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13-TF-0014

MAR 1 8 2013

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Ms. Hedges:

THE U. S. DEPARTMET OF ENERGY, OFFICE OF RIVER PROTECTION (ORP) SUBMITTAL OF REVISED 200 WEST AREA TANK FARMS INTERIM MEASURES INVESTIGATION WORK PLAN IN COMPLETION OF HANFORD FEDERAL FACILITIES AGREEMENT AND CONSENT ORDER (HFFACO) MILESTONE M-045-20

This letter transmits the revised 200 West Area Tank Farms Interim Measures Investigation Work Plan (RPP-PLAN-53808, Revision 1) in completion of HFFACO Milestone M-045-20. This milestone requires that ORP submit to the Washington State Department of Ecology (Ecology) for review and approval as a primary document, an interim measures investigation work plan for vadose zone characterization at 241-TX Farm and 241-U Farm, and soil desiccation/contaminant removal proof-of-principal testing at 241-SX Farm. The Work Plan was
1218267 previously transmitted by letter 12-TF-0054. The enclosed revision incorporates the changes requested by Ecology as submitted formally at the January 2013, Tri-Party Agreement (TPA) Project Managers' Monthly Meeting, and referenced in letter 13-NWP-011. All changes have been discussed with Ecology staff. 1219195

Milestone M-045-20 also states that a draft TPA change control form will be submitted with due dates replacing "to be determined" dates for M-045-22, M-045-22-T01, M-045-22-T02 and M-045-22-T03. The draft TPA change control form was previously transmitted, and the signed TPA change control form is also enclosed.

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If you have any questions, please contact me or your staff may contact Joni F. Grindstaff, Federal Project Director, Retrieval and Closure Projects, (509) 376-6202.

Thomas W. Fletcher, Assistant Manager
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ATTACHMENT 1

13-TF-0014

RPP-PLAN-53808, 200 WEST AREA TANK FARMS INTERIM MEASURES INVESTIGATION WORK PLAN

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Abstract: For regulatory purposes, the Hanford Site single-shell tank (SST) farms have been grouped into seven waste management areas (A-AX, B-BX-BY, C, S-SX, T, TX-TY, and U) which are subject to the requirements of the Hanford Federal Facility Agreement and Consent Order (HFFACO) as past-practice units. Closure of the Hanford Site SSTs is required under HFFACO Major Milestone M-045-00. Preparation of this Work Plan will fulfill the deliverable required by HFFACO Interim Milestone M-045-20, due December 31, 2012.

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RPP-PLAN-53808
Revision 1

200 West Area Tank Farms Interim Measures Investigation Work Plan

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Date
February 2013

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EXECUTIVE SUMMARY

This document describes soil investigation and proof-of-principle testing actions to be performed in support of interim measures planning at three single-shell tank farms located in the 200 West Area of the Hanford Site: 241-TX, 241-U, and 241-SX Tank Farms (the TX, U, and SX Farms). The TX, U, and SX Farms are all believed to have been associated with losses of radioactive, hazardous tank waste to the soil column as a result of overfilling, leaks from ancillary equipment, and/or leaks from the tanks themselves. Summaries of potential soil contamination in these three farms are provided in this Work Plan. Additional soil characterization and technology investigations, described in this Work Plan, will support planning of future interim measures.

The interim measures, soil remediation, and closure of the single-shell tank farms are subject to the requirements of the *Hanford Federal Facility Agreement and Consent Order* (HFFACO) (Ecology et al. 1989). The initial submittal of this Work Plan fulfilled the deliverable required by HFFACO Interim Milestone M-045-20, due December 31, 2012. This revision responds to comments made by the State of Washington Department of Ecology (Ecology).

In 2009, HFFACO Milestone M-045-92 was established for construction of interim surface barriers (ISBs) to reduce moisture influx into tank farm contaminated soil and reduce migration of subsurface plumes. In June 2012, the HFFACO M-045 Milestone series was revised to establish new interim milestones and target dates for interim measures investigation work at the TX, U, and SX Farms. The stated goals of the work were to improve understanding of the vadose zone contamination below the tank farms and to conduct further development of vadose zone treatment technologies, which allow for the investigation of potential vadose zone treatment prior to, in conjunction with, or in lieu of, construction of ISBs proposed in HFFACO Milestone M-045-92. The interim measures investigation work at the TX, U, and SX Farms is to be conducted in accordance with documents developed under HFFACO Milestones M-045-20 (this Work Plan) and M-045-21, and investigation results are to be documented and evaluated under HFFACO Milestone M-045-22. Completion of interim measures investigation work will be followed by a decision point that precedes additional barrier construction actions, and possible modification of HFFACO Milestone M-045-92.

This Work Plan addresses the following three activities.

- At TX Farm, vadose zone characterization will be undertaken using direct push logging and sampling. The purpose of this characterization activity will be to evaluate the potential need for an ISB or other interim measure. A sampling and analysis plan will be provided to address the laboratory analysis of the soil samples to be obtained in TX Farm in accordance with HFFACO Milestone M-045-21, due March 31, 2013. The results of the TX Farm vadose zone characterization work will be documented in accordance with HFFACO Target Date M-045-22-T01. The TX Farm characterization report will be submitted to Ecology by September 30, 2014.

- At U Farm, additional vadose zone characterization will be undertaken with surface geophysical exploration, employing the deep electrodes that are already in place in

U Farm. The purpose of this characterization activity will be to evaluate the potential need for an ISB or other interim measures. The results of the U Farm vadose zone characterization work will be documented in accordance with HFFACO Target Date M-045-22-T02. The U Farm characterization report will be submitted to Ecology by April 30, 2014.

- Near SX Farm, initial field testing of soil desiccation/contaminant removal technology will be undertaken to determine if the technology has potential to remediate identified contamination. The initial test is limited to installing new direct push holes and performing a proof-of-principle test of soil desiccation/contaminant removal. The results of the SX Farm field testing will be documented in accordance with HFFACO Target Date M-045-22-T03. The SX Farm field test report will be submitted to Ecology by July 31, 2014.

In accordance with HFFACO Target Date M-045-22-T03, the SX Farm field test report will include a recommendation for further soil desiccation/contaminant removal for tank farm contamination or for performing ISB construction. The U.S. Department of Energy and Ecology will review the report generated in M-045-22-T03 and determine whether to continue with soil desiccation/contaminant removal testing and other interim measures. If the agencies agree to modify the work remaining under HFFACO Milestone M-045-92, DOE will propose a modification to that milestone.

Although the work described in this Work Plan does not constitute an interim measure, the work performed in accordance with this Work Plan will provide information to support future interim measure decisions. These decisions could include ISB construction at various locations (e.g., SX Farm, U Farm), contaminant removal at some location, or additional contaminant removal and/or desiccation testing.

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LIST OF TERMS

2D	two-dimensional
3D	three-dimensional
ARCHO	Atlantic Richfield Hanford Company
bgs	below ground surface
CHPRC	CH2M HILL Plateau Remediation Company
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
Ecology	State of Washington Department of Ecology
FIR	Field Investigation Report
FY	fiscal year
GPR	ground penetrating radar
HDW	Hanford Defined Waste
HFFACO	*Hanford Federal Facility Agreement and Consent Order*
ILL	interstitial liquid level
ISB	interim surface barrier
MW	Bismuth phosphate process waste
ORP	Office of River Protection
PNNL	Pacific Northwest National Laboratory
R1	REDOX waste
RCRA	*Resource Conservation and Recovery Act of 1976*
REDOX	Reduction-Oxidation (S Plant)
RSLTCK	R-Saltcake waste type
SGE	surface geophysical exploration

SGLS	spectral gamma logging system
SIM	Hanford Soil Inventory Model
SST	single-shell tanks
UPR	unplanned release
WAC	Washington Administrative Code
WIDS	Waste Information Data System
WMA	Waste Management Area
WRPS	Washington River Protection Solutions, LLC
WTW	well-to-well

1.0 BACKGROUND, PURPOSE, AND SCOPE

This section of the 200 West Area Tank Farms Interim Measures Preliminary Investigation Work Plan generally describes the Hanford Site 241-TX, 241-U, and 241-SX Tank Farms (the TX, U, and SX Farms). This section also provides background information about the purpose and scope of this Work Plan.

1.1 GENERAL DESCRIPTION OF THE TANK FARMS

There are 177 large, underground tanks located at the Hanford Site, 149 of them single-shelled. These tanks and their associated facilities are grouped into 12 "farms." The tanks were used for storage of some of the most hazardous waste produced during the processing of irradiated fuel to obtain plutonium. The tank farms were located downhill from chemical separations plants so that the wastes would gravity-flow to the tanks. Six single-shell tank (SST) farms (241-S, 241-SX, 241-T, 241-TX, 241-TY, and 241-U) are located in the 200 West Area of the Hanford Site. This Work Plan focuses on the TX, U, and SX Farms (Figure 1-1).

The TX Farm was constructed between 1947 and 1948 and consists of eighteen 100-series SSTs. Each of the TX Farm tanks has a capacity of 758,000 gal and a diameter of 75 ft. The U Farm was constructed between 1943 and 1944 and consists of twelve 100-series SSTs and four 200-series SSTs. Each U Farm 100-series tank has a design capacity of 530,000 gal and a diameter of 75 ft. Each U Farm 200-series tank has a capacity of 55,000 gal and a diameter of 20 ft. The SX Farm was constructed between 1953 and 1954 and is comprised of 15 SSTs, each with a nominal 1-million-gal storage capacity and 75-ft diameter. In addition to the large, underground tanks, the TX, U, and SX Farm systems include diversion boxes, pipelines, and other ancillary equipment that supported the transfer of waste to and from the various Hanford Site waste tanks and farms.

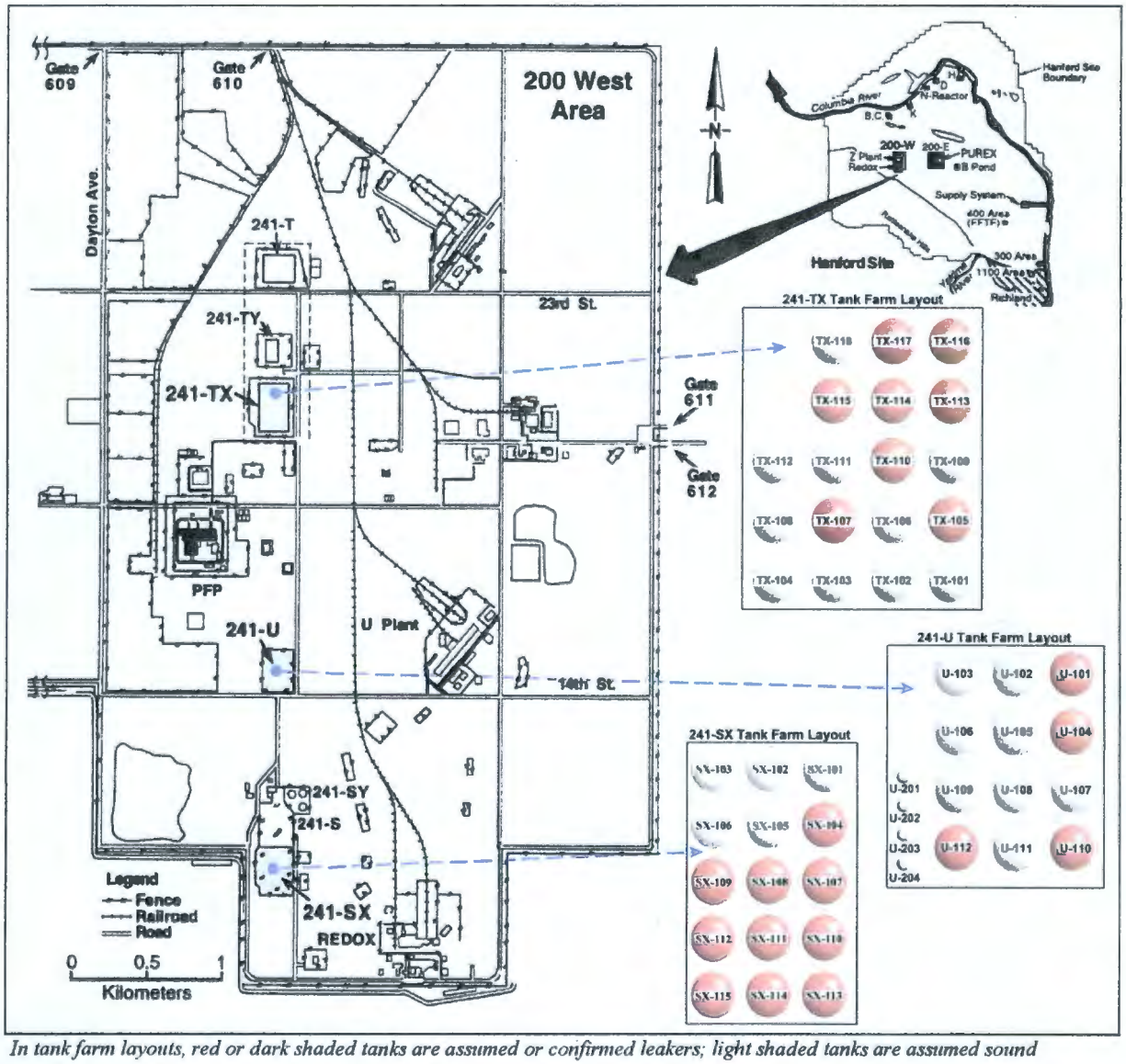
The TX, U, and SX Farms are all believed to have been associated with tank waste losses to the soil column as a result of overfilling, leaks from ancillary equipment, and/or leaks from the tanks themselves. Detailed estimates of soil waste inventories have been prepared for each of these tank farms and are documented in various reports identified later in this Work Plan. Summaries of potential soil contamination in these three farms are provided in Sections 2.0, 3.0, and 4.0 of this Work Plan. Additional soil characterization and technology investigations are required to more fully understand the scope of the impacts of tank waste losses to the soil column and to support planning of future interim measures.

1.2 PURPOSE OF THIS WORK PLAN

For regulatory purposes, the SST Farms have been grouped into seven waste management areas (WMAs): A-AX, B-BX-BY, C, S-SX, T, TX-TY, and U. These WMAs are treatment, storage, and disposal units to be closed under *Washington Administrative Code* (WAC) 173-303, "Dangerous Waste Regulations" and are subject to the requirements of the *Hanford Federal Facility Agreement and Consent Order* (HFFACO) (Ecology et al. 1989). Closure of the

Hanford Site SSTs is required under HFFACO Major Milestone M-045-00. The initial submittal of this Work Plan fulfilled the deliverable required by HFFACO Interim Milestone M-045-20, due December 31, 2012. This revision responds to comments made by the State of Washington Department of Ecology (Ecology).

Figure 1-1. Location of Hanford Site 241-TX, 241-U, and 241-SX Tank Farms.



In tank farm layouts, red or dark shaded tanks are assumed or confirmed leakers; light shaded tanks are assumed sound

Releases to soil that are associated with past operations and potential retrieval actions are part of the WMA. In accordance with the HFFACO M-045 milestone series and Appendix I, a *Resource Conservation and Recovery Act of 1976* (RCRA) corrective action process (e.g., investigation, remedy selection, and remedy implementation) will be used to evaluate releases to soil. As a part of this process, interim measures are to be considered where expedited actions are warranted. The HFFACO Milestone M-045-56 requires an annual meeting, where past SST farm interim measures are discussed and future interim measures are planned. As an

outcome of this process, an interim surface barrier (ISB) in the 241-T Tank Farm (T Farm) was constructed in 2007 and 2008 over an area including tank 241-T-106 (T-106), which experienced a large waste loss in 1973. The ISB was intended as a demonstration project to test the effectiveness of ISBs for reducing moisture influx and reducing migration of sub-surface plumes. Monitoring of barrier effectiveness is ongoing.

In 2009, HFFACO Milestone M-045-92 was established to provide additional ISBs for tank farm contaminated soil. Under this milestone, characterization was performed in several tank farms to determine whether any were likely candidates for barriers, and what the extent of a barrier might be. An ISB in 241-TY Tank Farm (TY Farm) was designed and constructed in 2010. In 2011, two barriers were designed to cover much of SX Farm. Construction of those barriers is currently planned for 2015, following completion of the contaminant removal proof-of-principle testing described in Section 4.0 of this Work Plan. Two additional ISBs may be designed and constructed under Milestone M-045-92, pending the outcome of all the studies described in this Work Plan.

When HFFACO Milestone M-045-92 was developed, there was a recognized need to address mobile contamination that had already been released to the soil from tank farm operations. Several factors were considered in developing this milestone, as follows.

- Other than soil removal, no promising vadose zone remediation technology was available.

- Mobile contaminants from tank farm sources were believed to migrate through the vadose zone at about 2 ft to 3 ft per year, and were thus expected to have reached around 80 ft to 100 ft below ground surface (bgs).

- Reduction of surface water infiltration was expected to reduce continued migration potential for existing contamination.

Since that time, additional progress has been made toward understanding the nature and treatment of mobile contaminants in the vadose zone, as documented in the following studies and reports.

- Initial vadose zone desiccation testing has shown that it is feasible to remove water from the vadose zone to limit contaminant migration. Under some circumstances, it may be possible to remove mobile contaminants as well as water from the vadose zone:

  - DOE/RL-2009-119, *Characterization of the Soil Desiccation Pilot Test Site*

  - PNNL-20507, *Pore-Water Extraction Intermediate-Scale Laboratory Experiments and Numerical Simulations*

  - PNNL-21882/RPT-DVZ-AFRI-011, *Pore-Water Extraction Scale-Up Study for the SX Tank Farm.*

- Characterization in the 200 West Area has shown that moisture and mobile contaminants can accumulate above the Cold Creek unit:

  - PNNL-13757-2, *Characterization of Vadose Zone Sediment: Borehole 299-W23-19 [SX-115] in the S-SX Waste Management Area*

  - RPP-RPT-41100, *Completion Report For TY Single-Shell Tanks Direct Push Barrier Investigation*

  - RPP-45961, *Completion Report for TY Interim Barrier Instrumentation Installation*

  - RPP-RPT-34870, *Small Diameter Geophysical Logging in the 241-TY Tank Farm*

  - RPP-RPT-51294, *Completion Report for the 241-S Tank Farm Direct Push Barrier Characterization*

  - RPP-47274, *2010 Completion Report for the 241-S/SX Tank Farm Direct Push Barrier Characterization*

  - RPP-6917, *SX-108 Slant Borehole Completion Report*

  - RPP-43548, *Completion Report for 241-SX Tank Farm Direct Push Barrier Characterization.*

- The Cold Creek unit may be acting as a natural sub-surface barrier in the 200 West Area, slowing the migration of moisture and contaminants to the groundwater.

The observation that mobile contaminants are associated with moisture plumes indicates a possible need to remove moisture already in the vadose zone. Removal of vadose zone moisture would also reduce or possibly prevent additional moisture and contaminant infiltration. Development of a removal technology for mobile contaminants offers opportunities to remove and treat the contamination, rather than just slow its migration to groundwater.

1.3 SCOPE OF THIS WORK PLAN

As identified in HFFACO Milestone M-045-20, the scope of this work plan encompasses three distinct actions. Completion of these actions will be followed by a decision point for determination of additional barrier construction actions. This Work Plan includes an implementation schedule (Section 5.0) that addresses the tasks described below.

- Perform vadose zone characterization in TX Farm, limited to direct push logging and sampling at ~12 locations. An average of three soil intervals will be collected and analyzed at each location. The purpose of this characterization activity will be to evaluate the potential need for an ISB or other interim measure (Section 2.0).

- Perform additional vadose zone characterization in U Farm, limited to surface geophysical exploration (SGE), which employs the deep electrodes that are already in place in U Farm. The purpose of this characterization activity will be to evaluate the potential need for an ISB or other interim measures (Section 3.0).

- Perform initial field testing of soil desiccation/water vapor and dissolved contaminant removal technology in or near SX Farm to determine if the technology has potential to remediate identified contamination (Section 4.0).

A separate sampling and analysis plan will be provided to address the laboratory analysis of the soil samples to be obtained in TX Farm in accordance with HFFACO Milestone M-045-21, due March 31, 2013.

Although the work described in this Work Plan does not constitute an interim measure, the work performed in accordance with this Work Plan will provide information to support future interim measure decisions. These decisions could include ISB construction at various locations (e.g., SX Farm, U Farm), contaminant removal at some location, or additional contaminant removal and/or desiccation testing.

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2.0 241-TX TANK FARM DIRECT PUSH SOIL INVESTIGATION

Milestone M-045-20 requires, in part, that this Work Plan describe the plan to perform initial direct push soil investigation in the TX Farm for purposes of evaluating potential need for an ISB or other interim measure.

2.1 SCOPE

This section of the Work Plan describes the plan to perform vadose zone characterization in TX Farm, limited to direct push logging and sampling at ~12 locations. The purpose of this characterization activity will be to evaluate the potential need for an ISB or other interim measure.

2.2 241-TX TANK FARM DESCRIPTION

The TX Farm was constructed between 1947 and 1948 in the 200 West Area and consists of eighteen 100-series SSTs, diversion boxes, pipelines, and other ancillary equipment (Figure 2-1). The tanks have a capacity of 758,000 gal, a diameter of 75 ft, and an operating depth of 23 ft. The base of the farm excavation is ~45 ft bgs, allowing space for footings and other construction requirements. The TX Farm tanks have a dished bottom with a 4-ft-radius knuckle. The tanks were designed with a primary mild steel liner and a concrete dome with various risers. They were set on a reinforced concrete foundation and covered with ~8 ft of backfill material (HNF-SD-WM-ER-321, *Supporting Document for the Historical Tank Content Estimate for TX Tank Farm*). Figure 2-2 shows a simple cross-sectional sketch of a TX Farm SST.

