tank leak causes was presented summarizing results for tank SX-107, SX-108, and SX-109 evaluations. The matrix will be revisited as each tank is assessed. The matrix will be modified to explain the importance of individual causes. The matrix is expected to evolve as tank information becomes available.

A tracking matrix was presented as a means to status the progress of Tank Leak Cause and Location assessments and reports for TPA Target M-045-91F-T04.

The 241-SX-111 draft report will be discussed in the next meeting.

ACTIONS:

Part 1

- 24. All: Review meeting summary for discussion in the next meeting.
- 25. J. Field: Prepare and distribute March 16, 2011 Meeting Summary
- 26. L. Fort: Prepare to present C Farm information for discussion during the next meeting.

Part 2

- 27. All: Review SX-109 information presented and provide feedback in the next meeting.
- 28. C. Giardot/D. Harlow: Prepare March 16, 2011 Meeting Summary
- 29. D. Washenfelter/ D. Harlow: Prepare to discuss leak location and cause assessment for tank SX-111 and distribute draft information prior to the next meeting.

NEXT MEETINGS:

Part 1. Revisit C Farm releases. Part 2. Discuss leak location and causes for tank 241-SX-111.

Date: March 23 (Part 1 only)
Time: 2:00-4:00
Location: ECOLOGY Office

Date: April 5 (Part 1 and Part 2)
Time: 2:00-4:00
Location: ECOLOGY Office

MEETING SUMMARY

From: J. G. Field
Phone: 376-3753
Location: Ecology Office,
Date: April 5, 2011
Subject: Tank Farm Leak Inventory and Tank Integrity Assessments

To: Distribution/Attendees

Attendees:

Mike Barnes, ECOLOGY
Joe Caggiano; ECOLOGY
Jim Field; WRPS
Les Fort, WRPS
Crystal Girardot; WRPS
Paul Henwood, S.M. Stoller

Jeremy Johnson, ORP
Jeff Lyon, ECOLOGY
Beth Rochette, ECOLOGY
Dennis Washenfelter, WRPS
Marc Wood, CHPRC

PURPOSE:

The purpose of this meeting was to:

- 1) Assess tanks 241-C-106, C-107, and C-108 (Part 1);
- 2) Discuss tank leak location and cause of liner integrity issues at tank 241-SX-111 (Part 2).

Review Previous Meeting Summaries and Actions:

The meeting summaries for March 16 and March 23, 2011, were reviewed and approved (with comments) by the team. Ecology requested that the reassessment discussion on the C-200 series tanks be moved forward to the next meeting and that near surface releases (including unplanned releases) be reassessed and discussed during a future meeting. The tank integrity report sections for tanks 241-SX-108 and 109 were distributed and marked as final drafts.

Part 1. Tank Farm Leak Inventory Assessments

Tanks C-106 and C-107 Assessments

Information presented on tanks C-106 and C-107 during the meeting will be incorporated in the revised C farm assessment report. Liquid level measurements show that both tanks were filled above the cascade line and spare inlet ports. Liquid level decreases in tank C-106 were attributed to the high heat waste content and evaporation of cooling water. Retrieval assessments (RHO-RE-EV-97) showed the need to continue adding cooling water to tank C-106, but determined that additional water was not needed for tank C-105. Water additions provide a potential driving force for contaminants if the water is released to the soil. There were no occurrence reports for liquid level decreases for tank C-107. Drywell SGLS readings around tanks C-106 and C-107 indicate less than 100 pCi/g of near surface ¹³⁷Cs. Drywells near tank C-106 show deep ⁶⁰Co activity attributed to releases from or near tank C-108. There was no indication of leaks from cascade lines, spare inlet ports, or from the liner for these tanks; nor a basis to quantify the measured low activity attributed to surface releases.

Tank C-108 Assessment

Information presented for tank C-108 will also be incorporated in the revised C farm assessment report. Temperature data were presented from 1989 to the present. Earlier data will be included in the assessment report or a statement that earlier data were not available. Liquid level measurements indicate that tank C-108 was filled well above the cascade line (to 568 kgal) with CW-HS waste in 1965. A liquid level decrease (0.5 inches) in 1976 was attributed to a shift in the surface solids. Other liquid level decreases may have been masked during cascade overflows and transfers. At drywell 30-08-02, close to the cascade line connected to tank C-109, a narrow ^{137}Cs and ^{154}Eu spike was observed at about 20-22 ft bgs. Drywell 30-08-02 also shows ^{60}Co activity from 46 to 80 ft. Similar ^{60}Co activity was found in other nearby drywells. It was suggested that the narrow peak of ^{137}Cs and ^{154}Eu probably indicated residual waste in the cascade line. The activity may also be migration from a known surface leak near tank C-108. The apparent lateral migration indicated by pulsing readings, a vertical gap of 25-30 ft between the ^{137}Cs spike and ^{60}Co activity, and the observation that the spike is probably from pipeline residuals all indicate the ^{60}Co likely migrated from a different source than the observed $^{137}\text{Cs}/^{154}\text{Eu}$ spike measured in Drywell 30-08-02. Based on activity in surrounding drywells a release volume of 18,000 gallons was estimated. Given the ^{137}Cs activity in the drywells, it was postulated that hot semi works waste was released during the time that the tank was overfilled in 1965. Explanations and inventory calculations discussed will be included in the assessment report.

Part 2. Tank Leak Location and Cause

Tank SX-111

The draft tank 241-SX-111 integrity assessment was discussed and reviewed; the draft will become part of the report on tank waste leak locations and causes. Thermal shock was identified as a factor causing some of the SX farm tanks to leak and a primary cause of the leak in tank SX-111. It was postulated that another factor in the tank SX-111 waste leak was the moderately high temperatures during storage of waste and to a lesser extent the rate of temperature increase. Other causes of tank SX-111 liner failure discussed were: tank design, nitrate leaching, and impacts resulting from construction during cold weather. No evidence was found as to the existence of a liner bulge in tank SX-111; however, it is possible a temporary bulge may have existed at one time.

The rate the temperature initially rose when tank SX-111 was first filled with waste and potential stresses in the tank liner caused by the rapid temperature increases will be investigated further. A matrix table (designated as a draft) showing a summary of causes contributing to leaks for tanks SX-107, SX-108, SX-109, and SX-111 was presented. This matrix will be revisited as each tank is assessed. Summary information was added to the matrix for each of the causes listed for each tank. The matrix is expected to evolve as tank information becomes available. The 241-SX-112 draft report will be discussed in the next meeting.

ACTIONS:

- 30. All: Review summary for discussion in the next meeting.
- 31. J. Field/C. Girardot: Prepare and distribute April 5, 2011 Meeting Summary
- 32. L. Fort: Prepare C-200s information for discussion in the next meeting.

- 33. D. Washenfelter Investigate the initial rate of temperature rise and potential liner stresses during the first filling of tank SX-111
- 34. D. Harlow Prepare draft SX-112 leak location and cause assessment for the next meeting.

NEXT MEETING:

Part 1. Assess the C-200 series tanks for waste releases. Part 2. Review leak location and causes for tank SX-112.

Date: April 19
Time: 9:00-11:00
Location: ECOLOGY Office CR 3B

MEETING SUMMARY

From: J. G. Field
Phone: 376-3753
Location: Ecology Office,
Date: April 19, 2011
Subject: Tank Farm Leak Inventory and Tank Integrity Assessments

To: Distribution/Attendees

Attendees:

Mike Barnes, ECOLOGY
Joe Caggiano; ECOLOGY
Susan Eberlein, WRPS
Jim Field; WRPS
Jordan Follett, WRPS
Les Fort, WRPS
Crystal Girardot; WRPS

Don Harlow, WRPS
Michelle Hendrickson, ECOLOGY
Paul Henwood, S.M. Stoller
Jeremy Johnson, ORP
Bob Lober, ORP
Jeff Lyon, ECOLOGY
Dennis Washenfelter, WRPS
Marcus Wood, CHPRC

PURPOSE:

The purpose of this meeting was to:

- 1) Discuss response to Nez Perce letter regarding C-104/C-105 leak volume assessment estimates and discuss rationale for direct pushes near C-200 series tanks and recommended work plan revisions. (Part 1);
- 2) Discuss tank leak location and cause of liner integrity issues at tank 241-SX-112 (Part 2).

Review Previous Meeting Summaries and Actions:

The meeting summary for April 5, 2011, was reviewed and approved (with comments). Actions from the previous meeting were completed and Michelle Hendrickson noted that the TPA Change Package to modify due dates for M-045-91F milestones was completed and sent for review.

Part 1. Tank Farm Leak Inventory Assessments

Review of Nez Perce email: C-104/C-105 cascade line leak

A draft response to the email was presented and reviewed. Three key comments were:

- Due to uncertainty as to when preliminary ⁹⁹Tc and nitrate laboratory analyses of the tank C-101 direct push samples will be reported it was suggested that the response letter exclude a date for the next revision of the C tank farm leak assessment report. These and other new C farm direct push and SGE results obtained since completing RPP-ENV-33418 Rev. 0 will be discussed and incorporated in the revised reports.
- Further clarification was needed regarding the assessment rating value of 0.42. Need to clarify that this is not a probability, but a review team confidence indicator.
- Delete the discussion on the primary focus of the leak assessments.

As indicated in the proposed response, a C farm reassessment approach and initial results will be presented and discussed during the next WMA C PA working session (May). Prior to release, a briefing on revisions to the C farm leak assessment report (RPP-ENV-33418) will be provided to the tribal nations for review and comment.

Results from the leak assessment report will be incorporated in the WMA C RCRA Facility Investigation Report.

Rationale for direct pushes near C-200 series tanks

The August 3, 2010 meeting summary for the C-200 series tanks assessment was addressed. This assessment concluded that although three of four 200 series tanks were overfilled the liquid level remained steady in those tanks, evaporation accounted for liquid level decreases and the C-200 series tanks were probably not the source of uranium and cyanide detected in samples from well 299-E27-7.

It was recognized that some direct pushes are still needed near the C-200 tanks, but fewer than currently planned. It was recommended that the focus of pushes near the C-200 tanks should be directed toward SGE investigations, investigations into potential leaking pipelines near the C-200 tanks and the source of uranium and cyanide at 299-E27-7. The direct pushes should be planned to optimize SGE investigations. Other locations, such as near tank C-105, that may benefit from direct push logging and samples were discussed. These and other alternatives will be further discussed in future WMA C work planning meetings.

ECOLOGY (Jeff Lyon) concurred with these recommendations.

Part 2. Tank Leak Location and Cause

Tank SX-111

The rate the temperature initially rose when tank 241-SX-111 was first filled with waste and potential stresses in the tank liner caused by the rapid temperature increases were investigated and will be incorporated into the final report.

Tank SX-112

The draft tank SX-112 integrity assessment was reviewed and discussed; the draft will become part of the report on tank waste leak locations and causes. Thermal shock was identified as a primary cause of the leak in tank SX-112, including moderately high temperatures during storage of waste and the rate of temperature increase upon initial filling of waste. Other causes of tank SX-112 liner failure discussed were: tank design, possible impacts resulting from construction during cold weather, and possible liner bulging. Tank SX-112 was not nitrate leached and therefore omitted as a plausible cause for liner failure.

Several comments and suggestions were made on the tank SX-112 draft report and will be addressed in the final report, including:

- Investigation of the causes of turnbuckle guy rod detachment from air lift circulators in the tank SX-112 as it relates to liner bulging, sludge rollover, and leak location.

- Addition of details in the summary segments to include the rationale for the causes of the tank leak and the location of the leak to better support the conclusions.
- Investigation of potential differences in the tank SX-111 report drywell 41-11-09 figure, page 29, referenced from HNF-3136 as it relates to drywell 41-11-09 data in the tank SX-112 segment.
- Drywell contamination rationale for a tank leak versus contamination that may be detected from a leaking cascade line.

Comments addressed for the tank SX-112 assessment will also be incorporated into the tank SX-107, SX-108, SX-109, and SX-111 reports as well as future reports as appropriate.

A trial timeline chart with peak drywell and lateral counts was presented as a means to show the time-phased relationship between surrounding drywells and laterals. If the chart is useful for depicting the drywell and lateral interactions it will be included in the tank SX-112 report.

The matrix table (designated as a draft) showing a summary of causes contributing to leaks for tanks SX-107, SX-108, SX-109, SX-111, and SX-112 was presented. This matrix will be revisited as each tank is assessed.

A tracking matrix was distributed to show the status and progress of the Tank Leak Cause and Location assessments and reports for TPA Target M-045-91F-T04.

The tank SX-113 draft report will be discussed at the next meeting.

ACTIONS:

35. All: Review summary for discussion in the next meeting.
36. J. Field/C. Girardot: Prepare and distribute April 19, 2011 Meeting Summary
37. L. Fort: Prepare C-109 through C-112 information for discussion in the next meeting.
38. D. Harlow. Prepare draft SX-113 leak location and cause assessment for the next meeting.

NEXT MEETING:

Part 1. Assess the C-109 through C-112 tanks for waste releases. Part 2. Review leak location and causes for tank SX-113.