The 18 tanks were constructed at different elevations with connecting overflow lines that allowed waste to cascade from tank to tank. The first two cascades (tanks 241-TX-101 [TX-101] through 241-TX-108 [TX-108]) were filled with T Plant metal waste. During the 1950s, six of the tanks were sluiced until empty and started receiving Reduction-Oxidation (S Plant) (REDOX) waste. Tanks 241-TX-103 (TX-103) and TX-108 were used for tributyl phosphate waste after sluicing. These tanks were used as evaporator bottoms waste feeder tanks and recycled for the 242-T Evaporator in later years. The third cascade (tanks 241-TX-109 through 241-TX-112 [TX-112]) stored first-cycle decontamination waste before use with the 242-T Evaporator. The last six tanks were not used until the early 1950s, and were used in combination with the 242-T Evaporator, as feed, bottoms and recycle waste tanks. The TX Farm has been completely interim stabilized and isolated. All raw water is cut off at the farm edge; however, minimal air and electrical supplies remain within the tank farm.

Figure 2-3 shows the location of drywells in TX Farm. There are a total of 96 drywells in TX Farm that are used as vadose zone monitoring wells; 9 of these drywells were installed in 1949, with the rest in 1970 or later.

Figure 2-1. Waste Management Area TX-TY and Surrounding Facilities.

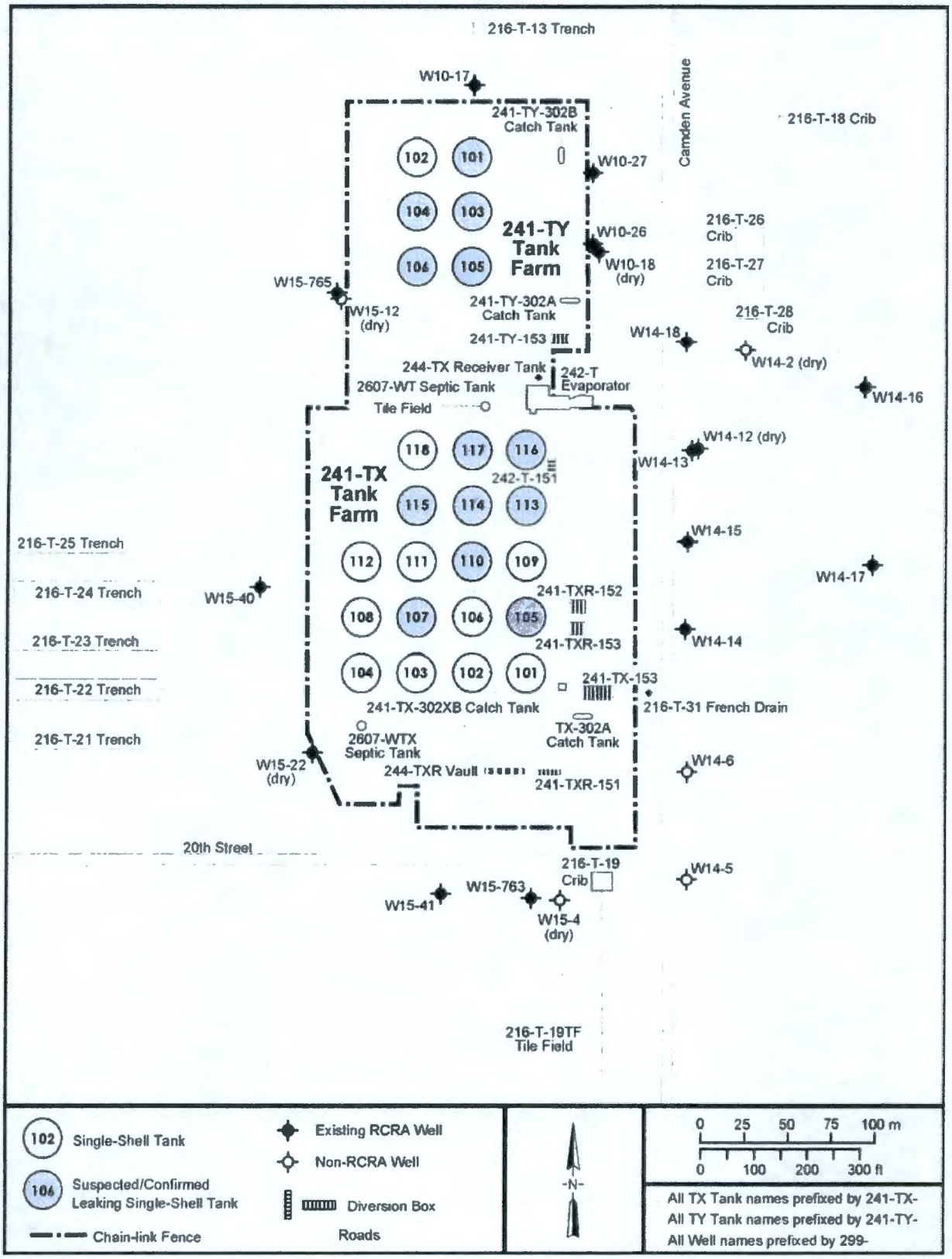


Figure 2-2. Simplified Sketch of 241-TX Farm Tank.

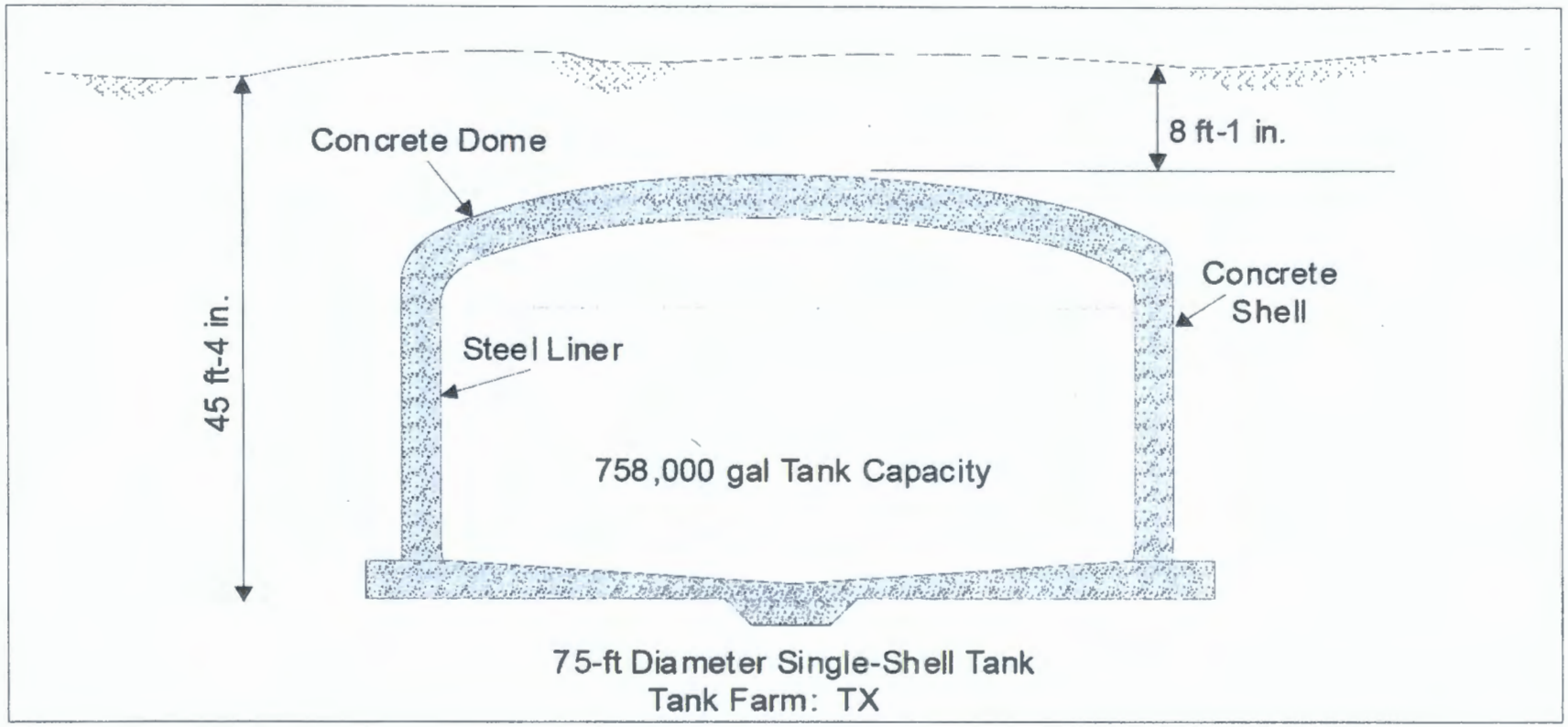
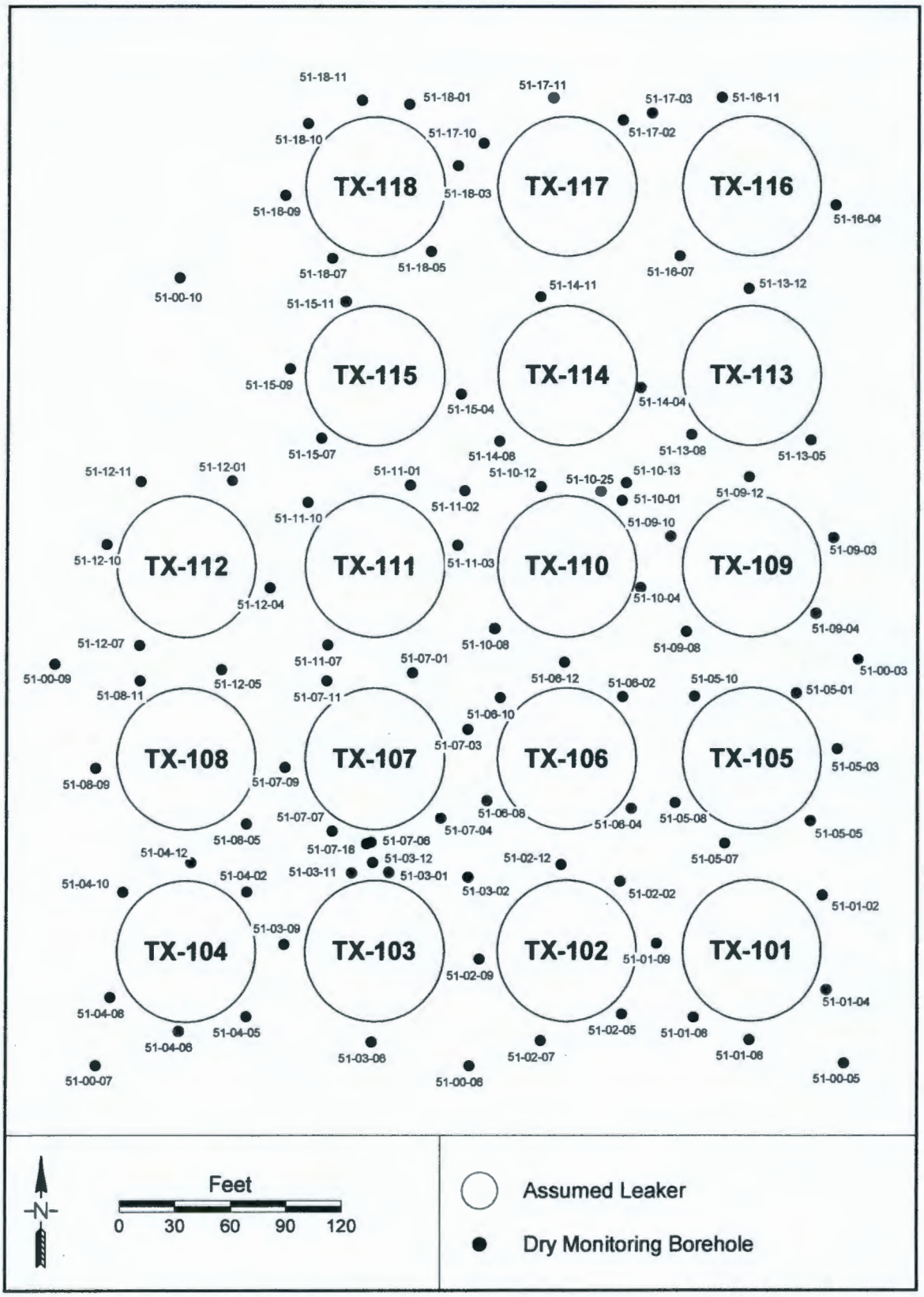


Figure 2-3. 241-TX Farm Single-Shell Tanks and Drywells.



2.2.1 Leak Assessment Information, Unplanned Releases, and Tank Best Basis Inventory

Ecology, along with the tank farm contractor for the U.S. Department of Energy (DOE), developed a process to reassess selected tank leak estimates (volumes and inventories), and to update SST leak and unplanned release (UPR) volumes and inventory estimates as emergent field data is obtained (RPP-32681, *Process to Assess Tank Farm Leaks in Support of Retrieval and Closure Planning*)[1]. This process was started for TX Farm in the summer of 2011 when a number of meetings with Ecology took place. However, the final report documenting this process was not completed in time for this Work Plan. The final report is due fiscal year (FY) 2013.

However, the meeting summaries that provide details about some of the TX Farm tanks are available in RPP-54073, *TX Tank Farm Leak Inventory Assessment Meeting Summaries*. This section provides brief summaries of the information, taken from RPP-54073. Information on other UPRs in TX Farm is taken from RPP-23752, *Field Investigation Report for Waste Management Areas T and TX-TY* and the Waste Information Data System (WIDS), which is an electronic database of waste site information for the Hanford Site. Following the description of the UPRs is a brief summary of the Best Basis Inventory of contaminants that may impact groundwater if a UPR occurred at TX Farm.

Known sources of contamination discussed in RPP-54073 and RPP-23752 include: tanks 241-TX-105 (TX-105), 241-TX-107 (TX-107), 241-TX-110 (TX-110), 241-TX-113 (TX-113), 241-TX-114 (TX-114), 241-TX-115 (TX-115), 241-TX-116, and 241-TX-117); and UPRs (UPR-200-W-12, UPR-200-W-17, and UPR-200-W-100). Each of these occurrences is described below.

- Tank TX-105 was reviewed by the leak assessment team during the June 14, 2011 and July 12, 2011 meetings (RPP-54073). 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, *Waste Tank Summary Report for Month Ending October 31, 2012*, Rev. 295). Process data show 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 that bismuth phosphate process waste (MW) may have been released in the early 1950s.

  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 RPP-19822, *Hanford Defined Waste Model – Revision 5.0* 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.

[1] This process does not represent a formal tank leak assessment per formal tank leak assessment processes.

- Tank TX-107 was categorized as "questionable integrity" in 1977 based on liquid level decreases and increasing drywell activity, and declared a confirmed leaker in 1984 with a leak volume estimate of 2,500 gal based on increasing activity in nearby drywells (HNF-EP-0182). Spectral gamma logging system measurements obtained in 1996 show ^{60}Co and ^{154}Eu gamma activity in the zones from 50 to 70 ft bgs in drywells 51-07-18 and 51-07-07 and in other drywells between SSTs TX-103 and TX-107, with a total estimated ^{60}Co activity of 0.075 Ci (using the ^{60}Co contaminated threshold values >1 pCi/g from GJO-97-13-TAR/GJO-HAN-11, *Hanford Tank Farms Vadose Zone: TX Tank Farm Report*). Gamma activity near tank TX-103 was attributed to a leak from tank TX-107. Based on the 2,500-gal leak from HNF-EP-0182, RPP-26744, *Hanford Soil Inventory Model, Rev. 1*, estimates the nitrate inventory for this UPR to be ~6,500 kg (~14,330 lbs) with a maximum of ~17,750 kg (~39,132 lbs).

  However, the UPR at Tank TX-107 was reviewed by the leak assessment team during the July 12, 2011 meeting (RPP-54073). The team concluded that a leak in the TX-107 tank liner released an estimated volume of 1,300 gal of strontium recovery waste, with an inventory of 300 Ci of ^{90}Sr (decayed to 1996). Based on the estimated ^{60}Co plume size (for >1 pCi/g) of 3,500 m^3 (124,000 ft^3) and assuming a 10% increase in moisture content as a result of the release, the diluted plume may be as large as 100,000 gal.

- Tank TX-110 information was presented and discussed by the assessment team on August 9, 2011 (RPP-54073). Tank TX-110 was declared "questionable integrity" in 1977 as a result of a low activity radiation peak detected at 54 ft bgs in drywell 51-10-01. The peak rapidly decayed between 1977 and 1985 following a ^{106}Ru decay line, and 1996 spectral gamma logging system (SGLS) data shows less than 1 pCi/g gamma activity in drywells near tank TX-110 except for small spikes to <10 pCi/g near surface and at the bottom of drywell 51-10-12. This indicates the historical gamma peak was likely due to waste migrating from another source, possibly in the area around tanks TX-107 or TX-114. The waste in tank TX-110 has not been sampled. No data or information was found indicating the presence of a liner leak and there is little data to suggest a release occurred near the tank.

- Tank TX-113 information was presented and discussed by the assessment team in the August 9, 2011 meeting (RPP-54073). Tank TX-113 was declared "questionable integrity" in 1974 as a result of increasing gamma activity in drywell 51-14-04. Historical transfer records show that the tank was filled above the cascade outlet as a result of cascade plugging of the cascade lines, and in-tank photographs show the waste level was well above the cascade line, indicating the potential for releases from the cascade lines or spare inlet ports. Drywells around tank TX-113 show ~10 pCi/g of ^{137}Cs activity between the surface and 20 ft below surface. This activity is attributed to cascade line leaks, near-surface transfer line leaks, or spills during operations. At about 45 ft bgs (below the tank base) in drywell 51-14-04, 1×10^5 pCi/g of ^{137}Cs activity was detected. Because there was a sharp ^{137}Cs spike at 45 ft with no path to it, the high ^{137}Cs activity has all indications to be from a liner leak from tank TX-114. Tank TX-114 appears to be the more likely source of the detected contamination. As a result, a waste inventory associated with this plume is assigned to tank TX-114.

- Tank TX-114 information was presented and discussed by the assessment team in the August 9, 2011 and August 23, 2011 meetings (RPP-54073). Tank TX-114 was declared "questionable integrity" in 1974, the same time as tank TX-113, as a result of increasing gamma activity in drywell 51-14-04, located only 2 ft from the east side of tank TX-114. Like tank TX-113, historical transfer records show that tank TX-114 was filled above the cascade outlet as a result of plugging of the cascade lines, and in-tank photographs show the waste level was well above the cascade line, indicating the potential for releases from the cascade lines or spare inlets. The drywells show ~100 pCi/g of ^{137}Cs activity between the surface and 20 ft below surface in drywells 51-14-04 and 51-14-11. This activity was attributed to cascade line leaks, near-surface transfer line leaks, and spills during operations.

  Drywell 51-14-04 shows a ^{137}Cs peak at about 45 ft bgs with nothing above it. Assuming the ^{137}Cs activity is from a leak near the bottom of the tank, based on the size and shape of the plume, if the drywell activity represents the edge of the plume and the entire plume is at ^{137}Cs sorption capacity (5×10^7 pCi/g), an estimated 6,000 Ci could have been released with a release volume of 7,000 gal based on 1974 tank samples (0.83 Ci/gal). This sample result is assumed to be representative of the waste leaked because the same waste type (evaporator bottoms) was in the tank from 1954 to 1974, and high gamma activity was present when drywell 51-14-04 was first installed in 1974. This estimate is based primarily on data from one drywell near the release location. The waste type and time of releases, the date and source of releases, the size and shape of releases, and the composition of waste released were assumed based on limited data. If better inventory estimates are required, additional data is needed.

- Tank TX-115 information was presented and discussed by the assessment team in the August 23, 2011 meeting (RPP-54073). Tank TX-115 was declared "questionable integrity" in 1977 as a result of gamma activity in drywell 51-15-04. Historical transfer records and photos show that tank TX-115 was filled above the cascade outlet in 1952, indicating the potential for releases from the cascade line. However, there is no evidence of a liquid level decrease until supernate was pumped in the first quarter of 1953. This suggests that little or no liquid was released when the tank was overfilled. The SGLS logs in drywells around the tank show low levels of ^{137}Cs activity (<10 pCi/g). Historical gamma peaks were observed in 1977 in drywells 51-15-04. The gamma peak started at about 20 ft bgs and migrated deeper and decayed away by 1994 indicating a mobile, short-lived radionuclide such as ^{106}Ru that may have migrated from a cascade line leak or spare inlet overflow (spare inlets are near drywell 51-15-04). Because drywell data shows low activity and there is no occurrence report or indication of a liquid level decrease, no inventory for a release was estimated for this tank.