Date: May 3, 2011
Time: 9:00-11:00
Location: ECOLOGY Office CR 3B

MEETING SUMMARY

From: J. G. Field *JG Field*
Phone: 376-3753
Location: Ecology Office,
Date: May 3, 2011
Subject: Tank Farm Leak Inventory and Tank Integrity Assessments

To: Distribution/Attendees

Attendees:

Mike Barnes, ECOLOGY
Joe Caggiano; ECOLOGY
Jim Field; WRPS
Jordan, Follett, WRPS
Crystal Girardot; WRPS

Don Harlow, WRPS
Michelle Hendrickson, ECOLOGY
Paul Henwood, S.M. Stoller
Jeremy Johnson, ORP

PURPOSE:

The purpose of this meeting was to:

- 1) Assess releases near tanks 241-C-109, -C-110, -C-111 and -C-112 (Part 1);
- 2) Discuss tank leak location and cause of liner integrity issues at tank 241-SX-113 (Part 2).

Review Previous Meeting Summaries and Actions:

The meeting summary for April 19, 2011 was reviewed and approved with comments. An action was taken to investigate if the uranium found in samples from groundwater well 299-E27-7 was depleted uranium to further assess the source. It was noted that cyanide was also detected in groundwater samples and ⁶⁰Co was detected in vadose zone geophysical logs.

Part 1: Tank Farm Leak Inventory Assessments

Re-assessment of Tanks 241-C-109, 110, 111 and 112

Information presented for tanks 241-C-109, 110, 111 and 112 will be incorporated in the revised C Farm assessment. There was no indication of a loss of liner integrity for any of these tanks. Drywell activity near tank C-109 was attributed to migration from C-108 cascade line releases.

There was no change in previous release estimates for tanks C-110 and C-111. Since the previous tank farm leak assessment a formal integrity assessment was performed for these tanks (RPP-ASMT-38219 and RPP-ASMT-39155). The assessment concluded that both tanks were "sound" (the integrity classification of a waste storage tank for which surveillance data indicate no loss of liquid attributed to a breach of integrity). Activity near tank C-110 in dry well 30-10-09 was likely from spare inlet overflows with an estimated release of less than 2,000 gal of evaporator bottoms – ion exchange (EB-IX) waste. Liquid level decreases in tank C-111, previously ascribed to a tank leak, can be explained by water evaporating from the waste. There was no evidence of a release near tank C-111.

Activity in drywells 30-12-01 and 30-12-13 was attributed to a transfer line release between the 252-C diversion box and tank C-112 and/or a salt-well pump pit release. The estimated size of the release was 7,000 gal based on an assumed distribution of the waste released, derived from measured increases in soil water content through direct push sampling and assessments and an assumed waste mix of cladding waste and ion exchange waste. Calculations and discussion of this leak estimate and waste composition will be included in the assessment report.

Comments received on the information presented and assessment observations will be included in the revised assessment report.

Part 2. Tank Leak Location and Cause

Tank SX-113

The draft tank SX-113 integrity assessment was reviewed and discussed; the draft will become part of the report on tank waste leak locations and causes. Thermal conditions within the tank were identified as a primary cause of the leak in tank SX-113, including the rate at which the temperature increased during the initial filling of the tank. Other conditions affecting the liner integrity of tank SX-113 were: ventilation drawing a vacuum on the empty tank prior to it receiving waste, liner bulging, tank design, and impacts resulting from construction during cold weather.

A comment suggested that the tank SX-113 assessment look into the possibility of a leak zone in the sidewall indicated by a liquid level decrease during a leak test. It was also suggested it may be premature to rule out nitrate leaching as a possible cause in the tank SX-113 leak since the tank did receive ~220 kgal of sodium nitrate REDOX HLW sludge leachate from tank SX-114 for leak testing. This may also affect the Tank Leak Cause Matrix button chart. The initial temperature of 42°F found for tank SX-113 was discussed in relationship to the 55°F initial temperature used for tanks reviewed up to this time. This may affect initial temperature of the tanks reviewed depending on the time of year (temperature) when initially filled with waste. A request was made to identify the radiation probe used for the tank SX-113 prototype laterals in the report and to include any available description of its measurement capabilities.

Comments received for each assessment will be incorporated in the previous tank SX-107, SX-108, SX-109, SX-111, SX-112, and SX-113 reports as well as future reports as appropriate.

The matrix table (designated as a draft) showing a summary of causes contributing to leaks for tanks SX-107, SX-108, SX-109, SX-111, SX-112, and SX-113 was presented. This matrix will be revisited as each tank is assessed.

ACTIONS:

Part 1

- 39. All: Review meeting summary for discussion in the next meeting.
- 40. J. Field: Prepare and distribute May 3, 2011 Meeting Summary
- 41. J. Field/L. Fort: Prepare to discuss Uranium waste type and sample results from 299-E27-7 in the next meeting.

Part 2

- 42. All: Review SX-113 information presented and provide feedback in the next meeting.
- 43. C. Giardot/D. Harlow: Prepare May 3, 2011 Meeting Summary
- 44. D. Washenfelter/ D. Harlow: Prepare to discuss leak location and cause assessment for tank SX-114 and distribute draft information prior to the next meeting.

NEXT MEETING:

Meeting delayed to May 31 due to WMA C PA Meeting, also, more than 2 weeks needed to prepare SX-114 write-up.

Part 1. Revisit C Farm unplanned releases for UPR-81, UPR-82 and UPR-86.

Part 2. Discuss leak location and causes for tank 241-SX-114.

Date: May 31
Time: 9:00-11:00
Location: ECOLOGY Office

MEETING SUMMARY

From: J. G. Field *J. G. Field*
Phone: 376-3753
Location: Ecology Office,
Date: May 31, 2011
Subject: Tank Farm Leak Inventory and Tank Integrity Assessments

To: Distribution/Attendees

Attendees:

Mike Barnes, ECOLOGY
Jim Field; WRPS
Jordan, Follett, WRPS
Les Fort, WRPS
Crystal Girardot; WRPS

Don Harlow, WRPS
Michelle Hendrickson, ECOLOGY
Paul Henwood, S.M. Stoller
Jeremy Johnson, ORP
Dennis Washenfelter, WRPS

PURPOSE:

The purpose of this meeting was to:

- 1) Assess near surface releases and Unplanned Releases (UPRs) in C Farm (Part 1);
- 2) Discuss tank leak location and cause of liner integrity issues at tank 241-SX-114 (Part 2).

Review Previous Meeting Summaries and Actions:

The meeting summary for May 3 was reviewed and approved with comments.