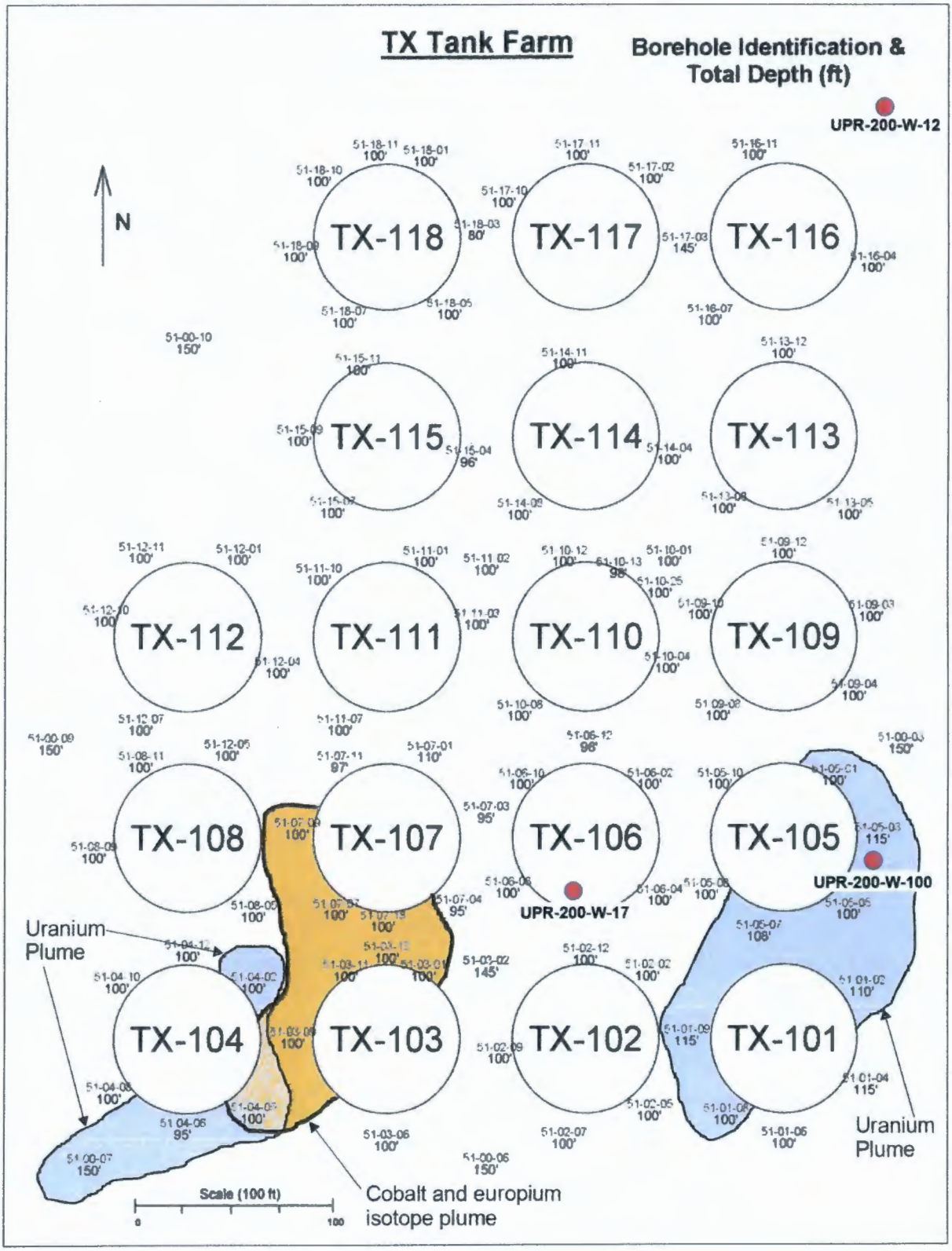
- Tanks 241-TX-116 and 241-TX-117 information was presented and discussed by the assessment team in the August 23, 2011 and September 13, 2011 meetings (RPP-54073). These tanks were both declared "questionable integrity" in 1977 as a result of gamma activity in drywells near the tanks. Historical transfer records and photos show that both tanks were filled above the cascade outlet, indicating the potential for releases from the cascade line or spare inlet overflow. The SGLS logs in drywells around the tank show

low levels of ^{137}Cs activity (<100 pCi/g) below 20 ft bgs. The historical gamma peaks of 2,000 and 3,300 counts per second were discovered in drywells 51-16-04 and 51-16-11 at ~40 and 50 ft bgs, respectively, when the wells were first logged in 1973. The gamma activity quickly decayed away in drywell 51-16-04, and decayed then increased to 6,500 counts per second in drywell 51-16-11 before it decayed away. Except for low levels of near-surface ^{137}Cs activity (<50 pCi/g) and occasional hits <1 pCi lower in the drywell, gamma activity was not present in 1996 SGLS logs. This indicates the presence of mobile and/or quick-decaying radionuclides that may have migrated from another source such as tanks TX-110 or TX-114, or may be related to small releases from tank systems releases (overflows) or transfer lines. Because there was no indication of a release from the tank waste surface measurements and because SGLS gamma activity was low, no inventory was estimated for these tanks.

- Of the UPRs of waste within TX Farm, only UPR-W-200-100 lost a significant volume of waste (2,500 gal). This was a transfer line leak between tanks TX-105 and 241-TX-118. First cycle waste was discovered leaking from a waste transfer line in November 1954. Coordinates included in ARH-2757 Pt. 4, *Radioactive Contamination in Unplanned Releases to Ground within the Chemical Separations Area Control Zone through 1972 (Exclusive of Liquid Waste Storage Tank Farms)* place the release adjacent to the east side of tank TX-105, inside the tank farm fence. The maximum dose rate was 4.5 rad per hour at a distance of 1.2 meters (4 ft). The liquid release covered an area of ~30 by 38 meters (100 by 125 ft). The waste contained ~10 Ci of fission products. The nitrate inventory associated with UPR-200-W-100 has been estimated to be ~1,050 kg (~2,315 lbs) with a maximum of ~2,400 kg (~5,291 lbs) (RPP-26744). The contaminated area was surrounded with a chain and radiation zone signs, and was covered with clean soil in 1954. RPP-26744 estimated a nitrate inventory of ~4 kg (~9 lbs) with a maximum of ~13 kg (~29 lbs) for UPR-200-W-12.

In addition to the UPRs discussed above, Revision 0-A of RPP-23752 delineated two uranium plumes and a co-mingled ^{60}Co and europium plume in the southern half of TX Farm from drywell measurements. The location of these plumes relative to the TX Farm tanks and adjacent UPRs is illustrated in Figure 2-4. The first plume is between tanks 241-TX-101 and TX-105 with ^{238}U values ranging from 1 to 100 pCi/g from 45 to 75 ft bgs. The ^{235}U concentrations mirror the ^{238}U values, but about an order of magnitude lower. The highest uranium levels occur at shallow depths toward the northeast. The second uranium plume with similar concentrations is found in drywells around tank 241-TX-104 at a depth of 45 to 100 ft bgs, again with the higher contamination levels occurring at shallow depths toward the northeast. The presence of uranium contamination at these concentrations strongly indicates leakage of metal waste in the early 1950s. No other substantive information is available that describes the nature or cause of this leak. There is also a ^{60}Co/europium plume (Figure 2-4, gold area) in the drywells between tanks TX-103, TX-105, and TX-107. The plume is located ~45 to 75 ft bgs and is related to the tank TX-107 leak event in the mid-1970s.

Figure 2-4. Waste Management Area TX-TY Elevated Gamma Data in Drywells Showing the Uranium, Cobalt-60, and Europium Plumes in Southern 241-TX Tank Farm.



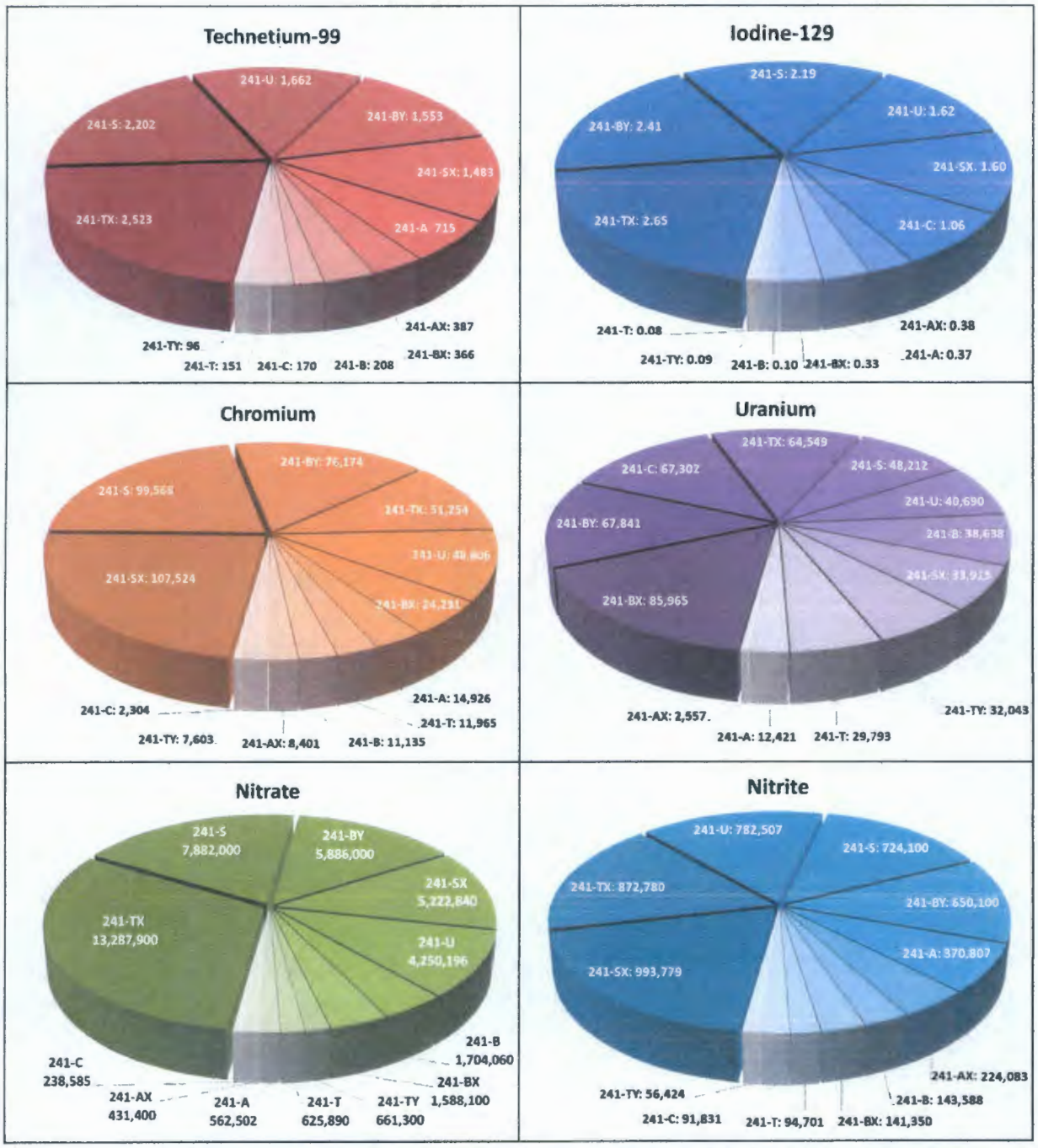
In addition to protecting groundwater from past UPRs, an interim measure such as the placement of an infiltration barrier over TX Farm may also protect groundwater by slowing and/or stopping a possible future leak from the SSTs. To understand the impacts of a possible future UPR from SSTs, the Best Basis Inventory database was queried for those constituents that could impact groundwater (^{99}Tc, ^{129}I, chromium, nitrite, nitrate, and uranium) if a UPR were to occur. This inventory was downloaded from Tank Waste Information Network System on April 10, 2012, with the radionuclides decayed to January 1, 2008. The inventory of groundwater-impacting constituents was summed to calculate a percentage of those contaminants for each tank farm over the total inventory. The results are shown in Figure 2-5 as a series of pie charts. Individual pie slices are sized to illustrate the relative quantities of a given contaminant in each SST farm. From these pie charts, it can be readily seen that TX Farm has the highest percentage of ^{99}Tc, ^{129}I, and nitrate. Installation of an interim measure such as an infiltration barrier would protect groundwater not only from past UPRs, but also from future releases if a UPR occurred before waste in these tanks is retrieved.

2.2.2 Geology, Stratigraphy, and Hydrology

The geology of the T, TX, and TY Farms and vicinity is well understood as a result of several decades of site characterization activities. It has been described in numerous reports including:

- ARH-LD-135, *Geology of the 241-T Tank Farm*
- ARH-LD-136, *Geology of the 241-TX Tank Farm*
- ARH-LD-137, *Geology of the 241-TY Tank Farm*
- RHO-ST-23, *Geology of the Separation Areas, Hanford Site, South-Central Washington*
- PNL-6820, *Hydrogeology of the 200 Areas Low-Level Burial Grounds – An Interim Report*, Volume 1
- PNL-7336, *Geohydrology of the 218-W-5 Burial Ground, 200 West Area, Hanford Site*
- WHC-SD-EN-TI-019, *Hydrogeologic Model for the 200 East Groundwater Aggregate Area*
- GJO-97-13-TAR/GJO-HAN-11; RPP-8531, *Vadose Zone Geology of Boreholes 299-W10-27 and 299-W11-39 T-TX-TY Waste Management Area Hanford Site, South-Central Washington*
- RPP-7123, *Subsurface Conditions Description of the T and TX-TY Waste Management Areas.*

Figure 2-5. Inventory of Contaminants That May Impact Groundwater in Single-Shell Tank Waste.



Note: Inventory units for radiological constituents are curies; inventory units for non-radiological constituents are kilograms.

The main source of information about geologic strata underlying the Hanford Site and the tank farms is data from the drilling of boreholes and the analyses of the sediments and contaminants within them. Four major stratigraphic units underlie the T, TX, and TY Farms (in ascending order) and include the following:

- Columbia River Basalt Group
- Ringold Formation (including members of Taylor Flats [Rtf] and members of Wooded Island [Rwi])
- Cold Creek unit (including subunits CCU_u and CCU_l)
- Hanford formation (including subunits H1 and H2).

East-West and North-South cross sections are given in Figures 2-6 and 2-7, respectively, which show the general layout of the sedimentary units underlying the tank farms. Of these, the backfill, Hanford formation, Cold Creek unit, and the upper portion of the Ringold Formation make up the vadose zone. The unconfined aquifer is contained within the lower portion of the Ringold Formation. All major stratigraphic units are inferred to be essentially continuous in this area, although unit thicknesses vary and some subunits are not present at a few boreholes. Waste Management Area TX-TY was constructed within the Cold Creek syncline and sits on the northern limb of the syncline; the major units to dip gently west to southwest toward the axis of the Cold Creek syncline.

Sediments in the vadose zone vary from open-framework gravels of the gravel-dominated facies and interbedded sand and silt of the silt-dominated facies of the Hanford formation to calcium carbonate-rich deposits of the Cold Creek unit and cemented gravels of the Ringold Formation. These sediments are characterized by numerous lateral discontinuities, such as pinchouts, erosion truncations, and irregular flow patterns. If clastic dikes are present, they may enhance vertical flow patterns. Therefore, there are numerous possible avenues for contamination to migrate through the vadose zone (HNF-4936, *Subsurface Physical Conditions Description of the S-SX Waste Management Area*).

Given the nature and extent of tank waste contamination in the vadose zone underlying WMA TX-TY, the most significant geologic features that have influenced contaminant migration and distribution through the vadose zone are the highly-cemented CCU_l layer (and perhaps the underlying silt-rich member of Taylor Flats, Ringold Formation [Rtf]) and the slight dip of all layers toward the south. The CCU_l, because of its thickness and low permeability, appears to have largely prevented vertical migration of tank waste contaminants below the subunit and enhanced lateral migration. Also, due to the general stratigraphic dip to the south, a greater portion of the inventory has migrated in this direction.

The excavation for WMA TX-TY tanks was constructed entirely in the Hanford formation sediments. The backfill placed around the completed tanks was the excavated materials that were stockpiled next to the tank farm during tank construction. The base of the excavation is ~45 ft bgs.

Figure 2-6. East-West Hydrogeologic Cross Section A-A' across the 241-TX Tank Farm.

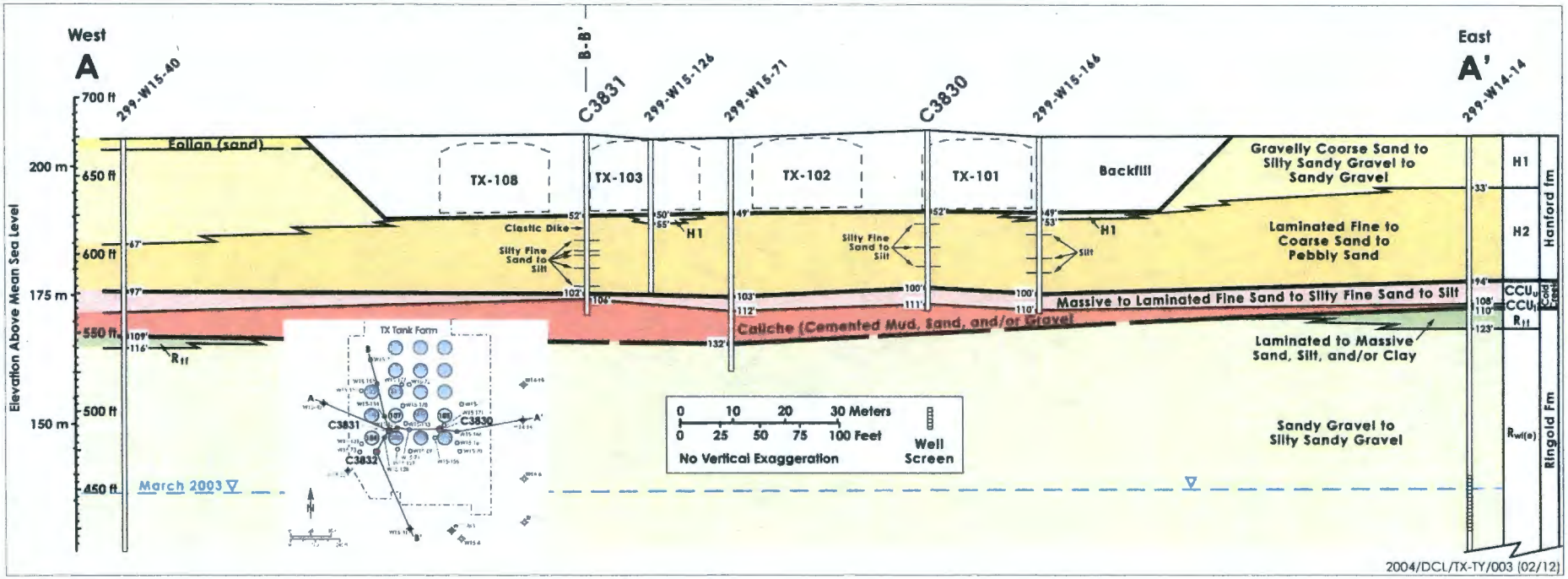
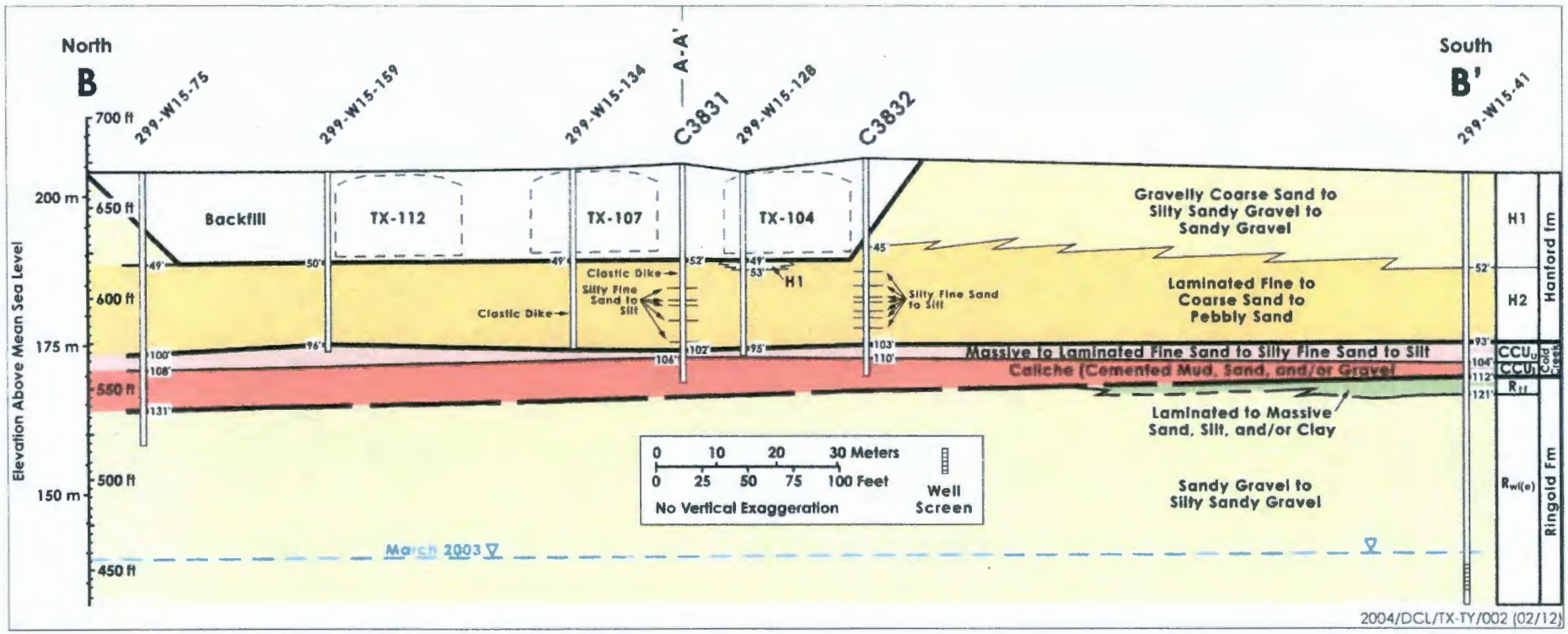


Figure 2-7. North-South Hydrogeologic Cross Sectiou B-B' across the 241-TX Tank Farm.



In the vicinity of TX Farm, the top of the saturated zone is 235 ft bgs and the base (top of the Columbia River Basalt Group) is about 495 ft bgs. The direction of current groundwater flow is southeasterly (eventually turning east to the river) in the southern portion of the 200 West Area, while it is north and northeast (through Gable Gap) in the northern portion of the 200 West Area. However, DOE/RL-2011-118, *Hanford Site Groundwater Monitoring for 2011* reports that the groundwater flow direction and rate at WMA TX-TY is influenced by the 200-ZP-1 pump-and-treat system.

2.2.3 Potential Soil Contamination

All wells were spectral gamma logged in the late 1990s (GJO-97-13-TAR/GJO-HAN-11 and GJO-97-13-TARA/GJO-HAN-11, *Hanford Tank Farms Vadose Zone: Addendum to the TX Tank Farm Report*). Of the 96 drywells in TX Farm, 43 of them had ^{137}Cs contamination greater than or equal to 10 pCi/g (Figure 2-8). Most of the ^{137}Cs contamination was found from 0 to 45 ft bgs, with only six drywells (Figure 2-9) having contamination above 100 pCi/g between ground surface and 45 ft bgs. Only drywell 51-14-04 had ^{137}Cs concentrations above 10 pCi/g at greater than 45 ft bgs, and no ^{137}Cs values were above 10 pCi/g at depths lower than 50 ft bgs. The highest recorded ^{137}Cs value was ~67,750 pCi/g at 46 ft bgs at drywell 51-14-04.