The draft leak assessment report for B Farm was distributed for review with a disk copy provided to Ecology at the meeting. Comments were requested by June 17.

Uranium data from groundwater well 299-E27-7 was reviewed. Only total uranium groundwater analyses were performed, so it could not be determined whether uranium in the groundwater is depleted. Geophysical logs show ^{235}U and ^{238}U in the vadose zone at concentrations of about 2 and 20 pCi/g, respectively. However, at the low concentrations measured, differences are within the margin of uncertainty. Consequently, it cannot be determined from the available data whether the uranium in the vadose zone is depleted.

As discussed in the April 19 meeting, transfer lines from the C farm 200 series tanks appear to be the most likely source for uranium and cyanide in well 299-E27-7.. Other potential sources discussed were tank leaks, overflows through spare inlets, discharges to French drains, and UPRs north of the well.

Part 1: Tank Farm Leak Inventory Assessments

Re-assessment of C Farm UPRs and Near Surface Releases

Information and conclusions from the previous C Farm leak assessment report (RPP-ENV-33418, Rev. 1) were reviewed and new data acquired since the release of the report presented.

Information presented will be included in Revision 2 of the assessment report. The new data discussed included 3D SGE analyses near UPRs 200-E-81, 200-E-82 and 200-E-86 and direct push logging and samples; ^{99}Tc and NO_3 direct push sample results were discussed.

The new data support the previous assessment results and inventory estimates for UPR 81 and UPR-82. The SGE data indicate resistivity anomalies are deep near UPR-86 and direct push holes and samples may have been too shallow. The results also suggest that the 17,385 gallon release volume for UPR-86 documented in the Maxfield report (RHO-CD-673) may be high. The volume estimate is based on an evaluation of AR vault processing and transfer information, but references cited in the Maxfield report could not be located. It is possible that once measured high gamma activity was entirely covered by the shotcrete cap and the investigative direct push holes did not get close enough.

The Nez Perce suggested that based on the coordinates in the Maxfield report the shotcrete cap, direct pushes, and SGE may be in the wrong location. The location for direct push samples was carefully reviewed against tank farm drawings and drawings in the Maxfield report. The Maxfield location coordinates are listed as approximate and it was determined that the pipeline leak was near a bend in the pipe and near the location where a bypass line was installed and the old line was cut and capped. The shotcrete CAP is located at these locations. The assessment team concurred that the shotcrete cap, SGE and direct push samples were probably in the right place. It was also noted that 3D SGE surveys cover the current assumed location and Maxfield coordinates. The SGE results will be completed in July and will be discussed in the re-assessment report.

Past near surface release estimates were also reviewed. A surface radiation map for C farm will be included in the revised report. Surface radiation areas will be correlated with other sample and logging data. Near surface direct push results will also be considered to refine inventory estimates and better estimate waste types and constituents for surface releases.

Part 2. Tank Leak Location and Cause

Tank SX-114

The draft tank SX-114 integrity assessment was reviewed and discussed; the draft will become part of the report on tank waste leak locations and causes. Nitrate leaching was identified as one of the causes of the leak in tank SX-114, including the duration leachate was stored in the tank (~20 months) and the subsequent timing of refill with REDOX HLW. Other conditions affecting apparent tank SX-114 liner failure were: thermal conditions and the attempt to control the temperature increase resulted in the pressurization event in August 1958, liner bulging, tank design, and impacts resulting from construction during cold weather.

Several comments and suggestions were made on the tank SX-114 draft report and will be addressed in the final report, including:

- Indicate the duration time from transfer of leachate to refill with REDOX HLW
- Identify the BGS equivalent level of the leachate (699 kgal) prior to transferring out of tank SX-114, indicate level on Figure 4-8

- Identify what conditions would have caused rupturing a joint upon receipt of hot waste in second paragraph of the quote referenced from HW-57274 on page 39
- Emphasize the duration of leaching and storage of leachate for tank SX-114 in the conclusion section
- Recheck the availability of drywell data from 1965 to 1972
- Investigate the possible steel composition variability from either different runs from the same supplier, or because multiple suppliers provided the steel
- Identify the waste liquid level prior to the leak from tank SX-114

Comments received on each SX tank specific report will be incorporated to previous reports as appropriate.

A draft matrix table showing a summary of causes contributing to leaks for tanks SX-107, SX-108, SX-109, SX-111, SX-112, SX-113, and SX-114 was presented. This matrix will be revisited as each tank is assessed.

A preliminary matrix table with information for leak location and causes for SX Farm tanks was also presented. This table will be included in the final report. ECOLOGY suggested including the designated sound tanks in this matrix.

At the next meeting an outline of the SX tank farm section of the final report will be proposed. The draft tank SX-115 report will also be discussed at the next meeting.

ACTIONS:

Part 1

45. All: Review meeting summary for discussion in the next meeting.
46. J. Field: Prepare and distribute May 31, 2011 Meeting Summary
47. L. Fort: Revise C Farm leak assessment report (RPP-ENV-33418).
48. J. Field/L. Fort: Prepare C-111 information and TX farm summaries for discussion in the next meeting.

Part 2

49. All: Review tank SX-114 presented information and provide feedback during the next meeting.
50. C. Giardot/D. Harlow: Prepare May 31, 2011 Meeting Summary
51. D. Washenfelter/ D. Harlow: Prepare to discuss leak location and cause assessment for tank SX-115 and distribute draft information prior to the next meeting.

NEXT MEETING:

Tuesday June 14

Part 1. Revisit tank C-111 liquid level information and the need for the planned direct push at Site V and begin TX Farm leak inventory assessments.

Part 2. Discuss SX Farm report format and leak location and causes for tank 241-SX-115.

Date: June 14
Time: Part 1: 9:00-10:00, part 2: 10:00-11:00
Location: ECOLOGY Office

MEETING SUMMARY

From: J. G. Field *JG Field*
Phone: 376-3753
Location: Ecology Office,
Date: June 14, 2011
Subject: Tank Farm Leak Inventory and Tank Integrity Assessments

To: Distribution/Attendees

Attendees:

Mike Barnes, ECOLOGY
Joe Caggiano, ECOLOGY
Jim Field; WRPS
Andrea Fillafer, WRPS Intern
Les Fort, WRPS
Crystal Girardot; WRPS
Don Harlow, WRPS
Andrea Hopkins, WRPS

Michelle Hendrickson, ECOLOGY
Brendan Hedel, WRPS Intern
Paul Henwood, S.M. Stoller
Jeremy Johnson, ORP
Natalie Kirch, WRPS Intern
Jeff Lyon, ECOLOGY
Megan Sax, WRPS Intern

PURPOSE:

The purpose of this meeting was to:

- 1) Revisit tank C-111 liquid level information and the need for the planned direct push at Site V and begin TX Farm tank leak inventory assessment. (Part 1);
- 2) Discuss SX Farm report format and tank leak location and cause of liner integrity issues at tank 241-SX-115 (Part 2).