Drywells 51-03-01, 51-03-11, 51-03-12, 51-07-18, 51-07-07, 51-03-09, and 51-04-05 show commonality in current spectral gamma characteristics and historical migration patterns, suggesting leakage from tank TX-107 beginning about 1975. The primary gamma emitter is ^{60}Co, which is present from 45 to 70 ft bgs. Europium-154 also is present at 50 to 60 ft bgs in all but the two southernmost drywells, 51-03-09 and 51-04-05. Historical gamma data indicate migration of ^{60}Co from northeast to the southwest over time between 1977 and 1992. Interpreted historical gamma data (RPP-6353, *Analysis and Summary Report of Historical Dry Well Gamma Logs for 241-TX Tank Farm – 200 West*) suggest more than one migration event in drywells 51-03-11, 51-07-18, 51-07-07, and 51-04-05. Given the time of the leak and the tank waste history, waste lost from this tank was B Plant waste, generated by ^{137}Cs recovery from Plutonium Uranium Extraction Plant supernatant liquid.

2.2.4 Surface Geophysical Exploration Information

Surface geophysical exploration techniques were used to investigate the subsurface of WMA TX-TY from September of 2007 to April of 2008. At this WMA, a full application of SGE, including well-to-well (WTW), surface-to-surface, and well-to-surface resistivity surveys was made. In addition, detailed ground-penetrating radar (GPR) surveys (RPP-RPT-38104, *Surface Geophysical Exploration of TX-TY Tank Farms at the Hanford Site: Results of Background Characterization with Ground Penetrating Radar*) were conducted in the farms, and both electromagnetic induction and differential magnetometry surveys (RPP-RPT-36893, *Surface Geophysical Exploration of TX and TY Tank Farms at the Hanford Site: Results of Background Characterization with Magnetics and Electromagnetics*) were run in areas outside of the farms. For WMA TX-TY, the surveys covered the extensive waste sites adjacent to the tank farms, as well as the actual tank farms. The results are documented in RPP-RPT-38320, *Surface Geophysical Exploration of the TX and TY Tank Farms at the Hanford Site* and RPP-ENV-38767, *Summary and Assessment of Surface Geophysical Exploration in the TX and TY Farms*.

Figure 2-8. Gamma Contamination > 10 pCi/g and < 100 pCi/g between 0 and 35 Feet below Ground Surface.

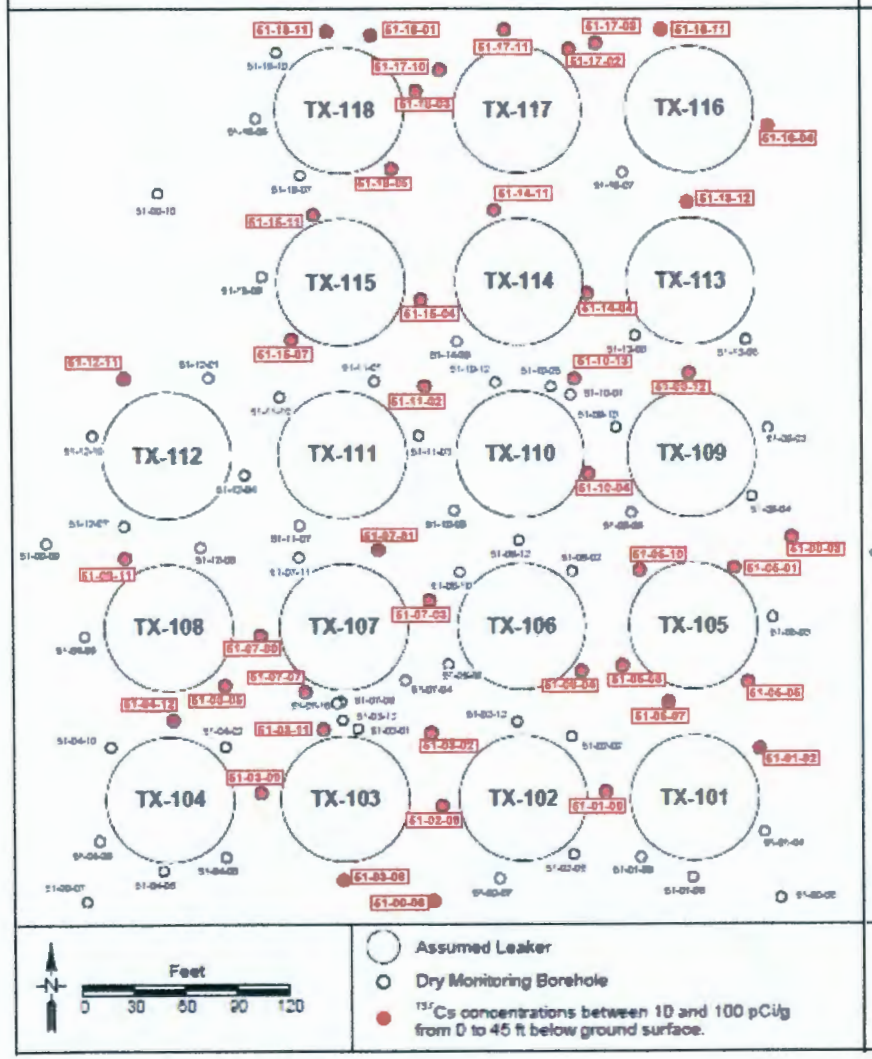
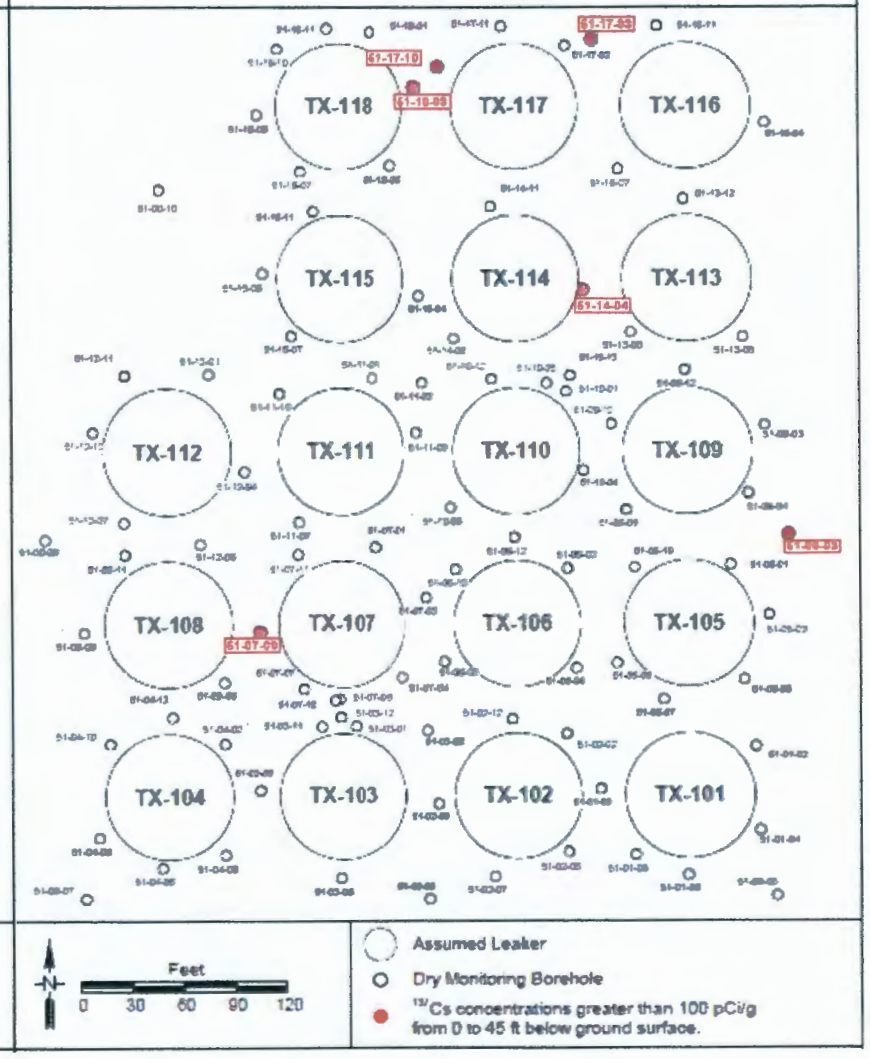


Figure 2-9. Gamma Contamination > 100 pCi/g between 0 and 35 Feet below Ground Surface.



A review of results of the TXTY-WTW8 inversion model domain (Figure 2-10) shows a primary low resistivity target of 0.1-5 ohm-m (red) and 5-10 ohm-m (green). The distribution of the primary and secondary targets in this model is more dispersed and irregular when compared to the TXTY-WTW6 domain, which covers TY Farm. This target dispersion may be influenced by the significantly higher number of buried pipes and other infrastructure shown within the TX Farm boundary. The clustering of low resistivity targets around tanks TX-107, TX-108, 241-TX-111, and TX-112 and the more dispersed low resistivity targets in other parts of the domain do not strictly follow the paths of known buried infrastructure, but they appear to be influenced by them to some degree in this area.

2.2.5 Groundwater Contamination Summary

The groundwater sample data shows elevated levels of ^{99}Tc, nitrate, and chromium near TX Farm. However, ^{99}Tc, ^{129}I, nitrate, and chromium showed the same declining trend during the reporting period. This may indicate that all four contaminants shared a common source. Figures 2-11 and 2-12 show ^{99}Tc and nitrate concentrations, respectively, in the aquifer in the vicinity of TX Farm. Accelerated recharge from these sources may have contributed to driving mobile contaminants such as ^{99}Tc to the groundwater. Additional information on contaminants in the groundwater near WMA TX-TY can be found in DOE/RL-2011-118.

2.3 DESCRIPTION OF PLANNED WORK

The description of the planned work is discussed in the following subsections:

- Goals of Current Investigation
- Parameters of Interest and Action Levels
- Direct Push Sample Intervals.

2.3.1 Goals of Current Investigation

There has been extensive characterization work conducted in WMA TX-TY as part of the Phase 1 characterization effort and the installation of an ISB over TY Farm. Information gathered during those characterization efforts indicates that TX Farm contaminant transport could be reduced or removed by an ISB or other interim measure. Gathering additional vadose zone characterization information at TX Farm would result in a better understanding of the benefits of an interim measure at TX Farm. The goals of the current investigation are to determine the approximate boundary of the contaminated zone under TX Farm and the approximate depth of the mobile contaminants, to support a decision regarding the potential effectiveness of an ISB or other interim measure.

Figure 2-10. Well-to-Well Resistivity Inversion Model Results for the TXTY-WTW8 Domain.

Figure 2-11. Technetium-99 in Upper Aquifer at Waste Management Area TX-TY.

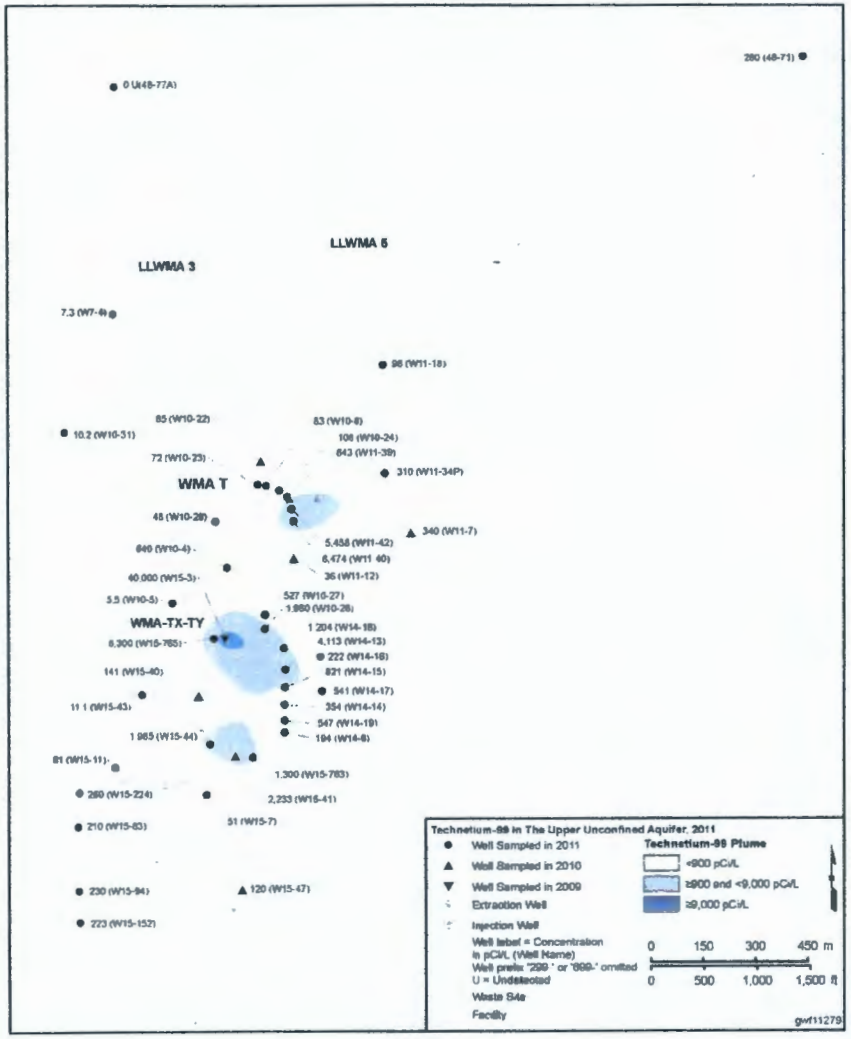
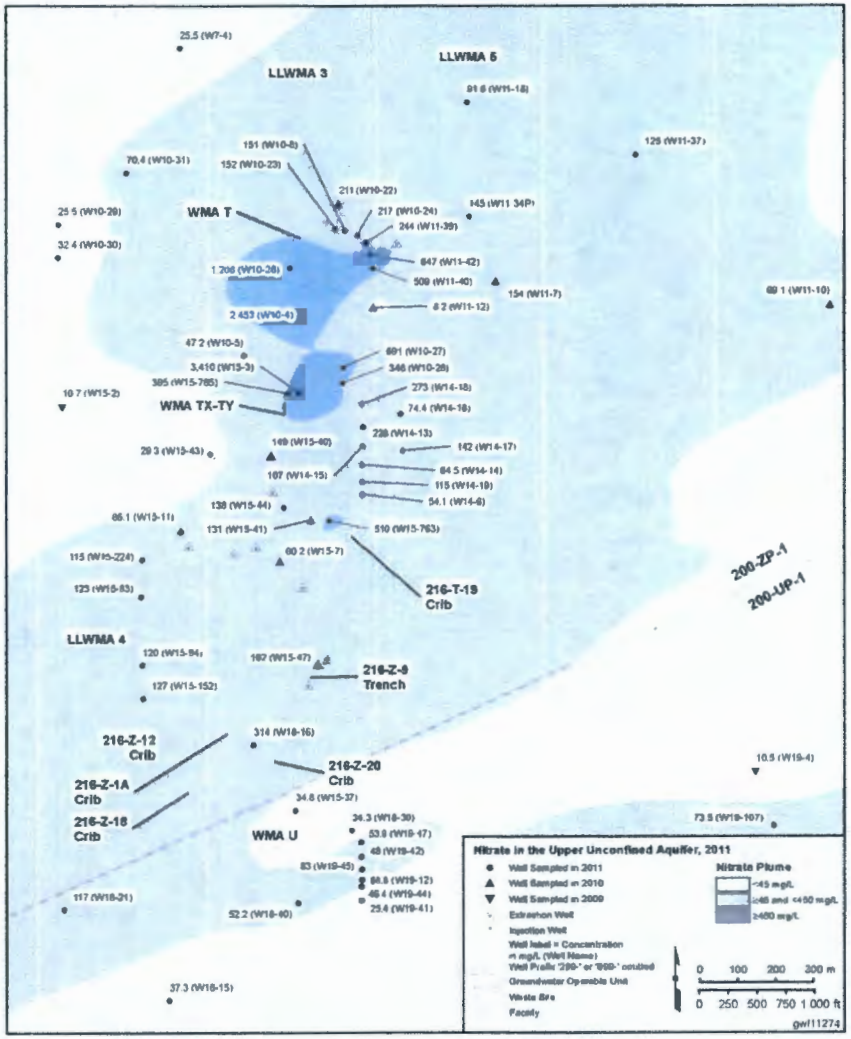


Figure 2-12. Nitrate in Upper Aquifer at Waste Management Area TX-TY.



Approximately 12 direct push sites have been allotted for TX Farm interim measure evaluation efforts. First, eight locations will be pushed to outline the area of interest. The remaining four sites will be selected after the initial results (i.e., logging and quick turn-around results) are reviewed. These four locations will be selected to further define vadose zone contamination. It is anticipated that depths up to 150 ft bgs will be reached; however, it is likely that the Cold Creek unit will be a barrier to the direct push and the direct push will stop at the Cold Creek unit (~100 to 132 ft bgs).

With respect to direct push efforts in TX Farm, the initial eight sample locations have been selected by targeting the following areas:

- where there have been known and possible waste releases and leaks (i.e., tanks TX-105, TX-107, 241-TX-117, and UPR-200-W-100) detected by drywell monitoring,
- suspected vadose zone plume areas southwest of tanks 241-TX-104 and TX-101,
- SGE anomalies between tanks TX-108 and TX-112 and between tanks 241-TX-115 and 241-TX-118,
- along outer edges of tank locations to assist in identifying the boundary of the contaminated vadose zone underneath TX Farm.

Direct push placement locations avoid contact with, and pushing through, existing infrastructure (whether on the surface or in the subsurface; e.g., tanks, pipes, diversion boxes). Figure 2-13 shows the topography in and around WMA TX-TY and the recommended initial direct push locations for the TX Farm. These direct push locations were recommended in a meeting held on September 6, 2012 in the State of Washington Department of Ecology (Ecology)'s offices. The personnel that attended the meeting consisted of staff from Ecology, U.S. Department of Energy (DOE) Office of River Protection (ORP), Washington River Protection Solutions, LLC (WRPS), and Pacific Northwest National Laboratory (PNNL). The meeting minutes, documented in Appendix A, identify the approach of sampling eight locations, then four additional locations.

Since no staff attending that meeting had been to TX Farm in some time, a field trip was arranged with the same participants to visit the site to ensure that the recommended initial eight locations were accessible. That field trip occurred on the morning of September 18, 2012, with a follow-up meeting in the afternoon. At the field trip, it was recognized that the direct push location close to tank TX-105 and UPR-200-W-100 (Site #1) was not accessible because of the topography, and three alternative sites (1A, 1B, and 1C) were identified (refer to Figure 2-12). All other sites appeared accessible from the surface. However, it was noted that the sites still might not be accessible due to underground infrastructure. Allsites are to be evaluated by GPR, prior to the direct push. If underground infrastructure is identified that would prohibit a site from being accessible and the location would have to be changed, that information would be shared with the participants of the meeting in order to recommend an alternative site.

Table 2-1 identifies the general logic for selecting these eight direct push locations. Appendix B provides notes based on the field trip of September 18, 2012 and the follow-up meeting.

Figure 2-13. Topography and Proposed Initial Direct Push Sites at 241-TX Tank Farm.

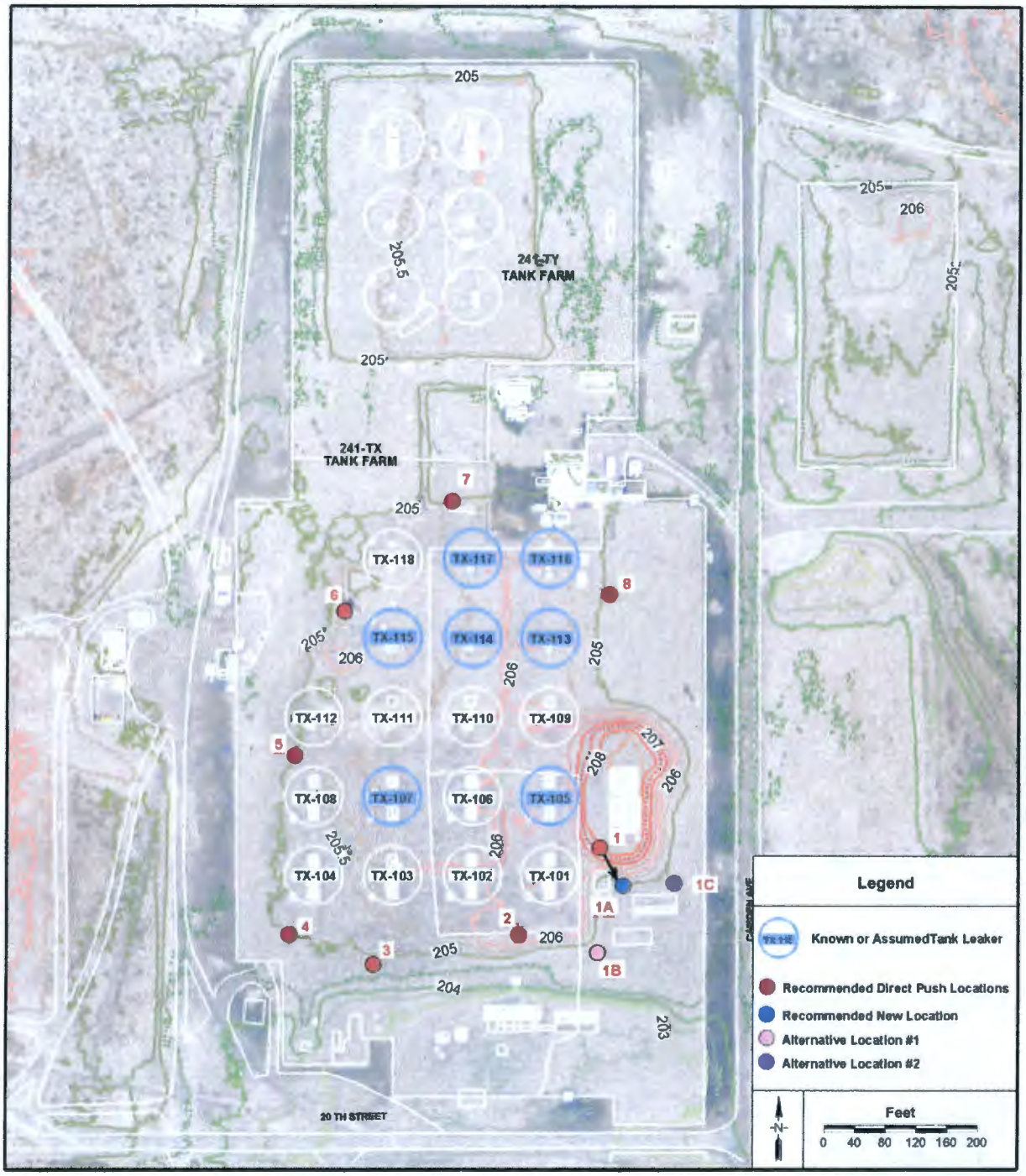


Table 2-1. Direct Push Location Strategy for 241-TX Tank Farm. (2 sheets)

Site #	Approximate Location	Input Factors Associated with Location[a] Reason for Sampling with Respect to Interim Measure
1A (Agreed Upon Location – Refer to the 6th bullet in third column of this row)	Southeast of tank 241-TX-105 (TX-105)	• Tank TX-105 designated as a leaker (at least 150,000 gal) • Nearby diversion boxes and pipelines • Process records indicate it was overfilled in 1952 and between 1961 and 1964 • Gross gamma activity detected in drywells 51-05-01, 51-05-03, and 51-05-05 on East – Southeast side of tank • UPR-200-W-100 is also to the east of tank TX-105 • Direct push initial location (1) cannot be reached due to topography; three alternative sites have been identified (1A, 1B, and 1C), all further to the south but in the vicinity of transfer lines and diversion boxes. Location 1A is the preferred alternative location based on site visit dated September 18, 2012. If 1A is not accessible, then 1B will be selected, and if 1B is not accessible, then 1C will be selected. **Further assess the path and inventory of tank TX-105 and UPR-200-W-100 Releases (see Figure 2-4 for uranium plume map)**
2 (Agreed Upon Location)	Southwest of tank 241-TX-101	• Releases associated with tank TX-105 and UPR-200-W-100 appear to be trending to the southwest (see Figure 2-4) • Tc-99 groundwater plume is to the south of 241-TX Tank Farm (TX Farm) (Figure 2-11) **Further assess the nature and depth of migration of releases near tank TX-105 and UPR-200-W-100; also to attempt to define a boundary for the migration**
3 (Agreed Upon Location)	South of tank 241-TX-103	• Tank 241-TX-107 is designated as a leaker (1,300 gal) • Noted Co-60 and Eu-154 activity in drywells 51-07-07, 51-07-18 and in drywells between tanks 241-TX-107 and 241-TX-103 • Tc-99 groundwater plume is to the south of TX Farm (Figure 2-11) **Confirm Previous Results: Gather additional data to assist in determining nature and extent of contamination (i.e., Tc-99) south of the TX Farm tanks, also to attempt to define boundary to vadose zone contamination**
4 (Agreed Upon Location)	South of tank 241-TX-104	• Tank 241-TX-104 is not designated as a leaker • Uranium vadose zone plume to the east and south of tank 241-TX-104, may be the result of a transfer line or cascade line leak • Tc-99 groundwater plume is to the south of TX Farm (Figure 2-11) **Confirm Previous Results: Gather additional data to assist in determining nature and extent of contamination (i.e., Tc-99) south of the TX Farm tanks, also to attempt to define boundary to vadose zone contamination**
5 (Agreed Upon Location)	In between tanks 241-TX-108 and 241-TX-112 and slightly to the west of the centerline between these tanks	• Higher conductivity area based on resistivity information in this area (Figure 2-10) **Explore surface geophysical exploration (SGE) anomaly close to tanks 241-TX-108 and 241-TX-112. Gather data to assist in determining nature and extent of contamination (i.e., Tc-99).**

Table 2-1. Direct Push Location Strategy for 241-TX Tank Farm. (2 sheets)

Site #	Approximate Location	Input Factors Associated with Location[a] Reason for Sampling with Respect to Interim Measure
6 (Agreed Upon Location)	In between tanks 241-TX-115 (TX-115) and 241-TX-118 and to the NW of tank TX-115	• Tank TX-115 was declared "questionably integrity" in 1977 based on gamma activity in drywell 51-15-04 and arbitrarily assigned a leak volume of 8,000 gal • May have been overfilled in the early 1950s • SGE anomaly to the north and northwest of tank TX-115 **Explore SGE anomaly close to tanks TX-115 and 241-TX-118. Gather data to assist in determining nature and extent of contamination (i.e., Tc-99).**
7 (Agreed Upon Location)	North of tank 241-TX-117	• Tank 241-TX-117 was declared "questionably integrity" in 1977 based on gamma activity nearby vadose zone drywells and arbitrarily assigned a leak volume of 8,000 gal • Tc-99 in groundwater in this vicinity (Figure 2-11) **Gather data to assist in determining nature and extent of contamination (i.e., Tc-99) and to attempt to define boundary to vadose zone contamination**
8 (Agreed Upon Location)	East of tank 241-TX-113 and 241-TX-116	• Tank 241-TX-113 was declared "questionably integrity" in 1977 based on gamma activity nearby vadose zone drywells and arbitrarily assigned a leak volume of 8,000 gal • Historical transfer records show that the tank 241-TX-113 was filled above the cascade outlet as a result of cascade plugging of the cascade lines and in-tank photographs show the waste level was well above the cascade line, indicating the potential for releases from the cascade lines or spare inlet ports • Tank 241-TX-116 was declared "questionably integrity" in 1977 based on gamma activity nearby vadose zone drywells and arbitrarily assigned a leak volume of 8,000 gal **Gather data to assist in determining nature and extent of contamination (i.e., Tc-99) and to attempt to define boundary to vadose zone contamination**

[a] Tank leak and pipeline failure information is provided in RPP-54073, *TX Tank Farm Leak Inventory Assessment Meeting Summaries.*

2.3.2 Parameters of Interest and Action Levels

The extent of a plume is defined by its most mobile constituents. The most mobile constituents are nitrate and ^{99}Tc. The conceptual model indicates that, once released, these constituents move down vertically with some horizontal spreading (unless diverted horizontally by capillary barriers or low conductivity layers). For this reason, nitrate and ^{99}Tc are the constituents primarily considered in interim measure evaluation. The established action limit with respect to past barrier evaluation was 10 parts per million (ppm) for nitrate and 2.5 pCi/g for ^{99}Tc (RPP-43551, *Tank Farm Interim Barrier Data Quality Objectives*). The action limit for nitrate is approximately three times the soil background concentration, and the action limit for ^{99}Tc was based on approximately three times the detection limit of ^{99}Tc (0.85 pCi/g) from analyses conducted by PNNL.

For interim measure evaluation, contaminants producing gamma radiation are unlikely to provide direct information (^{137}Cs is expected to be relatively immobile, and mobile ^{60}Co is expected to be too low in concentration, based on past logging efforts). These constituents (^{137}Cs and ^{60}Co) and others will be analyzed (via the laboratory) to aid in vadose zone characterization efforts, which are needed to determine how areas will be dispositioned for cleanup and closure (refer to Appendix C for the entire list of constituents to be analyzed).

2.3.3 Direct Push Sample Intervals

At each location, one direct push hole will be pushed to target depth or refusal, and gross gamma and moisture logging performed. Based on review of gross gamma and moisture log results (to include discussion with Ecology), approximately three sample depths will be selected at each direct push location. On average, three depths were sampled in 241-BY Tank Farm, TY Farm, and WMA S-SX, where previous direct pushes for an ISB evaluation were conducted. Three depths were chosen to assist in defining the extent of the vertical boundaries of contamination. Based on experience gained from sampling in other farms, it is anticipated that three depths will help define the vertical extent of contamination to support interim measures at TX Farm.

Optimization efforts will be instituted with regard to choosing sample depths. The following factors will be considered in order to efficiently and appropriately select sample depths.

Moisture logging

- Areas of saturated and near-saturated water content. Because the central plateau of the Hanford Site is in an arid region, subsurface saturated areas above the water table often indicate abnormal sources of water (e.g., water line leaks, high liquid discharges). These sources may be a source of contamination or of the water driving force.

- Areas of high moisture. As mobile contaminants move with water, high moisture content often indicates high amounts of key contaminants.

Gamma logging

- Areas of increased gamma radiation. These areas may indicate a change of geology, which is useful to determine the position of the general features mentioned in the geology above; or such areas may indicate the presence of man-made gamma-emitting contaminants.

Geology/Stratigraphy

- Zones of interest.

- Sediment layers immediately above a layer with low hydraulic conductivity. In these cases, there may be lateral flow down the slope of the low-conductivity layer or ponding if the gradient is flat.

- Fine-grained sediment layers over coarse-grained layers. In such cases, there will likely be lateral flow within the fine-grained unit.

Analytical Information

- Available indicator parameters (^{99}Tc and nitrate). Direct push sample information from other locations already sampled may be used to help determine other borehole sample intervals. If a sample interval at one location has higher concentrations, then this sample interval may be of interest at other locations.

2.4 KEY DELIVERABLES AND SCHEDULE

Section 5.0 of this Work Plan provides the schedule for the activities associated with direct push logging and sampling in TX Farm. The anticipated deliverables are as follows:

- Sampling and analysis plan: the plan required by M-045-21

- Field work completion summary: an informal report (provided as a briefing to Ecology) that describes the completion of field work, including the location of each direct push borehole, the logging results, and the results of the quick-turnaround analysis of soil samples

- Recommendation regarding interim measures in TX Farm: a letter, summarizing DOE's recommendation regarding whether an ISB or other interim measures is appropriate for TX Farm, based on the information obtained by the direct push campaign

- Characterization report: a secondary document (M-045-22-T01) describing the results of the vadose zone characterization in TX Farm.

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3.0 241-U TANK FARM ELECTRICAL RESISTIVITY INVESTIGATION

Milestone M-045-20 requires, in part, that this Work Plan describe the plan to perform SGE (i.e., electrical resistivity) investigation in the U Farm for purposes of evaluating potential need for an ISB or other interim measure.

3.1 SCOPE

The scope of this section of the Work Plan is to describe the plan to perform electrical resistivity investigation in U Farm for purposes of evaluating potential need for an interim barrier or other interim measure.

3.2 241-U TANK FARM DESCRIPTION

The U Farm was constructed between 1943 and 1944 in the 200 West Area and consists of twelve 100-series SSTs, four 200-series SSTs, and diversion boxes, pipelines, and other ancillary equipment. A summary of the waste types received by U Farm can be found in RPP-RPT-50097, *Hanford 241-U Farm Leak Inventory Assessment Report* and the references contained therein.

The 100-series tanks are 75-ft diameter underground tanks made of reinforced concrete with a steel liner on the bottom and sides and a dished bottom. The steel liner extends to a height of 19 ft from the center of the tank bottom. Each 100-series tank has a design capacity of 530,000 gal at a liquid depth of ~16.67 ft (measured from center of tank) (Figure 3-1). The 200-series tanks are of similar construction as the 100-series tanks, but are only 20 ft in diameter with a design capacity of 55,000 gal (Figure 3-2). The sediment cover from the apex of the tank domes to ground surface is 7.3 ft for the larger SSTs and 11 ft for the smaller SSTs.

3.2.1 Leak Assessment Information, Unplanned Releases, and Tank Best Basis Inventory

The body of historic information on tank leak monitoring, and the best current evaluation of waste losses to the soil, is provided in RPP-RPT-50097. The evaluation in that document led to the summary of tank waste loss events in Table 3-1. Tank waste loss events were initially reassessed for SSTs currently classified as "assumed leakers" (the integrity classification of a waste storage tank for which surveillance data indicate a loss of liquid in the past attributed to a breach in the liner integrity, i.e., a tank leak) (HNF-EP-0182). Table 3-1 summarizes the results of tank waste loss reassessments for these tanks and provides a comparison to the waste loss estimates contained in HNF-EP-0182. The estimated volumes of waste lost and the waste composition (types) were evaluated to update the estimated inventory of constituents in RPP-26744. In addition, tanks currently assumed as "sound" (the integrity classification of a waste storage tank for which surveillance data indicate no loss of liquid attributed to a breach of tank integrity) were reviewed to assess the potential for loss of waste containment. There was no indication of releases from any of the other tanks in U Farm.

Figure 3-1. Simplified Sketch of 100-Series 241-U Farm Tank.

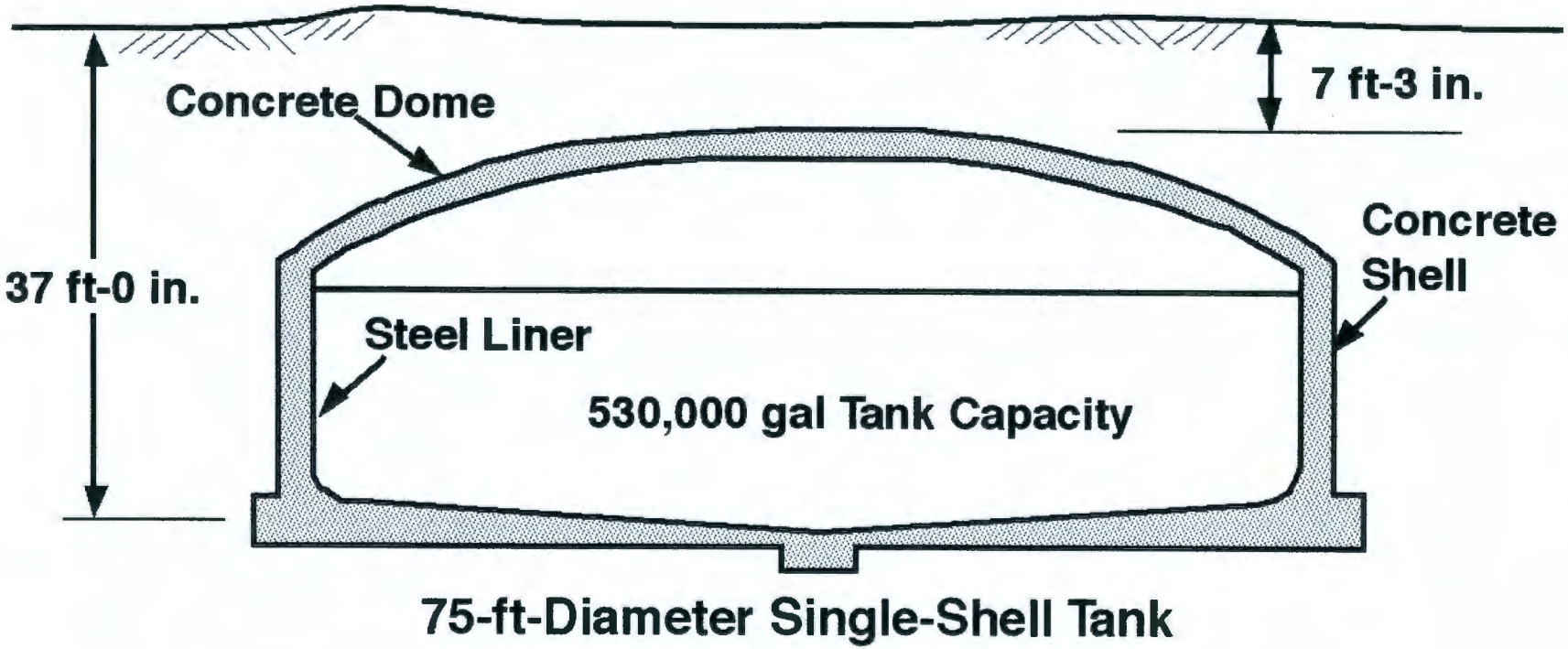


Figure 3-2. Simplified Sketch of 200-Series 241-U Farm Tank.

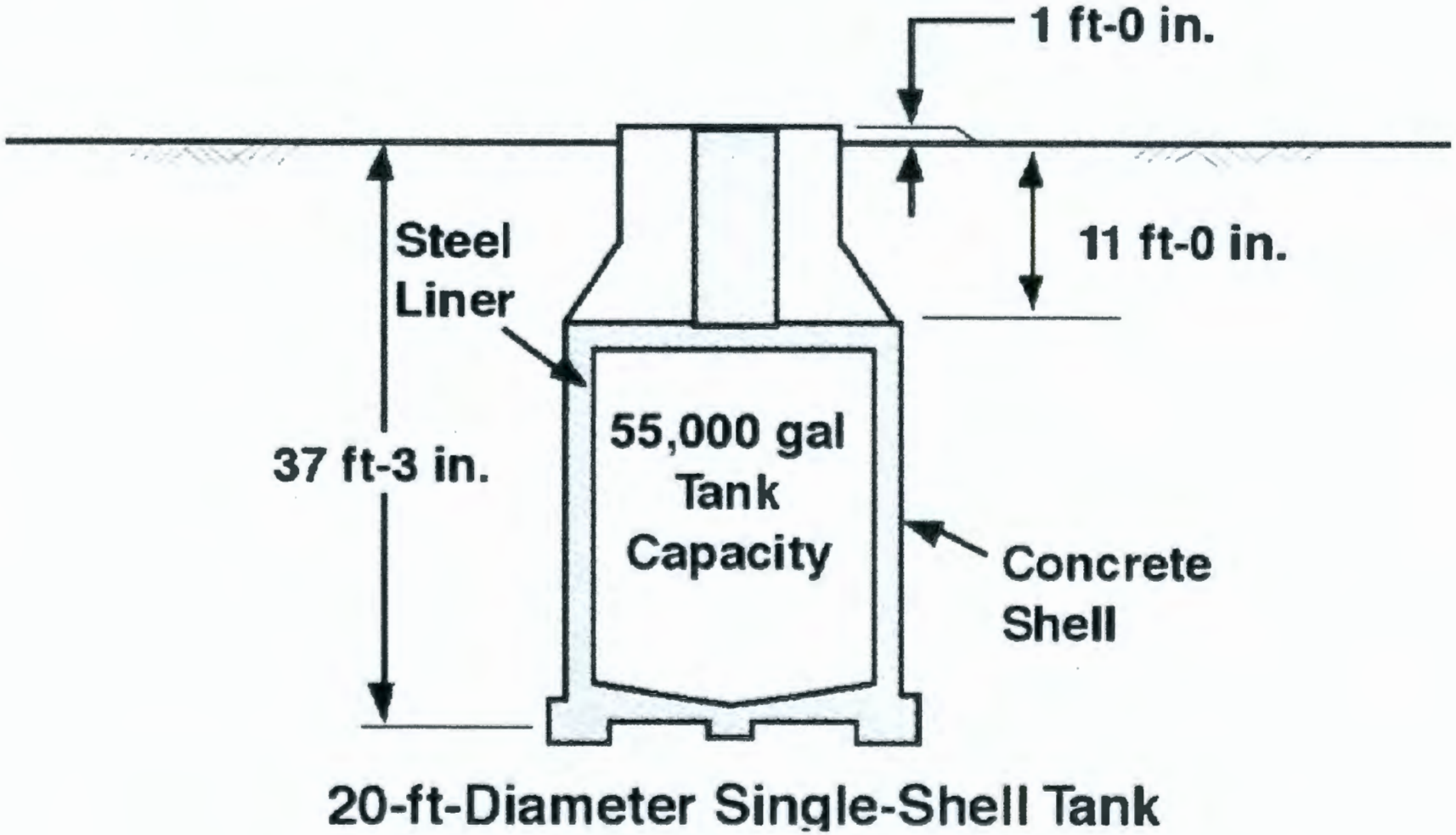


Table 3-1. Summary of Tank Waste Loss Events in 241-U Farm.

Tank	Description	HNF-EP-0182 (Rev. 295) Estimate	Revised Estimate[1]
241-U-101 (U-101)	Tank U-101 was suspected of leaking based on liquid level decreases in 1960. Neither gamma activity nor low resistivity was found near tank U-101 and tank surveillance data appear to be inconsistent and unreliable. Lacking additional information, the tank U-101 leak volume estimate is considered highly uncertain with a range of zero to the reported 30,000 gal. The inventory of waste released should be based on 1965 tank 241-U-106 sample results; current SIM inventory estimates (^{137}Cs = 1,300 Ci, ^{99}Tc = 0.46 Ci) should be multiplied by a factor of 6 for the upper leak volume estimate.	30,000 gal SIM uses 5,000 gal	0 to 30,000 gal Recommend tank integrity assessment per TFC-ENG-CHEM-D-42. ^{137}Cs = 0 to 7,400 Ci
241-U-104 (U-104)	Tank U-104 was first suspected of leaking based on a reported bulge near the center of the tank and a liquid level decrease in 1956. A leak test was performed between 1957 and 1961, confirming the suspected leak. It was concluded that tank U-104 leaked during the leak test and likely leaked as early as 1953 during sluicing. The leak volume is highly uncertain because of the tank bulge and uncertainty in liquid level measurements. Based on drywell data, as much as 46,000 lbs (7 Ci) of ^{238}U may have been released from the tank.	55,000 gal	109,000 gal ^{238}U = 7 Ci
241-U-110 (U-110)	Tank U-110 was first suspected of leaking based on a liquid level decrease and simultaneous drywell gamma activity increase in 1975. It was concluded that tank U-110 leaked during 1975, and that the composition of the leak should be based on the 1975 sample. Current SIM estimates use a ^{137}Cs concentration that is a factor of 22 higher than the measured 1975 ^{137}Cs concentration. Also SIM estimates for Cs are high; SIM estimates for other analytical constituents should be divided by a factor of 5.5 to coincide with the new upper bound estimate.	5,000 to 8,100 gal	5,000 to 25,000 gal ^{137}Cs = 126 Ci
241-U-112 (U-112)	Tank U-112 was classified as "questionable integrity" based on a 3-in. liquid level decrease between February 1969 and March 1970 and increased gamma activity in drywell 60-12-01. The tank was reclassified as an assumed leaker in 1980. Based on process records and the high ^{137}Cs concentration in drywell 60-12-01, the waste leak was probably mostly REDOX waste (R1) with a higher ^{137}Cs concentration (0.34 Ci/gal) compared to the current waste mix and concentration in SIM (0.2 Ci/gal).	8,500 gal	8,500 to 57,000 gal ^{137}Cs = 24,000 Ci
Other 241-U Farm SSTs	Some SSTs show activity in nearby drywells that has previously been attributed to operational spills, overflows or line leaks; but no evidence of a liner failure was found for any of these tanks and there is no basis for an inventory estimate for releases from these tanks.	NA	NA

[1] Except as noted, ^{137}Cs inventories are decayed to January 1, 2001 consistent with values in SIM.