Review Previous Meeting Summaries and Actions:

The meeting summary for May 31 was reviewed and approved with comments.

Part 1: Tank Farm Leak Inventory Assessments

C-111 liquid level information and the need for the planned direct push at Site V

Information and conclusions from the C Farm leak assessment report (RPP-ENV-33418, Rev. 1) were reviewed. The assessment concluded that, "Evaporation calculations and plotted liquid level and evaporation rates clearly indicated that the liquid-level decrease can be attributed to evaporation and suggests that high tank waste temperature information was apparently not available for previous assessments. The assessment team believed that the data supports the potential to reclassify tank C-111 as sound and recommended that it be reassessed per TFC-ENG-CHEM-D-42.

The tank classification for C-111 was reassessed per TFC-ENG-CHEM-D-42 in 2008 and the assessment team concluded that, "The combined effects of evaporation and thermal waste contraction caused the observed 8.5 in surface level decrease in tank C-111 during the 1965 –

1969 period” and recommended that the integrity status of tank C-111 be changed from “Assumed Leaker” to “Sound” (RPP-ASMT-39155).

Given the information presented, Ecology concurred that a push near tank C-111 (Site V) is not needed to further assess whether the tank leaked or overflowed. Alternate push locations will be considered through the WMA C work planning process.

TX-105 Assessment

Information was reviewed associated with operations at tank 241-TX-105 (TX-105). This information will be included in the TX Farm leak assessment report. Tank TX-105 was classified as an assumed leaker based on gross gamma activity detected in drywells (51-05-01, 51-05-03 and 51-05-05) when the drywells were drilled. However, no estimate for the size of the leak is included in tank waste summary reports (HNF-EP-0182). Process data shows that the tank was overfilled in 1952 and between 1961 and 1964 and that waste may have been released from the spare inlets. Spectral gamma logging data show ^{235}U and ^{238}U activity in the drywells, suggesting MW may have been released in the early 1950's.

GJO-97-13-TARA (*Addendum to the TX Tank Farm Report*) estimates a ^{238}U plume of 5,819 m³ with a total uranium activity of 0.18 curies. A 10% increase in moisture content of the soils contacted by the ^{238}U plume would result in an estimated plume volume of ~154,000 gallons (5,819 m³ X 10%). The Hanford defined waste model estimates a ^{238}U concentration for Metal Waste (MW) of supernatant is ~1.2 (10)⁻⁶ Ci/gallon. Dividing 0.18 Ci by this concentration equates to about 150,000 gallons of MW. Therefore a 150,000 gallon supernate overflow appears plausible.

Tank TX-105 release estimates will be further discussed at the next meeting

Part 2. Tank Leak Location and Cause

Tank SX-114

Comments from the 5/31/2011 meeting for the draft tank SX-114 integrity assessment and the resolutions to these comments were distributed and are attached (attachment 1).

Tank SX-115

The draft write-up of tank SX-115 integrity assessment was reviewed and discussed; this draft will become part of the SX Farm report on tank waste leak locations and causes. The liquid level decrease of 50 kgal resulting from an initial leak rate of 5.2 gal/min over 8 days was considered to be one of the more severe leaks in the SX Tank Farm. The rate at which the temperature rose during the initial filling of the tank was identified as one of the primary causes for the leak in tank SX-115. Other conditions affecting the tank SX-115 liner failure were: nitrate leaching, bulging of the liner, tank design, and impacts resulting from construction during cold weather.

Several comments and suggestions were made on the tank SX-115 draft report and will be addressed in the final report, including:

- Emphasize that the liner bulge was detected prior to addition of REDOX HLW during the year long preheating

- Double check the units (pCi/g) on Figure 4-1
- Validate the 2,914 K cpm value that was stated for lateral 44-15-03 in Figure 4-2 as well as the values in Table E-1
- Indicate on the figures the location of where the core was drilled
- Explore possible liner failure mechanisms (bulging, effects of temperature, issues associated with pressurization of grout pore water) in general and especially for the magnitude of the tank SX-115 leak
- Include a chronological nitrate leaching table (Table 3-1 in the SX-115 segment) where appropriate in previous tank SX segments

Comments received for each tank specific leak location and cause report will be incorporated into the previous reports as appropriate.

Distributed to the group for discussion was a draft table, “Tank Leak Cause Matrix,” showing a summary of causal factors that appear to contribute to waste leaks from tanks SX-107, SX-108, SX-109, SX-111, SX-112, SX-113, SX-114, and SX-115. This matrix will be revisited as each tank is assessed.

A proposal for the SX Tank Farm outline for the final report was presented and is attached (attachment 2).

A preliminary table, “Salient Information for Leak Location and Causes,” was distributed to the group and discussed; and will be included in the final report. Also included in this table was information for non-leaking SX Farm tanks.

It was agreed that a draft of the SX farm leak cause and location report will be presented at the next meeting.

ACTIONS:

Part 1

- 52. All: Review meeting summary for discussion in the next meeting.
- 53. J. Field: Prepare and distribute June 14, 2011 Meeting Summary
- 54. L. Fort: Prepare TX farm summaries for discussion in the next meeting.

Part 2

- 55. All: Review tank SX-115 presented information and provide feedback during the next meeting.
- 56. C. Giardot/D. Harlow: Prepare June 14, 2011 Meeting Summary
- 57. D. Harlow: Prepare draft SX farm leak cause and location report for discussion in the next meeting.

NEXT MEETING:

Part 1. Continue TX Farm leak inventory assessments for tanks TX-105, TX-107 and TX-110.

Part 2. Discuss SX Farm report format and content.

Date: July 12, 2011
Time: Part 1: 9:00-10:00, part 2: 10:00-11:00
Location: ECOLOGY Office

Attachment 1**Comment Resolution for Tank SX-114 Segment from 5/31/2011 meeting**

1. Indicate the duration time from transfer of leachate to refill with REDOX HLW

Tank SX-114 stored leachate for ~20 months, the longest for the leaking SX Farm tanks and was addressed in the Chemistry-Corrosion sections (Sections 3.4 and 6.3). Tank SX-114 was refilled with REDOX HLW approximately 11 months after transferring the leachate out of the tank.

2. Identify the BGS equivalent level of the leachate (699 kgal) prior to transferring out of tank SX-114, indicate level on Figure 4-8.