REDOX = Reduction-Oxidation (S Plant) SIM = Hanford Soil Inventory Model SST = single-shell tank

References:
HNF-EP-0182, *Waste Tank Summary Report for Month Ending October 31, 2012*, Rev. 295.
TFC-ENG-CHEM-D-42, Rev. B-5, "Tank Leak Assessment Process."

DOE/RL-88-30, *Hanford Site Waste Management Units Report* contains the official listing of UPRs identified at the Hanford Site. The operational history for U Farm was reviewed to determine if additional information exists for the UPRs within U Farm that are not associated with tank waste loss events. No significant new information was located for these UPRs. However, potential new UPRs as a result of pipeline failures were identified through review of the operational histories for U Farm. There was insufficient available information to estimate a volume or inventory of tank waste potentially discharged to the soil from most of the identified UPRs.

To date, there has not been an opportunity to re-evaluate the UPRs not directly associated with tanks. As such, the most recent information available for these releases is summarized in RPP-35485, *Field Investigation Report for Waste Management Area U.* Unplanned release summaries from the Waste Information Data System (WIDS) are presented in Table 3-2.

Table 3-2. Unplanned Releases in Waste Management Area U, Taken from the 241-U Tank Farm Field Investigation Report.

WIDS Site Number	Location	Date	Release Type	Waste Type	Quantity
200-W-95	Contaminated Soil at 241-U Tank Farm			Consolidated WIDS Site containing UPR-200-W-24 UPR-200-W-128 UPR-200-W-132 UPR-200-W-154 UPR-200-W-155 UPR-200-W-156 UPR-200-W-157 200-W-91	
UPR-200-W-24	244-UR	04/30/1953	Spray from Riser (30 sec)	Bismuth phosphate process waste (MW)	
UPR-200-W-128	241-U-103	01/08/1971	Underground Piping Spill	Reduction and Oxidation Process Waste	
UPR-200-W-132	241-UR-151	07/06/1956	Overflow	MW	1,900 L (502 gal)
200-W-91	Adjacent to the North Side of 241-U Tank Farm	Spring 1950	Underground		

WIDS = Waste Information Data System

Source: RPP-35485, *Field Investigation Report for Waste Management Area U.*

To understand the impacts of a possible future UPR from SSTs, the Best Basis Inventory database was queried for those constituents that could impact groundwater (^{99}Tc, ^{129}I, chromium, nitrite, nitrate, and uranium) if a UPR were to occur. This inventory was downloaded from Tank Waste Information Network System on April 10, 2012, with the radionuclides decayed to January 1, 2008. The inventory of groundwater-impacting constituents was summed to calculate

a percentage of those contaminants for each tank farm over the total inventory. The results are shown in Figure 2-5 as a series of pie charts. The waste inventory remaining in the U Farm tanks, although higher than the inventory remaining in several other tank farms, is relatively low when compared to the TX Farm.

3.2.2 Geology, Stratigraphy, and Hydrology

The geology of WMA U and immediate vicinity is well understood as a result of several decades of site characterization activities. The geology of this site has been described in numerous reports, including the following publications:

- ARH-LD-138, *Geology of the 241-U Tank Farm*
- DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold-Formation Sediments Within the Central Pasco Basin*
- GJO-97-1-TAR/GJO-HAN-8, *Vadose Zone Characterization Project at the Hanford Tank Farms: U Tank Farm Report*
- PNNL-13282, *Groundwater Quality Assessment for Waste Management Area U: First Determination*
- PNNL-13612, *Groundwater Quality Assessment Plan for Single-Shell Tank Waste Management Area U*
- PNNL-15808, *Subsurface Conditions Description of the U Waste Management Area*
- PNNL-15955, *Geology Data Package for the Single-Shell Tank Waste Management Areas at the Hanford Site*
- PNNL-17163, *Characterization of Direct Push Vadose Zone Sediments from the 241-U Single-Shell Tank Farm*
- RHO-ST-23, *Geology of the Separations Areas, Hanford Site, South Central Washington*
- RPP-16608, *Site-Specific Single-Shell Tank Phase 1 RCRA Facility Investigation/ Corrective Measures Study Work Plan Addendum for Waste Management Areas C, A-AX, and U*
- RPP-23748, *Geology, Hydrogeology, Geochemistry, and Mineralogy Data Package for the Single-Shell Tank Waste Management Areas at the Hanford Site*
- RPP-35485, *Field Investigation Report for Waste Management Area U*
- WHC-EP-0883, *Variability and Scaling of Hydraulic Properties for 200 Area Soils, Hanford Site*.

The main source of information about geologic strata underlying the Hanford Site and the tank farms is data from the drilling of boreholes and the analyses of the sediments and contaminants within them.

Four major stratigraphic units underlie U Farm. These units are divided as follows (in ascending order):

- Columbia River Basalt Group
- Ringold Formation (including members of Taylor Flats [Rtf] and members of Wooded Island [Rwi])
- Cold Creek unit (including subunits CCU_u and CCU_l)
- Hanford formation (including subunits H1 and H2)
- Backfill.

The general characteristics of these units are described in more detail in RPP-23748. The SSTs at U Farm were emplaced within the Hanford formation sediments. All but the surface of the Hanford formation have a general tendency to dip west to southwest toward the axis of the Cold Creek unit. The vadose zone beneath WMA U is as much as 65 meters (213 ft) thick and consists of the Hanford formation, the Cold Creek unit, and the upper part of the Ringold Formation. Both the water table and the unconfined aquifer reside entirely within the Ringold Formation.

Sediments in the vadose zone vary from open-framework gravels of the gravel-dominated facies and interbedded sand and silt of the silt-dominated facies of the Hanford formation, to calcium carbonate-rich deposits of the Cold Creek unit and cemented gravels of the Ringold Formation. These sediments are characterized by numerous lateral discontinuities, such as pinchouts, erosion truncations, and irregular flow patterns. If clastic dikes are present, they may enhance vertical flow patterns. Therefore, there are numerous possible avenues for contamination to migrate through the vadose zone (PNNL-15808). Figures 3-3, 3-4, and 3-5 depict geologic cross sections at WMA U (from RPP-23748).

The following is an overview of the hydrology of the uppermost unconfined aquifer beneath WMA U. More detailed information can be found in RPP-23748, RPP-35485, DOE/RL-2009-74, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area U*, and DOE/RL-2011-118.

The current primary groundwater flow direction in the unconfined aquifer beneath WMA U is to the east-southeast. The estimated hydraulic gradient in this region is 2.1×10^{-3}. The general groundwater flow velocity ranges from 0.018 to 0.20 meters/day (0.06 to 0.66 ft/day) (DOE/RL-2011-118).

Figure 3-3. Geologic Cross-Section Location Map for Waste Management Area U.

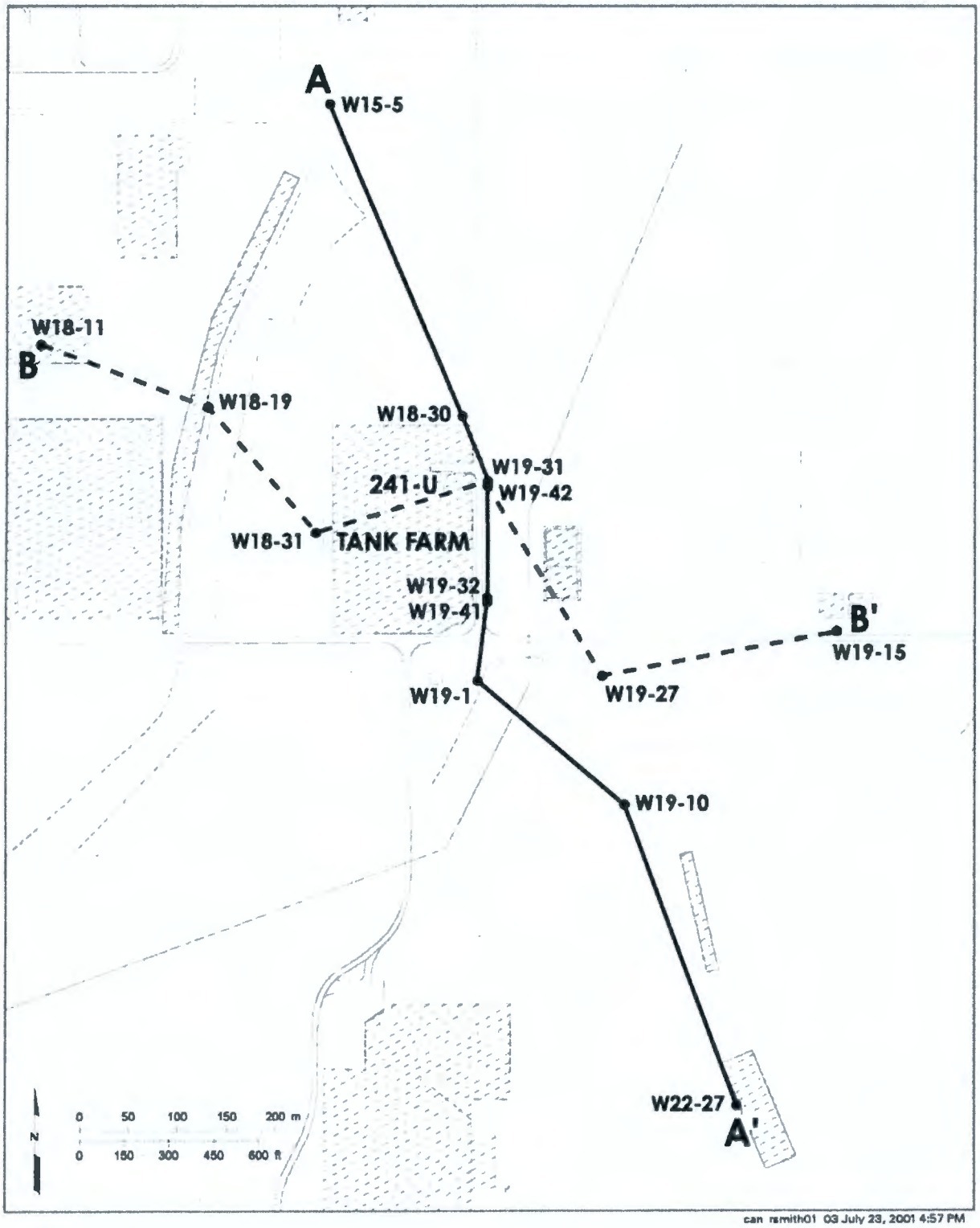
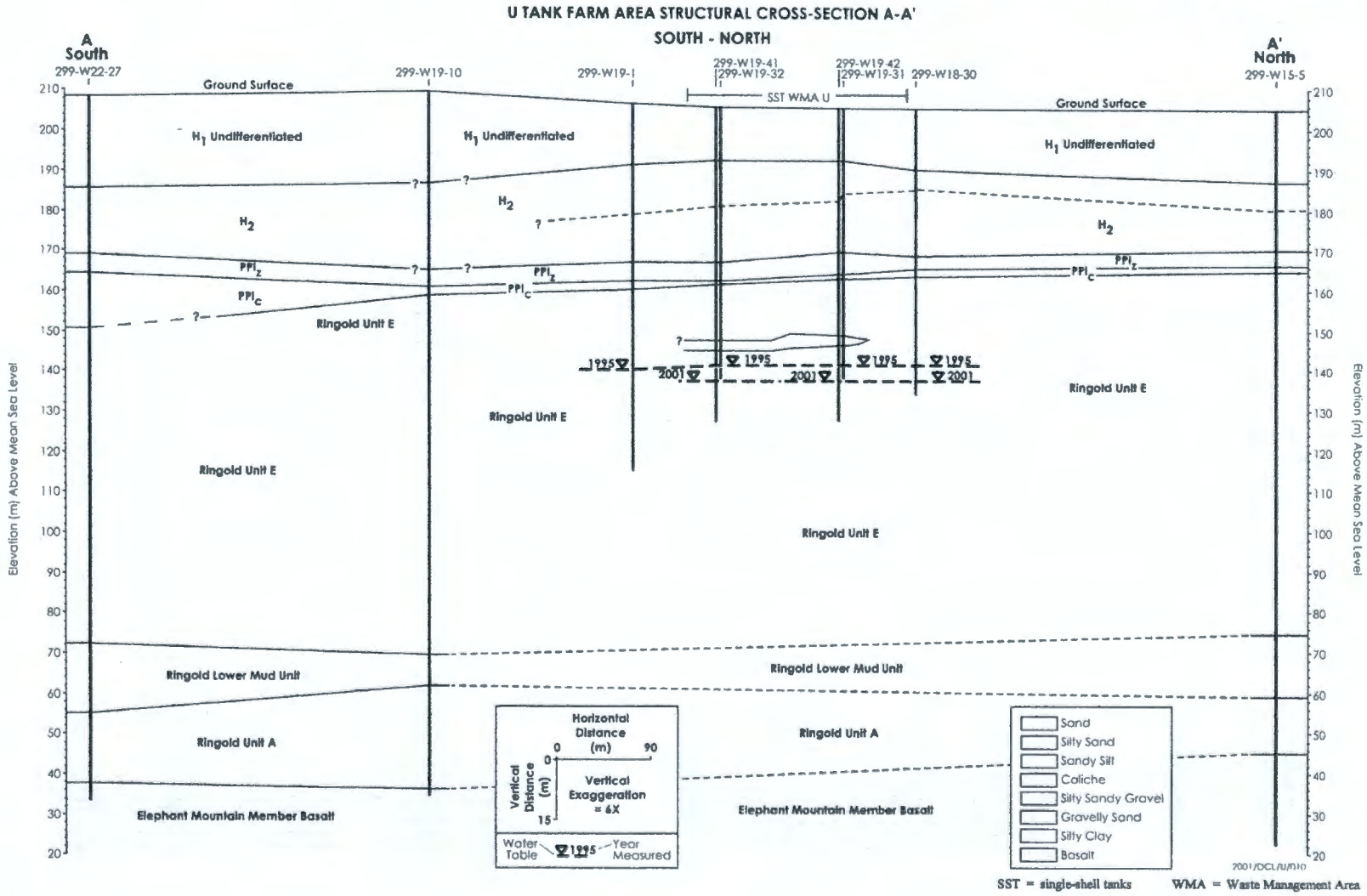
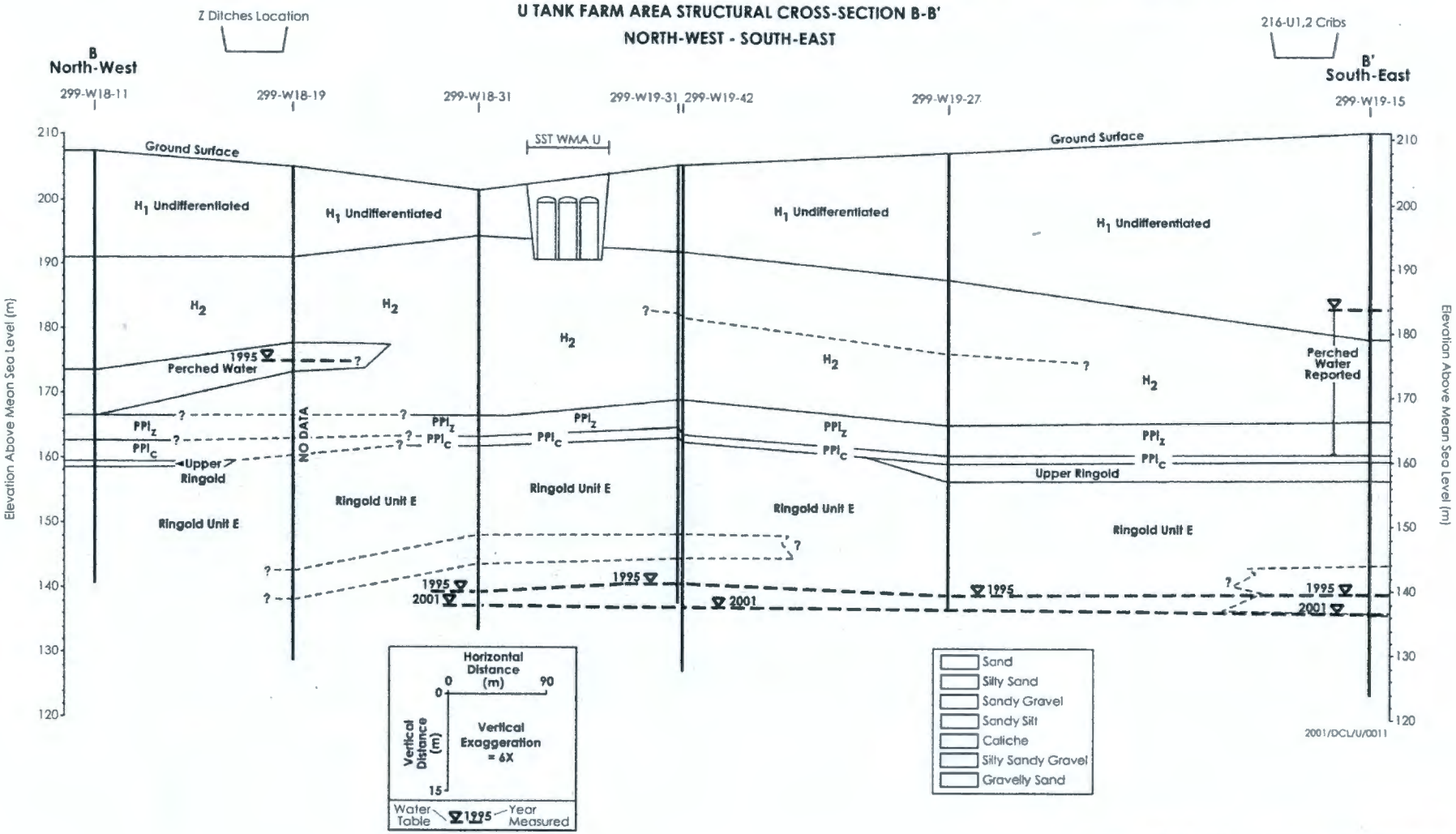


Figure 3-4. Geologic Cross-Section A – A' at Waste Management Area U.



SST = single-shell tanks WMA = Waste Management Area

Figure 3-5. Geologic Cross-Section B – B' at Waste Management Area U.



SST = single-shell tanks WMA = Waste Management Area

General groundwater flow directions under WMA U have changed substantially because of Hanford Site operations. Before the initiation of fuel processing activities at the Hanford Site, the regional flow across the site was generally west to east. The first significant perturbation to groundwater flow was probably discharge to 216-T-4A Pond north of WMA U in the 1940s, which would have had the effect of diverting flow to a more southerly direction under WMA U and perhaps raising the water table. A similar scenario has been postulated to have affected groundwater flow under WMA S-SX (HNF-4936). No groundwater wells were located near WMA U in this time period to measure these postulated events.

The next significant perturbation created by Hanford operations was the development of 216-U-10 Pond and wastewater discharge to the unconfined aquifer. A water mound developed, and groundwater flow direction was altered beginning in the mid-1950s. At WMA U, elevation of the water table was measured at groundwater monitoring well 299-W19-1. Given the location of the 216-U-10 Pond to the southwest of WMA U and the radial flow induced by the expansion of the groundwater mound underneath the pond, groundwater flow changed toward a northeasterly direction under WMA U. This directional control continued through 1985 when discharge to the pond ceased, at which point the water table began to drop, and the general flow direction began to move toward the pre-Hanford easterly orientation.

The aquifer resides in partially cemented sands and gravels of the Ringold Formation member of Wooded Island (subunit E). Currently, the water table beneath WMA U lies ~136 meters (~446 ft) above mean sea level, resulting in ~78 meters (~255 ft) of vadose zone (RPP-17209, *Modeling Data Package for an Initial Assessment of Closure of the S and SX Tank Farms*). The unconfined aquifer is ~67 meters (~219 ft) thick (RPP-23748).

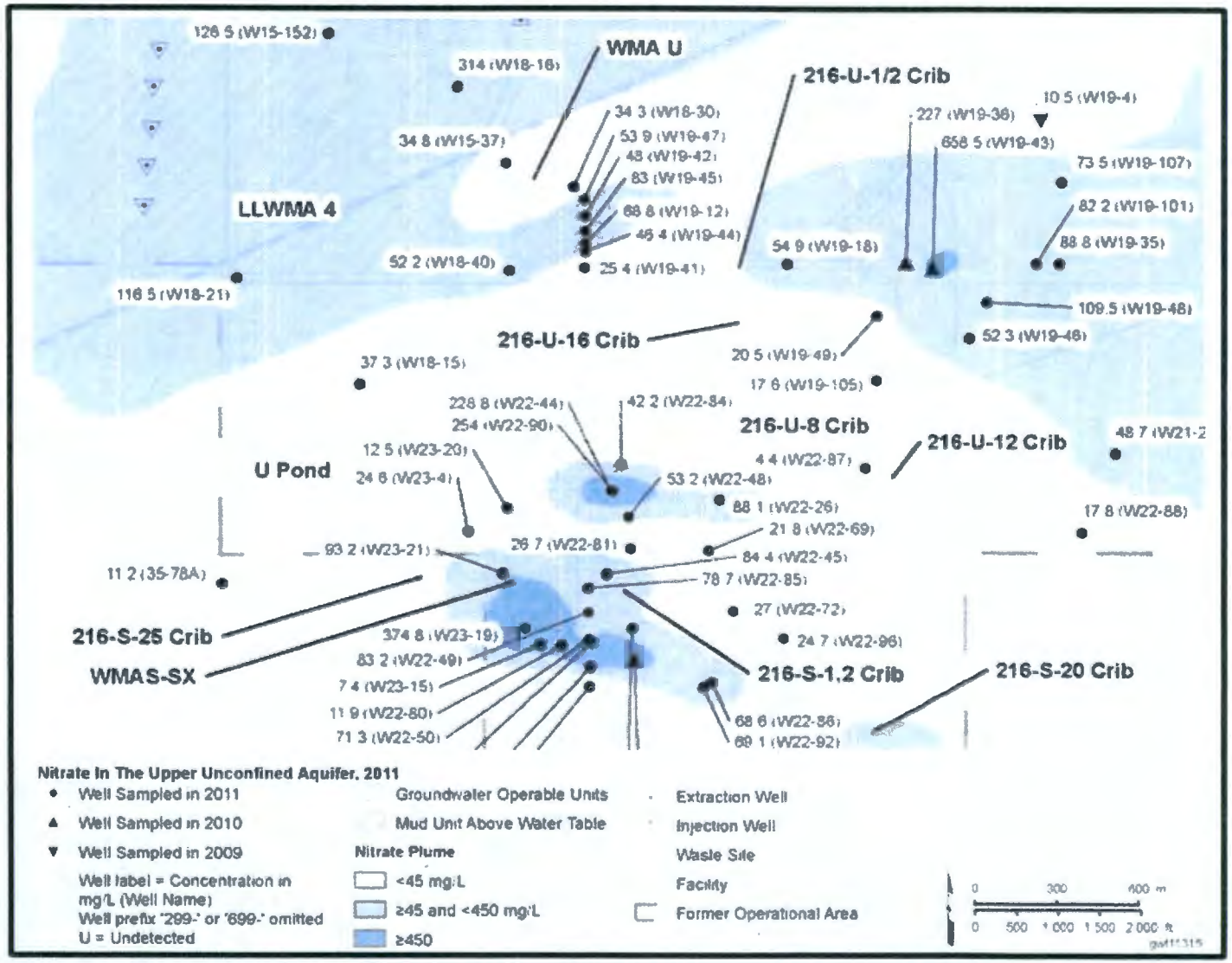
Resource Conservation and Recovery Act of 1976 assessment monitoring indicates that groundwater beneath WMA U continues to fall. The WMA has been identified as the source of groundwater contamination that is limited to the down gradient (east) side of the site. Plume constituents of interest include nitrate and ^{99}Tc, as well as carbon tetrachloride that is also found above drinking water standards at WMA U (DOE/RL-2011-118). The nitrate plume data is displayed in Figure 3-6. The ^{99}Tc concentrations are higher in the northern wells at WMA U, while nitrate concentrations are higher in the southern wells.

3.2.3 Potential Soil Contamination

Several soil investigation activities in U Farm have provided insight into the potential distribution of sub-surface contamination. RPP-35485 compiles and evaluates the body of historic information on soil contamination and vadose zone data collected through 2007. Based on this analysis, it was determined that two main areas of contamination exist in the vadose zone underlying U Farm. These two zones include the areas around the following tanks:

- Tanks 241-U-101 and 241-U-104 (U-104)
- Tanks 241-U-110 and 241-U-112.

Figure 3-6. Average Nitrate Concentrations in a Subset of the 200-UP-1 Groundwater Interest Area, Upper Portion of Unconfined Aquifer.



The extent of the footprint of the metal waste distribution from a tank U-104 leak, indicated by uranium contamination, is illustrated in Figure 3-7. Figure 3-7 also shows the physical layout of the tanks, drywells, and direct push probe holes in U Farm, including the official status (sound or assumed leaker) of the tanks according to HNF-EP-0182.

Historical records indicate that the primary sources of tank waste contamination in the northern part of WMA U were generated by leaks from tanks U-104 and 241-U-101. The tank U-104 leak is well substantiated (e.g., direct observation of liner deformation and rupture and drywell gamma measurements of waste contaminants, primarily uranium, in the vadose zone nearby). Historical records also indicate that the primary sources of tank waste contamination in the southern part of WMA U were generated by leaks from tanks 241-U-110 and 241-U-112. Both leaks are well substantiated (e.g., drywell gamma measurements of waste contaminants, primarily ^{137}Cs, in the vadose zone nearby). Direct push probe holes were installed near all four of these tanks, with results confirming the presence of contamination beneath the tanks (RPP-35485). During decommissioning of each direct push logging hole, a single electrode was placed at a depth of ~100 ft bgs for use in a future electrical resistivity evaluation. Recently a reassessment of the total leaked volumes and tank waste inventory has been compiled, results of which are presented in Table 3-1 (RPP-RPT-50097).

3.2.4 Surface Geophysical Exploration Information

Previous soil characterization activities in U Farm included a 2006 electrical resistivity study that employed electrical currents between drywells to measure soil resistivity anomalies. All drywells in the U Farm as well as nearby groundwater monitoring wells were used as electrodes. In addition, lines of surface electrodes were placed outside of and roughly parallel to the U Farm fences. All combinations of wells (WTW) were interrogated in the pole-pole resistivity survey.

Inversion modeling of the WTW data set was accomplished in two steps using the inversion code EarthImager 3D[2]. The first step inverted resistivity data collected solely using the drywells. The second step inverted resistivity data collected using both the drywells and adjacent groundwater monitoring wells. Drywells are steel-cased structures with the casing extending 75 to 150 ft (23 to 47 m) bgs; the water table at WMA U is ~210 ft (65 m) bgs. Groundwater monitoring wells are located outside the tank farm and are generally ~100 ft (30 m) to the east and west of the farm.

Figure 3-8 shows the results of the inversion using drywells only. The WTW inversion is shown in plan view due to the depth integrating nature of using long (75+ ft) electrodes. The smaller, dark-colored resistivity anomaly represents values of up to 2.7 ohm-m and the larger, light-colored anomaly represents values up to 5.4 ohm-m. The general shapes of the anomalies show an increase in either ionic strength or moisture primarily beneath tanks U-104 and 241-U-105. Figure 3-9 shows the combined results of an inversion using both the drywell data and the groundwater monitoring well data. The colors used in Figure 3-8 are the same as those used in Figure 3-9 to allow direct comparison. The smaller anomaly is nearly the same in the two figures. The larger anomaly is similar in shape but is slightly larger when all wells are used in the inversion; this increase in size is postulated to be due to slightly different current paths that

[2] EarthImager 3D is a product of Advanced Geosciences, Inc., 2121 Geoscience Drive, Austin, Texas.

Figure 3-7. Area Footprint of Metal Waste Distribution from 241-U-104 Tank Leak Indicated by Uranium Contamination in Drywells and Probe Hole C5602.

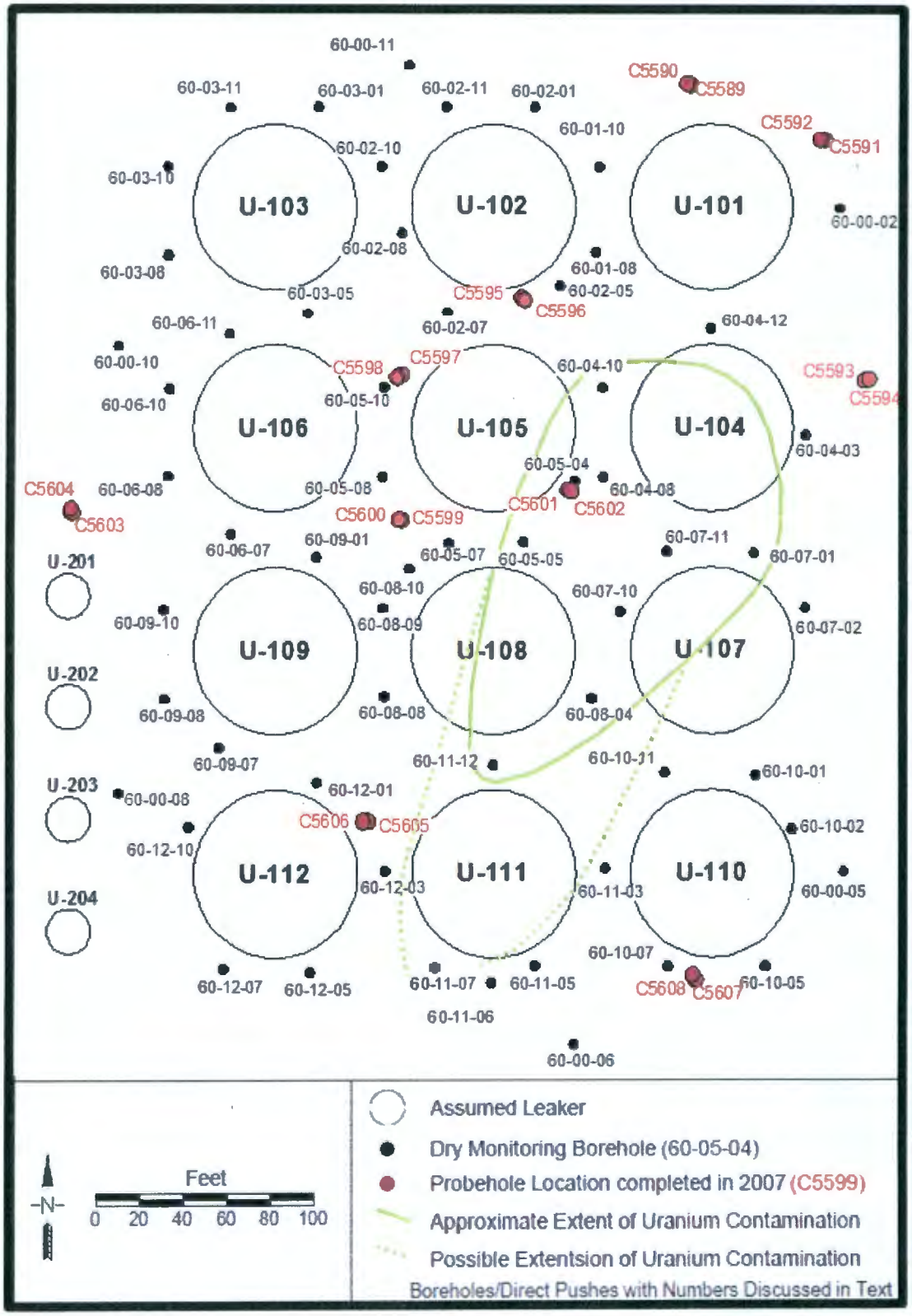


Figure 3-8. Results of Well-to-Well Inversion, Waste Management Area U.

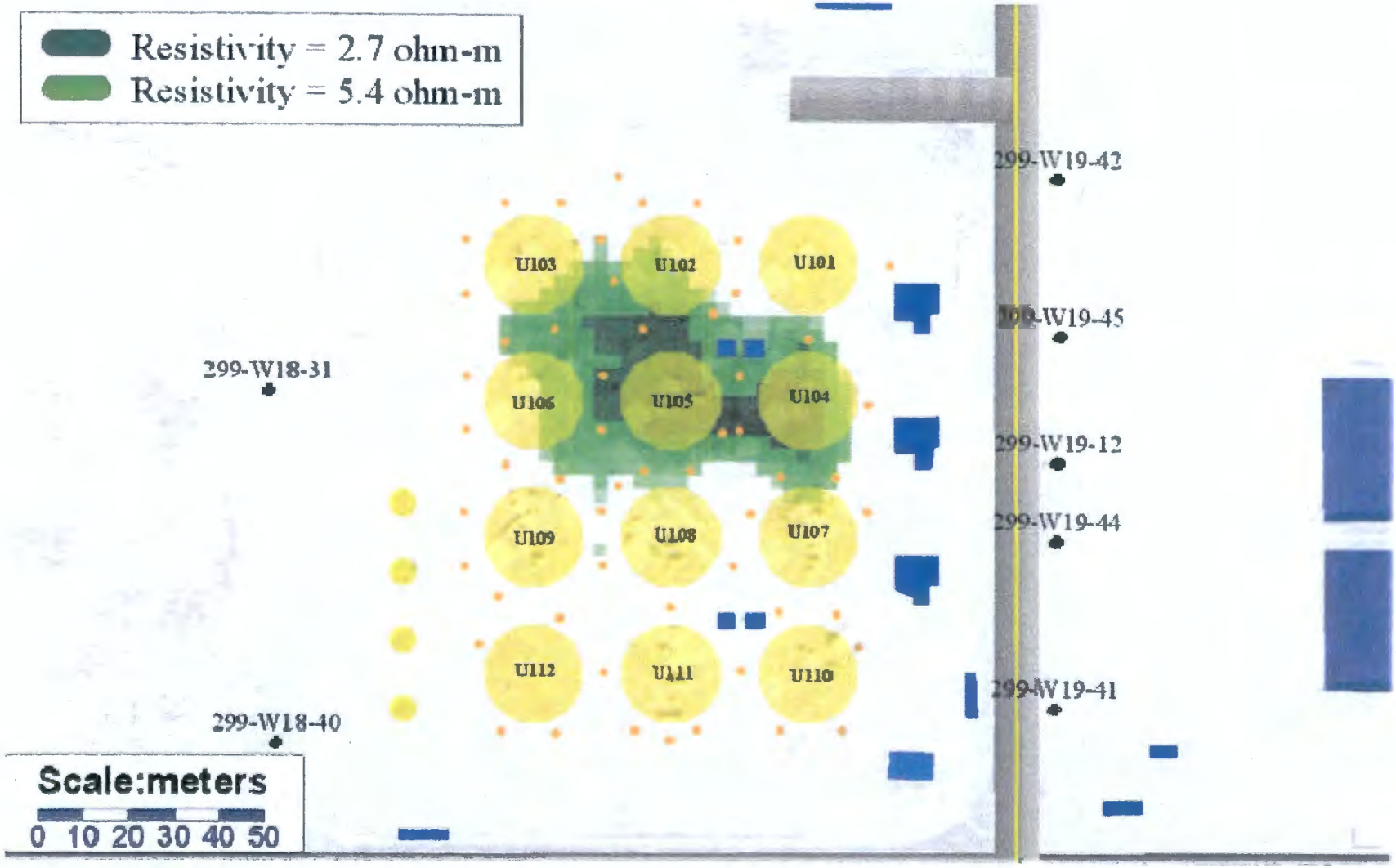
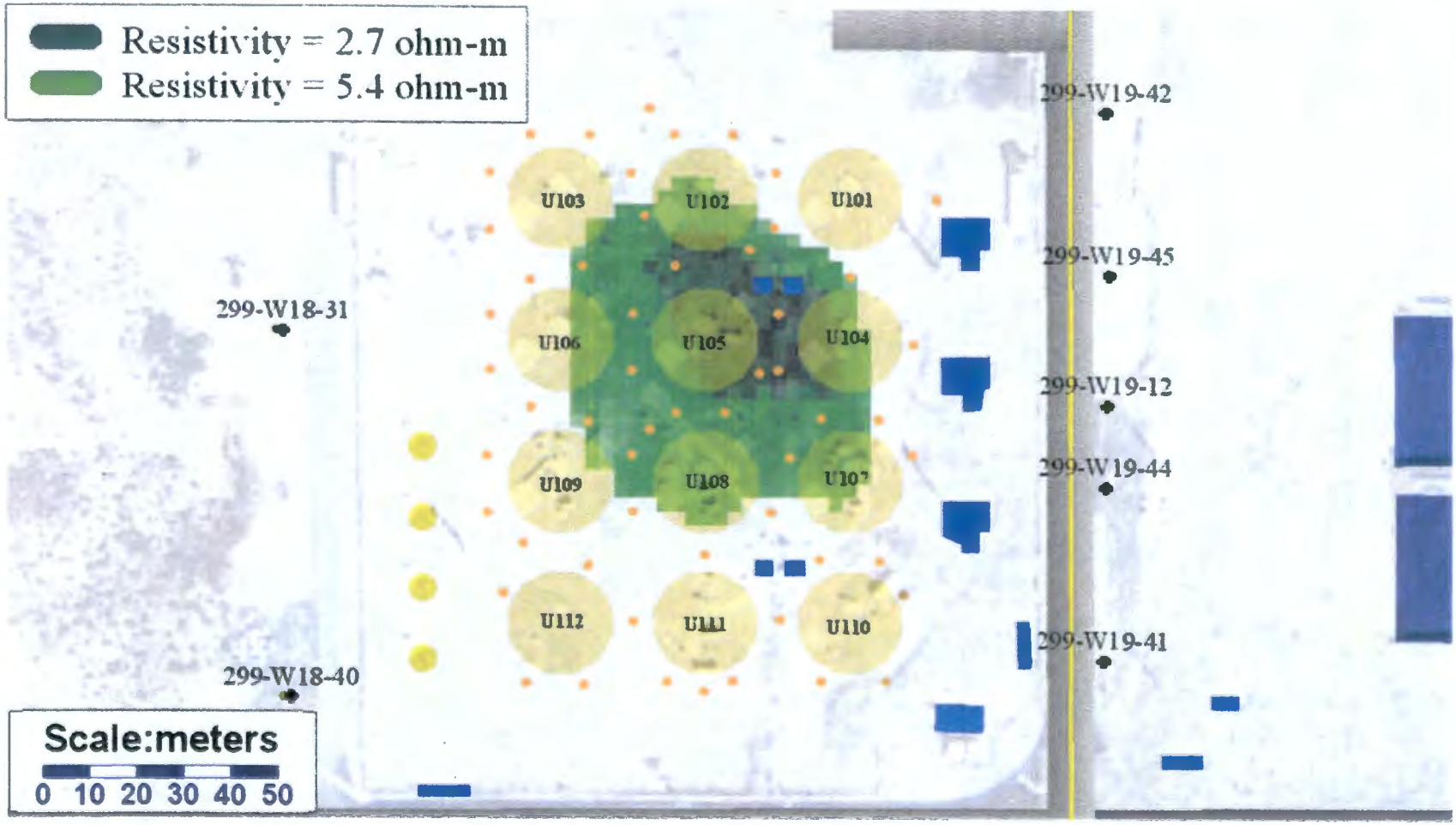


Figure 3-9. Results of Combined Well-to-Well and Limited Surface Electrode Survey, Waste Management Area U.



include both groundwater and the vadose zone. Two resistivity values are selected for display in the image, 2.7 and 5.4 ohm-m (RPP-RPT-31557, *Surface Geophysical Exploration of U Tank Farm at the Hanford Site*). Note a zone of low resistivity/high conductivity is indicated, centering between tanks 241-U-105 and U-104.

3.2.5 Groundwater Contamination Summary

Waste Management Area U was placed in assessment monitoring in 2000 due to elevated specific conductance. At that time it was concluded that the tank farm had impacted groundwater quality (DOE/RL-2009-74). The source of groundwater contamination at WMA U is limited to the downgradient (east) side of the site (Section 6.0 of PNNL-13282). The dangerous waste constituent chromium and supporting constituent nitrate were originally found in the groundwater, but monitored chromium concentrations had decreased in the past to below the analytical detection limit. Detailed background information on the groundwater contamination and conceptual model at WMA U can be found in DOE/RL-2009-74. Recent groundwater monitoring results for the 200-UP-1 Operable Unit, which extends beneath WMA U, can be found in DOE/RL-2011-118.

During 2011, nitrate concentrations were greater than the 45 mg/L drinking water standard in six of the eight monitoring wells at U Farm. This included the upgradient well (299-W18-40) indicating an upgradient source, which is interpreted to be the 200-ZP-1 interim-action pump-and-treat system injection wells. This conclusion is supported by several lines of evidence. First, the 200-ZP-1 interim-action extraction wells are located within a nitrate plume. Thus, nitrate is certainly being drawn into the extraction wells. Second, the 200-ZP-1 interim-action treatment process uses an air stripper system that removes volatile organic compounds (e.g., carbon tetrachloride) from the water, but this system is not capable of removing non-volatile contaminants, such as nitrate. Although the water from the treatment system is not sampled for nitrate, it must be the case that water containing nitrate is being injected back into the aquifer. This is further supported by the nitrate sample results from wells near and downgradient of the injection wells. In addition, the distribution of this plume is consistent with the mapped groundwater flow system, assuming the injection wells as the source. Thus, the nitrate forms a plume between the injection and extraction wells, and U Farm is on the southeast edge of this plume.

The maximum nitrate concentration measured at U Farm during 2011 was 87 mg/L (October) in 299-W19-45. Concentrations are higher in the downgradient wells compared to the upgradient well, confirming that U Farm is also a source of nitrate to the groundwater.

In the future, the rate of decline of the water table beneath WMA U may change in response to groundwater remedial action measures. In Letter 09-AMCP-0003, "Record of Decision, Hanford 200 Area, 200-ZP-1 Superfund Site, Benton County, Washington," the selected remedy for the present groundwater contamination is a combination of pump-and-treat, monitored natural attenuation, flow-path control, and institutional controls. Until recently, an interim remedial measure pump-and-treat system operated in the 200-ZP-1 Operable Unit. The recommended Record of Decision pump-and-treat system, the 200 West Area groundwater treatment facility, became operational during calendar year 2012; this system is designed to include extraction and injection wells in and near the northern 200 West Area (DOE/RL-2008-78, *200 West Area*

200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan). The contaminants of concern identified for this new system are carbon tetrachloride, total chromium, nitrate, trichloroethylene, ^{129}I, ^{99}Tc, and tritium. Operation of this new system is expected to affect water levels and the groundwater flow direction at WMA U. Analysis of the future flow field indicates that the groundwater flow direction at WMA U may become more northeasterly during operation of the pump-and-treat system. Therefore, evaluation of the adequacy of the monitoring well network at WMA U and the need for replacement wells will be an ongoing process, and the list of new wells under consideration for installation at the WMA will evolve.

3.3 DESCRIPTION OF PLANNED WORK

The description of the planned work is discussed in the following subsections:

- Goals of Current Investigation
- Data Collection
- Data Processing.

3.3.1 Goals of Current Investigation

Direct push samples collected in TY Farm and SX Farm in support of ISB design have revealed that mobile contaminants are accumulating over the top of the Cold Creek unit in 200 West Area. The same behavior would be expected of past releases in U Farm, where the top of the Cold Creek unit is ~100 ft bgs.

The purpose of the current investigation is to determine the approximate extent of any sub-surface plume in U Farm, in order to assess whether an ISB or other interim measure is warranted. The lateral extent of a plume is of importance in designing the effective extent of a barrier, if one is warranted. The depth of a plume is important in determining whether an ISB would be effective in the near term, and whether other interim measures should be considered. Any information gleaned from the current investigation will also help guide the planning for the eventual Phase 2 field investigation of WMA U, as required by the HFFACO. However, the limited scope of the current investigation is not intended or required to be a complete Phase 2 field investigation.