The 699 kgal is equivalent to 21-ft 9-in BGS level and was added to Figure 4-8:

3. Identify what conditions would have caused rupturing a joint upon receipt of hot waste in second paragraph of the quote referenced from HW-57274 on page 39

Added in paragraph at the end of Section 6.1:

“The rupture of a joint upon filling with hot waste could heat any water existing below the steel liner which was described as trapping pressurized vapor (HW-57274) this could result in forces that cause the liner to deform (bulge). The design of the orthogonal sidewall to bottom joint was postulated to trap the pressurized vapor under the liner as opposed to previous knuckle designs. This in turn increased the temperature due to the lower vapor space heat transfer coefficient and decreased the heat transfer from the bottom of the tank which compounded the situation.”

4. Emphasize the duration of leaching and storage of leachate for tank SX-114 in the conclusion section

Added sentence to the conclusion section (7.0) stating leachate stored in SX-114 for ~20 months which was the longest out of the leaking SX farm tanks and wasn't refilled with REDOX HLW for ~11 months.

5. Recheck the availability of drywell data from 1965 to 1972

Rechecked database however no additional drywell data has been added for tank SX-114.

6. Investigate the possible steel composition variability from either different runs from the same supplier, or because multiple suppliers provided the steel.

A statement will be included in the common information before individual segments in the SX Farm section of the final report. At the present time, no information has been found.

7. Identify the waste liquid level prior to the leak from tank SX-114

The waste volume prior to the leak in April 1972 was reported as 937 kgal or ~29-ft which is stated in Section 1.1. Details will be added to Liquid Level Section 3.1.

Attachment 2

SX Tank Farm Outline Proposal for M045-91F-T04 Expanded Leak Assessments LD-1

Concept

Create an SX Farm Summary that also includes common information for all of the leaking SX Farm Tanks

Include all of the 8 Tank segments but delete the common information details and retain the appendices with the individual tank segments

Details

- SX Farm Introduction
 - Overview of the SX Farm section such as the layout of the farm
- Summary for leaking SX Tank Farm tanks
 - Time line figure for overall operational history for SX farm, blame button chart,
 - Salient information for leak location and causes chart which includes the rate of rise temperature information, liner bulge, nitrate leaching, first filled, etc.
- Common information for all the leaking SX Farm Tanks including: tank design and construction, liquid level uncertainties, temperature limitations, liner observations, nitrate leaching process, lateral and drywell installation and probe types, leak causes, etc.
 - Should include all the commonality information that is in each of the individual tank segments
- Tank by tank segments excluding the detailed information that was mentioned above. Goal is to be able to read each segment and still get the necessary information on leak cause and location without reading the entire document.
 - All of the individual segment except the detailed information that was included above
 - Includes detailed information pertaining to each individual tank
 - Appendices also included with each segment
- Conclusions for SX Tank Farm
 - Include any overall conclusions for SX tank farm.

MEETING SUMMARY

From: J. G. Field *JG Field*
Phone: 376-3753
Location: Ecology Office,
Date: July 12, 2011
Subject: Tank Farm Leak Inventory and Tank Integrity Assessments

To: Distribution/Attendees

Attendees:

Mike Barnes, ECOLOGY
Joe Caggiano, ECOLOGY
Jim Field; WRPS
Les Fort, WRPS
Crystal Girardot; WRPS
Don Harlow, SC101/WRPS
Andrea Hopkins, WRPS
Brendan Hedel, WRPS Intern
Paul Henwood, S.M. Stoller
Jeremy Johnson, ORP
Gretchen Reeploeg, WRPS
Chelsea Rosenkrance, WRPS
Marc Wood, CHPRC

PURPOSE:

The purpose of this meeting was to:

- 1) Assess tanks TX-105, TX-107 and TX-110 (Part 1);
- 2) Discuss SX Farm report format and content (Part 2).

Review Previous Meeting Summaries and Actions:

The meeting summary for June 14 was reviewed and approved with comments.

Part 1: Tank Farm Leak Inventory Assessments

Comments were received from Ecology, S.M. Stoller, and CHPRC on the B tank farm leak inventory assessment report. The comments are being reviewed and the report revised as needed. The U tank farm leak assessment report draft is expected to be completed and ready for review in the next two weeks.

The team discussed the criteria established to recommend reassessment of a tank leak status classification (sound vs. assumed leaker) per TFC-ENG-CHEM-D-42 (the procedure used to assess SST liner integrity). In general, the tank leak status classification should be reassessed if the tank is classified as "assumed leaker" and there is no clear technical indication of a release to the soil, if liquid level decreases in tanks can be explained by something other than a breach in the tank liner and/or if other release sources (e.g. line leaks, or overflows) provide alternate explanations for radioactivity measured near the tanks in the vadose zone. Alternatively, the tank leak classification should be reassessed if the tank is classified as "sound" and there is a clear technical indication of a release to the soil near the base of a tank, if liquid level measurements in a tank cannot be reliably used and cannot be used to explain the lack of/or a

breach in the tank liner, and/or if no other release source (e.g. line leaks, or overflows) provide alternate, credible explanations for radioactivity measured near the base of tanks. Ecology noted that one of their comments for the B Farm assessment report and other reports is the need to clearly and consistently identify only liner leaks as tank leaks; other releases are not tank leaks.

TX-105 Assessment

Information presented in the June meeting was revisited and inventory estimates for ^{238}U and ^{235}U activity near tanks TX-105 and TX-101 were discussed by the assessment team.

The primary basis for the inventory estimate is the release estimate documented in GJO-97-13-TARA (*Addendum to the TX Tank Farm Report*). The report estimates a ^{238}U plume of $5,819\text{ m}^3$ with a total uranium activity of 0.18 curies.

A 10% increase in moisture content of the soils contacted by the ^{238}U plume would result in an estimated plume volume of $\sim 154,000$ gallons ($5,819\text{ m}^3 \times 10\%$). The Hanford defined waste model estimates a ^{238}U concentration for Metal Waste (MW) of supernatant is $\sim 1.2 (10)^{-6}$ Ci/gallon. Dividing 0.18 Ci by this concentration equates to about 150,000 gallons of MW. Therefore a 150,000 gallon supernate overflow appears plausible.

There was some question as to whether the $5,819\text{ m}^3$ plume estimate includes the lower levels of ^{238}U activity near tank TX-101 not shown in plume visualizations in GJO-97-13-TARA.

Following the meeting, S.M. Stoller confirmed that the lower activity TX-101 plume volumes were not included in the estimate. Therefore the waste stream released may have been more diluted and could be larger than 154,000 gal.

It was also noted that the ^{137}Cs activity in drywell 51-05-03 at ~ 30 ft bgs is listed as possible ^{90}Sr activity in the SGLS logs based on shape factor analysis; ^{137}Cs activity was < 10 pCi/g at this drywell.

The team concluded that the release near tank TX-105 appears to be a MW release from a transfer line and/or spare inlet, or may be from a tank leak, with an estimated 0.18 Ci of ^{238}U and a release volume of 150,000 gal, or larger if a dilute waste stream. Inventory estimates for other constituents released should use the HDW Rev. 5 MW constituent concentrations multiplied by 150,000 gal. It was noted that the plume size estimates are based on a limited data set and additional direct push logging was recommended as part of future TX farm investigations to better estimate the distribution and inventory of the plume. The current tank leak classification should be reassessed per TFC-ENG-CHEM-D-42. This reassessment should include an evaluation of whether additional characterization of the vadose zone underneath the tank is warranted to determine the appropriate classification.

Part 2. Tank Leak Location and Cause

Tank SX-115

Comments from Joe Caggiano for the draft tank SX-115 integrity assessment and the resolutions to these comments were distributed by e-mail and are provided as Attachment 1.

SX Farm Leak Location and Causes Draft Report

The conclusion section of the draft SX Farm leak location and causes report was reviewed and discussed. A proposed consolidated table of contents was distributed and will be included in the final report as well as a table of contents for each individual tank segment.

Five conditions that may have contributed to SX Farm tank liner failures include: tank design, thermal shock, chemistry-corrosion, liner behavior (bulging), and construction temperature. High temperatures and the rapid rate of heat-up appear to be major factors contributing to tank liner failure. Also, all but three of the eight leaking tanks were nitrate leached and all of the nitrate leached tanks leaked. One tank classified as sound (tank SX-105) held leachate waste the longest out of all the SX Farm tanks; however, the temperatures during storage were much lower (~115°F) compared to the temperatures during leachate storage in the other tanks.

A bulged tank bottom was present or possible in all of the eight leaking SX Farm tanks. However, there were varying degrees of tank bottom bulging documentation including; actual recorded measurements, indications of bulge inspection with and without supporting documentation, and photographic evidence used either as supporting evidence of a bulge or as the only evidence. In addition one of seven SX Farm tanks classified as “sound” (SX-110) had some indication (bent piping) that a bulge might have occurred. There was no documentation available on tank bottom bulging for the other six SX Farm “sound” tanks. A bulge of the tank bottom imparts stresses in the liner that could have caused the tank liner to fail or predisposed the liner to stress corrosion cracking.

The team concluded that no one specific characteristic of the SX Farm tanks caused the tank liners to fail. It appears the application of many stressors (heat up rate, high temperature, loss of corrosion protection, and tank design) working jointly or serially on the eight identified leaking tanks, resulted in their failure.

Suggestions for the SX Farm leak location and causes report included:

- State that sound SX Farm tanks are classified as sound tanks. It is possible that some of these tanks have also leaked but the leaks are/were undetected.
- Investigate the solid content at the time the liner bulge was measured and see if there is a relationship between the amount of solids (with/without supernatant) and whether a bulge was present.
- Distinguish between a bulge and a ripple and indicate any dimensions that would separate the two.
- State in the conclusions section that the identified eight leaking SX Farm tanks were exposed to cold atmospheric temperatures during construction compared to the ground covered (insulated) SX-101 through SX-106 sound tanks.
- Discuss the SX-110 tank conditions and classification as a sound tank. See ERDA letter IDMS Ascension 293-006467.
- Discuss the rigor required to research the information assembled to determine leak location and causes.

A proposal was presented to separate the Leak Locations and Causes final report into five volumes.

- Volume 1 would contain the introduction/background information as well as the overall conclusions.
- Volume 2 would include the A Farm leak location report.
- Volume 3 would include the BCTU Farm leak location report.
- Volume 4 would include the BY and TY Farm leak location report,
- Volume 5 would include the SX Farm leak location report.

A draft of the tank TY-103 segment will be presented at the next meeting along with the available portions of the overall BY and TY Tank Farm section.

ACTIONS:

Part 1

- 58. All: Review meeting summary for discussion in the next meeting.
- 59. J. Field: Prepare and distribute July 12, 2011 Meeting Summary
- 60. L. Fort: Prepare TX farm summaries for discussion in the next meeting.

Part 2

- 61. All: Review meeting summary for discussion in the next meeting.
- 62. C. Giardot/D. Harlow: Prepare July 12, 2011 Meeting Summary (Part 2)
- 63. D. Harlow: Prepare draft tank TY-103 leak cause and location report for discussion in the next meeting.

NEXT MEETING:

Part 1. Continue TX Farm leak inventory assessments for tanks TX-107 and TX-110.

Part 2. Review leak location and cause for tank TY-103.

Date: July 26, 2011
Time: Part 1: 9:00-10:00, part 2: 10:00-11:00
Location: ECOLOGY Office

Attachment 1

Joe Caggiano, June 15, 2011 e-mail comments/suggestions with responses.

We will address the comments/suggestions in other SX tank reports as appropriate.

1. How certain are you of the depth of the temperature readings; i.e., were the temperature measuring devices (presumably Hg bulbs) firmly fixed in depth and not subject to changes in elevation considering the dynamics of moving fluids within the tank ? This is a concern for all tank temperature measurements. Given this, what uncertainty could be attributed to these readings?

Response:

Our review of the nomenclature found in documentation leads us to be fairly certain of the depth of the temperature element that are reported to be 2-3-in off the bottom of the tank as indicated in the fourth paragraph of Section 3.2. These bottom temperatures are associated with the sludge which has the more restrictive temperature requirements and may not be as mobile as the liquid phase. We will add some clarification and explanation to Section 3.2. We have tried to find details on the bulb temperature design or documentation that might lead to the degree of uncertainty for the bottom temperature readings but have not found any information except for the depth information in Section 3.2. We will indicate that the degree of uncertainty with regards to temperature was not able to be determined from available information.

2. Liner bulges are reported in some tanks that failed and in others that did not. Is there some threshold for liner bulge height that, if not exceeded, would keep the liner integrity “intact”? That would also depend on how such liner bulges are measured and how often.

Response:

The information we have so far is that there was a bulge present in most of the leaking SX Farm tanks. However, none of the sound SX Farm Tanks were inspected for a bulge as documented in RHO-R-39. If changes occur as more information becomes available we will address as appropriate. Sound tanks SX-101 and SX-104 did experience bumping but there was no information found that indicated bulges.

The only information we have on the extent of bulging as it relates to liner integrity is for the four foot bulge in tank SX-113 from WH-57274 page 5, as follows:

“When asked about the possibility of failure of this joint (steel shell to steel bottom), F.H. Waldrep, welding inspector, (Bldg. 2723-W) stated that in his opinion some part of the bottom circumferential joint would surely be expected to fail if the bottom liner were raised 4 feet”.

This is the most extreme bulge that was experienced and may not be applicable to smaller bulges. There is the possibility of performing a calculation of the yield strength given a specific height and horizontal extent but there are a number of other parameters like number of flexes that would require assumptions. This would produce one or more family of curves that may not be able to be related to any one tank as the vertical height,

horizontal extent, and number of flexes are unknown as well as the quality of tank fabrication and other construction variables.

3. For the less informed, could you explain the significance of missing pieces of ALCs and what it could mean in terms of liner bulges?

Response:

Each ALC was anchored to the tank floor liner by three one-half inch diameter guy rods. Missing or disconnected ALC guy rods could indicate that there was bulging of the bottom liner sufficient to cause the upper connection to fail with the guy rod sinking below the liquid surface (missing). Or, the guy rod may hang free from the upper connection if it becomes disconnected from the tank bottom attachment plate or the plate itself pulls away from the bottom of the tank. We will address this possible indicator of a bulged bottom in the common information section up front in the SX Farm section. It should be noted that there are cases of ALC guy rod anomalies that are visible in sound tanks.

4. On pg. 18, you note that no records of vertical or horizontal deviation of the lateral lines exist. Was the driller(s) required to measure for such, given the experiences in the earlier SX-113 prototype lateral construction?

Response

The driller was required to check the alignment of the laterals every 20-ft and there was a procedure to install and check for the alignment for the laterals installed after the tank SX-113 prototype. We will address this in the upfront common section on laterals.

5. Readings from the lateral data are in cpm. What is the background in cpm for soil, given that K-40, U, and Th are present in Hanford Site soils? How were the cpm values converted to Ci values? For example, values on Fig. 4-1 are stated to be in pCi/g, yet elsewhere, data from BNWL-CC-701 are given in $\mu\text{Ci/g}$. Something seems awry. As the difference is 10^6 , this is no small matter.

Response:

The lateral data in table D-1 is in cpm, the 2005 lateral data in appendix G from RPP-RPT-27605 is reported in the document as pCi/g for which there was a conversion in the document. BNWL-CC-701 test well soil samples were used to come up with the contour contamination locations in relationship with available lateral cpm data which they indicated was being "quite subjective". BNWL-CC-701 test well soil samples were reported in $\mu\text{Ci/g}$ which we converted to pCi/g to be able to compare with the 2005 pCi/g information in RPP-RPT-27605. Naturally occurring K-40, U, and Th are present in the soil and are taken into account in RPP-RPT-27605 2005 lateral data. Not sure how or if they are addressed in cpm drywell, early lateral data, or test well soil samples. The units for Fig. 4-1 are indicated as (Contour value $\times 10^6$, pCi/g). This should be a way of providing the conversion from $\mu\text{Ci/g}$ in the original BNWL-CC-701 document to pCi/g.

6. On pg. 19 (line 1) data from 44-12-01 are reported as “erratic”. In what way were they “erratic”? Does this mean highly variable and unreliable or what?

Response:

“Previous data erratic” was what was reported for lateral 44-15-01 before 11/24/73 in document SD-WM-TI-356. It is unknown if this means highly variable or unreliable or something different as previous data was not found.

7. On pg. 20, data from the mid 1960s in the laterals are cited, yet these data do not appear in Appendix D. Shouldn’t they be in App. D?

Response:

The only lateral data found from the 1960s (BNWL-CC-701) for tank SX-115 was in lateral 44-15-02 with a peak of 2,000 cpm at a distance of 14.2 to 26.2-ft from the northeast edge of the tank which is stated in Table D-1 as well as Section 4.1. Radioactivity levels in the other laterals were not stated in the BNWL-CC-701 document nor were they found in other documentation or data sheets.

8. Pg. 21, Fig. 4-2. A black dot is shown for drywells, but the same symbol is used to locate above background values along the laterals. These symbols should be revised so the two are distinguishable.

Response:

The figures have been updated to distinguish these differences.

9. For the 1966 “test wells”, information should be given as to the depth of the borings, type and thickness of casing, casing diameter, drill method and condition of the holes, as these parameters can affect the detector readings if not properly considered. In preparing the report, it would be probably good to provide a table of these parameters for each of the drywells and laterals for each tank.

Response:

We will refer to document BNWL-CC-701 for the test well details in Section 4.2.1.

10. For several of the laterals, activity was detected in the mid-1960s, with a couple of years of no data until about 1969 when no readings were detected. These are probably short-lived isotopes. Then you state that these lateral data will not be used as a basis for determining leak location. Why is that? Is that because these are likely mobile constituents that migrated from an original point of egress? Isn’t the point of egress possibly different from the actual location of liner failure?

Response:

The comment may be referring to drywells. Five of the drywells indicated radiation after the tank leak and then decayed away. The contour map in Figure 4-1 indicates that all of these five drywells (41-15-02, -03, -05, -09, and -10) are on the outside of the cesium

contamination boundary which used the information from the test well soil samples. This indicates that the early radiation in the drywells was probably due to shorter lived radioisotopes that decayed away. This was probably due to the nitrate leached waste present in the tank when the leak occurred. The nitrate leached waste was depleted in cesium as the cesium rich supernatant had been previously transferred from the tank. The explanation has been added to the SX-115 segment.

11. Pg. 31, for the uninformed, could you specify what a “haunch” is in referring to core drilling of the reinforced concrete?

Response:

We will specify what a “haunch” is referring to on page 31.

12. An estimated leak loss of 50,000 gals. Is provided based on the 18” drop in liquid levels. Might this estimate be low considering that liquid could continue to leave the tank during pumping?

Response:

It is possible the estimated leak loss of 50 kgal is a low estimate. We will address the leak volume could be larger than 50 kgal in Section 3.1.

For the SX Farm outline, I have the following suggestions:

1. A Glossary of acronyms and abbreviations would be helpful.

Response:

A glossary of acronyms and abbreviations will be added along with units.

2. As I asked during our meeting yesterday and Michelle has asked previously, there ought to be some analysis, given the available data, as to why some tanks that experienced conditions similar, if not identical, to failed tanks did not fail. Bulges seemed to occur in many, if not all tanks, but not all failed. You are in the best position to speculate or raise hypotheses as to why this might be.

Response:

A conclusion section will be added to the SX Farm section.