More focused geophysical characterization of U Farm is planned to expand on and augment the results of previous surveys. Previous and planned survey areas are illustrated in Figure 3-10. Surveys shown in Figure 3-10 include past two-dimensional (2D) resistivity as well as 2D and three-dimensional (3D) resistivity proposed under this Work Plan.

A WTW survey was conducted at U Farm in 2006. Results of this survey are presented in RPP-35485 and RPP-RPT-31557. Subsequently, four lines of surface electrodes were placed at the perimeter of the U Farm (green and red dotted lines shown on Figure 3-10). These four resistivity survey lines were processed as separate 2D lines, and results are presented in Appendix A of RPP-RPT-31557. Results from the south and east lines were severely limited due to interference from subsurface infrastructure (red lines on Figure 3-10).

Figure 3-10. Proposed Surface Geophysical Exploration Coverage Area for Interim Surface Barrier Investigation.

2D = two-dimensional 3D = three-dimensional

As an initial part of the planned work, results from the north and west resistivity survey lines (green lines on Figure 3-10) will be reprocessed to exploit recent technological advances in data processing codes. The reprocessing results will be factored into planning for the proposed field data acquisition.

3.3.2 Data Collection

The field data acquisition portion of the proposed investigation will include GPR imaging, 3D resistivity imaging, and 2D resistivity imaging. For the purposes of this work, 2D resistivity imaging consists of arranging surface electrodes along a linear surface path and alternating voltage and current along that line. This will result in a cross section, or profile, of subsurface electrical resistivity measurements that can be used to interpret physical subsurface conditions. The pink lines on Figure 3-10 show the approximate extent of the proposed lines of 2D electrodes. Arranging electrodes in a grid pattern and varying the local current and voltage electrodes results in 3D measurements made at varying depths and geometries in the subsurface, effectively generating a large volume of non-invasively obtained subsurface data. The yellow box on Figure 3-10 shows the approximate extent of the proposed 3D imaging location. More detailed descriptions of the proposed data acquisition methodology are provided in RPP-RPT-50452, *Surface Geophysical Exploration – Compendium Document*, and RPP-RPT-38104.

The presence of subsurface infrastructure can negatively affect resistivity measurements; therefore, before surface resistivity survey electrodes are placed, GPR imaging will be completed to map subsurface infrastructure, inform decisions about electrode placement, and provide information that will be used in the modeling of the resistivity results. Following the GPR investigation and prior to electrode placement, an electrical utility ground scan for live electrical utilities will be performed.

Surface electrodes will be installed, and appropriate connections with long electrodes and depth electrodes will be made. Before resistivity data acquisition is initiated, known electrical interferences will be suspended for the duration of the data acquisition period, including cathodic protection in 200 West Area. No high-resolution resistivity leak detection and monitoring systems are currently operating in 200 West Area, and the systems near 241-C Tank Farm are not expected to affect the U Farm data acquisition. Background electrical conditions will be observed, and every effort to suspend additional noise sources will be made.

Resistivity measurements will use as many as possible of the 10 deep electrodes that were placed as part of previous direct push efforts (if the electrical connection with a particular deep electrode has degraded over time, it may not be possible to include that electrode in investigation). The measurements will also use as many of the 66 groundwater and drywells as deemed technically necessary to achieve acceptable coverage. Surface electrodes will be placed orthogonally nominally every 6 meters (19.8 ft) over the extent of the 3D investigation area; the 2D investigation survey lines will also use a nominal 6-meter (19.8-ft) electrode spacing. In some cases the placement will be adjusted due to infrastructure or safety considerations.

The 3D investigation currently planned for U Farm is modeled after the ISB investigation completed at 241-BY Tank Farm, which used the 6-meter (19.8-ft) electrode spacing due to the size of the area and necessary depth of investigation (RPP-RPT-50758, *Three-Dimensional Surface Geophysical Exploration of the Eastern Portion of the BY Tank Farm*; RPP-RPT-49129, *Three-Dimensional Surface Geophysical Exploration of the BY Tank Farm*). The 3D work completed at 241-C Tank Farm (i.e., UPRs 81, 82, and 86) used smaller 3-meter (10-ft) spacing,

because the area of interest was smaller and the necessary depth of investigation was less (RPP-RPT-41236, *Surface Geophysical Exploration of UPR 200-E-81 Near the C Tank Farm*; RPP-RPT-50052, *Surface Geophysical Exploration of UPR-200-E-82 Near the C Tank Farm*; RPP-RPT-47486, *Surface Geophysical Exploration of UPR-200-E-86 Near the C Tank Farm*). The planned 2D profiles will also use the standard 6-meter (19.8-ft) electrode spacing, which covers a greater distance and allows a greater depth of investigation.

The 3D resistivity surveying will be completed using surface electrodes, previously placed depth electrodes, drywells, and groundwater wells as appropriate. The additional resistivity measurement points at the surface will allow for greater near-surface imaging resolution and subsequent characterization. The depth electrodes and well measurements will help compensate for the extensive metallic infrastructure in the tank farm, and also provide information on the vertical location of resistivity anomalies. The 2D resistivity surveying will be completed to augment the understanding of subsurface conditions outside of the tank farm. Four survey lines of ~500 meters (~1,640 ft) in length will be used in the 2D surveying, as depicted in Figure 3-10 (pink lines).

Standardized processes are used for equipment set-up, operation and maintenance. Calibration of equipment is performed per the manufacturer's requirements. As an example, one manufacturer of resistivity data acquisition instruments recommends a yearly calibration of internal calibration resistors. The calibration is performed at the manufacturer's facility, and a certificate of calibration is provided. A copy of the calibration documentation, serial numbers, and expiration dates, as well as daily inspection records of the receiver calibration when the system is in use, are maintained in the sub-contractor's project files.

3.3.3 Data Processing

Field resistivity measurements must be processed to obtained true resistivity values. This investigation will use an inversion modeling process. Generally a variety of models are completed to account for the range of expected sub-surface conditions. Real subsurface conditions that can affect resistivity imaging results include changes in subsurface mineralogy, porosity, grain size distribution, moisture content, and varying concentrations of conductive contaminants such as nitrates. Nitrates are a major component of tank waste and are commonly associated with the presence of other mobile contaminants in tank farm soil ("Inorganic Plume Delineation Using Surface High-Resolution Electrical Resistivity at the BC Cribs and Trenches Site, Hanford" [Rucker and Fink 2007]).

Data processing is performed using a number of software packages. The requirements and responsibilities for the identification, evaluation, development, testing, and maintenance of quality-affecting software acquired, developed, or modified in support of the SGE efforts flow from DOE O 414.1C, *Quality Assurance*, as implemented through the Tank Operations Contractor Quality Assurance Program, and the implementing programs of the sub-contractors.

A direct quantitative relationship between resistivity measurements and soil contamination levels has not yet been developed due to the many variables associated with bulk measurements like resistivity. However, previous comparisons of resistivity results show very good correlation with

nitrate and technetium levels from soil analytical results (Rucker and Fink 2007; "Three-dimensional electrical resistivity model of a nuclear waste disposal site" [Rucker et al. 2009]; "The application of magnetic gradiometry and electromagnetic induction at a former radioactive waste disposal site" [Rucker 2010]; "Surface geophysical exploration: developing noninvasive tools to monitor past leaks around Hanford's tank farms" [Rucker et al. 2012]). The characterization report for this U Farm investigation will include a review of available soil contaminant data similar to that of previous SGE reports (e.g., RPP-RPT-49129, RPP-RPT-50758, RPP-RPT-41236, RPP-RPT-50052, RPP-RPT-47486, RPP-34690, *Surface Geophysical Exploration of the B, BX, and BY Tank Farms at the Hanford Site*).

3.4 KEY DELIVERABLES AND SCHEDULE

Section 5.0 provides the schedule for the activities associated with resistivity investigation in U Farm. The anticipated deliverables are as follows:

- Field work completion summary: an informal report (provided as a briefing to Ecology) that describes the completion of field work, including a diagram showing the surface electrodes, deep electrodes, and drywells (long electrodes) used in the data collection activity

- Characterization report: a secondary document (M-045-22-T02) describing the results of the vadose zone resistivity characterization in U Farm, and evaluating the results to provide recommendations regarding the need for additional characterization work

- Recommendation regarding interim measures in U Farm: a letter summarizing DOE's recommendation regarding whether an ISB or other interim measure is appropriate for U Farm, based on the information obtained by the resistivity campaign.

4.0 241-SX TANK FARM PROOF-OF-PRINCIPLE CONTAMINANT REMOVAL TESTING

Milestone M-045-20 requires that this Work Plan describe the plan for initial proof-of-principle testing of contaminant removal testing at SX Farm for purposes of determining whether more extensive testing is warranted.

4.1 SCOPE

This section of the Work Plan describes the initial proof-of-principle testing of soil desiccation/ contaminant removal near SX Farm. The purpose of the initial proof-of-principle testing is to determine whether more extensive testing is warranted. This work is scheduled to be performed during FY 2013 and FY 2014. Results of the work completed during FY 2013 will be used to define the test configuration and monitoring work scope for FY 2014.

4.2 241-SX TANK FARM DESCRIPTION

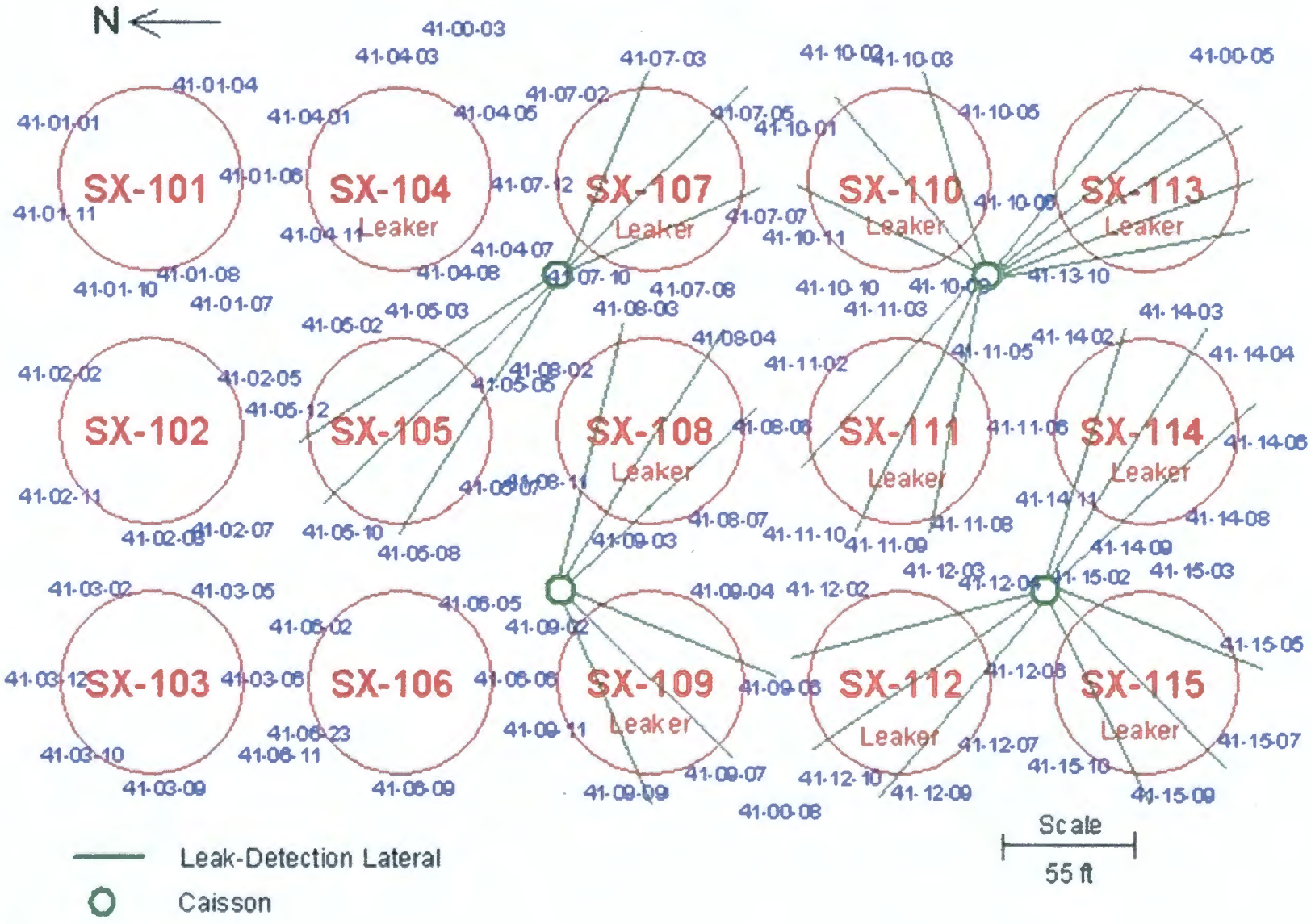
Constructed between 1953 and 1954, SX Farm is comprised of 15 SSTs. The SX Farm tanks are arranged in rows of three tanks each, forming a cascade. Each of the SX Farm tanks has a nominal 1-million-gal storage capacity. Each SX Farm tank consists of a carbon steel liner inside a reinforced concrete shell. 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 ~3.3% from the sidewall to the tank center (i.e., 14.875-in. elevation drop over 37.5-ft radius).

Ten of the tanks in SX Farm have laterals installed below the tank bottoms as part of the leak detection system. In addition to laterals, vadose zone monitoring wells (drywells) are installed throughout the farm for leak detection as well. The SX Farm drywells and laterals are shown in Figure 4-1.

4.2.1 Leak Assessment Information and Unplanned Releases

RPP-7884, *Field Investigation Report for Waste Management Area S-SX* (FIR) reported soil waste inventory estimates resulting from projected tank releases. The in-tank inventories as a function of time were derived from the Hanford defined waste model, providing tank-specific waste composition estimates at the time of the postulated waste releases. Recently, the estimates presented in the FIR were further refined using a systematic process to evaluate historic losses of waste from tank farm sources. This systematic process is described in RPP-32681. This systematic process resulted in the estimates presented in RPP-ENV-39658, *Hanford SX-Farm Leak Assessments Report*. The "leaker" status designated in Figure 4-1 reflects the status as reported in RPP-7884 and HNF-EP-0182 and has not been updated to show the new designations presented in RPP-ENV-39658 awaiting formal tank leak assessment. The RPP-ENV-39658 reassessment suggests that the releases previously associated with tanks 241-SX-104 and 241-SX-110 are unlikely to have occurred.

Figure 4-1. 241-SX Tank Farm Laterals and Drywells.



RPP-7884 also provides detailed descriptions of subsurface hydrogeologic and geologic conditions at SX Farm.

Historic information on tank leak monitoring and the current evaluation of waste losses to the soil are provided in RPP-ENV-39658. The evaluation of the tank waste loss events reported in that document led to the information summarized in Table 4-1. Tank waste loss events were initially reassessed for SSTs currently classified as "assumed leakers" (HNF-EP-0182). Table 4-1 summarizes the results of tank waste loss reassessments for these tanks and provides a comparison to the waste loss estimates contained in HNF-EP-0182. The estimated volumes of waste lost and the waste composition (types) were evaluated to update the estimated inventory of constituents in RPP-26744. In addition, tanks currently assumed as "sound" were reviewed to assess the potential for loss of waste containment. There was no indication of releases from any of the other tanks in SX Farm.

As reported in RPP-ENV-39658, document DOE/RL-88-30 contains the official listing of UPRs identified at the Hanford Site. The operational history for SX Farm was also reviewed as part of the reassessment reported in RPP-ENV-39658 to determine if additional information exists for the UPRs within SX Farm that are not associated with tank waste loss events. No significant new information was located for these UPRs. However, potential new UPRs as a result of pipeline failures were identified through review of the operational histories for SX Farm. There was insufficient available information to estimate a volume or inventory of tank waste potentially discharged to the soil from most of the identified UPRs.

To date, there have been no additional assessments or re-evaluations of the UPRs not directly associated with tanks. As such, the most recent information available for these releases is summarized within WIDS and is presented in Table 4-2.

4.2.2 Geology, Stratigraphy, and Hydrology

The geology of the 241-S and 241-SX Tank Farms and immediate vicinity is well understood as a result of several decades of site characterization activities. The geology of this site has been described in numerous reports, including the following publications:

- HNF-4936, *Subsurface Physical Conditions Description of the S-SX Waste Management Area*
- PNNL-15955, *Geology Data Package for the Single-Shell Tank Waste Management Areas at the Hanford Site*
- PNNL-11810, *Results of Phase I Groundwater Quality Assessment for Single Shell Tank Waste Management Area S-SX at the Hanford Site*
- PNNL-13757-4, *Characterization of Vadose Zone Sediment: Slant Borehole SX-108 in the S/SX Waste Management Area*

Table 4-1. Summary of Tank Waste Loss Events in 241-SX Farm. (2 sheets)

Tank	Description	HNF-EP-0182 (Rev 295) Estimate	Revised Estimate
241-SX-104 (SX-104)	Tank SX-104 was classified as questionable integrity based on ILL decreases from 1994 to 1998. ILL decreases were also observed in 1998 and 2008. Previous assessments concluded that the 1998 and 2008 ILL decreases were not attributed to a tank leak. There are several potential explanations for the ILL decrease observed from 1984 to 1988; evaporation is the most likely explanation. Assessment team members concluded there is no evidence tank SX-104 lost containment.	6,000 gal	0 (leak unlikely)
241-SX-107 (SX-107)	Tank SX-107 was classified a suspect leaker in 1967 based on drywell and lateral activity. The revised ^{137}Cs inventory is based on vadose zone data and kriging analyses. No representative sample data was found, so the leak volume was calculated assuming an average, model based, REDOX waste concentration at the time of the leak (2.7 Ci/gal for ^{137}Cs).	<5,000 gal	6,000 gal ^{137}Cs: 14,500 Ci SIM Ratio: 0.81
241-SX-108 (SX-108)	Tank SX-108 was removed from service and identified as a confirmed leaker in 1964 based on drywell and lateral activity. The revised ^{137}Cs inventory is based on vadose zone data and kriging analyses. The waste concentration at the time of the leak (3.8 Ci/gal for ^{137}Cs) is based on December 1965 SX-108 sample data. This equates to a leak volume of 11,000 gal; the revised leak volume range is based on this estimate plus unaccounted water losses.	2,400 to 35,000 gal	50,000 to 100,000 gal ^{137}Cs: 34,900 Ci SIM Ratio: 0.83
241-SX-109 (SX-109)	Tank SX-109 was identified as a suspect leaker in 1967 based on drywell and lateral activity. The revised ^{137}Cs inventory was based on vadose zone data and kriging analyses. No representative sample data was found, so the leak volume was calculated assuming an average, model based, REDOX waste ^{137}Cs concentration.	<10,000 gal	1,000 gal ^{137}Cs: 2,270 Ci SIM Ratio: 0.95
241-SX-110 (SX-110)	Tank SX-110 was removed from service and identified as a potential leaker in July 1976 as a result of an apparent unexplained liquid level decline of ~0.75 in. Based on the lack of drywell and lateral radiation readings, along with no evidence of corrosion of the steel liner, the assessment team concluded that a tank leak is unlikely and no leak inventory is assigned.	5,500 gal	0 (leak unlikely)
241-SX-111 (SX-111)	Tank SX-111 was declared an assumed leaker on May 1974 based on a liquid level decline and an increase in radiation detected in lateral 44-11-02. The revised ^{137}Cs inventory was based on a maximum leak volume in an occurrence report and September 1, 1974 sample analyses. The HDW model estimates for RSLTCK should be used to estimate inventory for other analytes.	500 to 2,000 gal	2,800 gal ^{137}Cs: 1,830 Ci Other analytes: Multiply HDW RSLTCK concentration by 0.55 and multiply by 2,800.

Table 4-1. Summary of Tank Waste Loss Events in 241-SX Farm. (2 sheets)

Tank	Description	HNF-EP-0182 (Rev 295) Estimate	Revised Estimate
241-SX-112 (SX-112)	Tank SX-112 was declared a leaking tank in January 1969 due to liquid level decreases and increased activity in tank laterals. The revised leak volume and ^{137}Cs inventory are from a 1969 ARHCO report* and appear to be consistent with drywell data. The high ratio is needed because SIM uses a leak volume of only 1,000 gal.	30,000 gal	27,000 gal ^{137}Cs: 19,200 Ci SIM Ratio: 16.1
241-SX-113 (SX-113)	Tank SX-113 was confirmed as leaking in 1962 based on the leak test and gamma activity detected in laterals underneath the tank. No change was made to earlier leak volume estimates. A small change in the ^{137}Cs inventory was made based on October 1962 sample data.	15,000 gal	15,000 gal ^{137}Cs: 4,080 Ci SIM Ratio: 0.96
241-SX-114 (SX-114)	Tank SX-114 was classified a potentially leaking tank in 1972 based on increasing drywell activity. No previous leak volume or inventory was given. A review of data confirmed the probability of a tank leak. The leak is assumed to be less than 2,000 gal based on uncertainty in manual tape liquid level measurements. The ^{137}Cs inventory estimate is based on a 1974 SX-111 sample. Inventories for other analytes are assumed to be the same as the revised SX-111 inventory multiplied by a volume ratio of 0.715.	No estimate	<2,000 gal ^{137}Cs: 1,310 Ci Other analytes: multiply SX-111 analytes by 0.715
241-SX-115 (SX-115)	Tank SX-115 was confirmed as a leaking tank in 1965 based on measured liquid level decreases and gamma activity in drywells and laterals. The revised leak volume is the upper volume in a process report (HW-83906 E RD, page 62c**) and the revised ^{137}Cs inventory is based on September 1964 tank sample results. The SIM ratio accounts for volume and sample differences from current SIM estimates.	50,000 gal	51,000 gal ^{137}Cs: 16,800 Ci SIM Ratio: 1.13

Note: Except as noted, ^{137}Cs inventories are decayed to January 1, 2001 consistent with values in Hanford Soil Inventory Model (SIM).

Reference: HNF-EP-0182, *Waste Tank Summary Report for Month Ending October 31, 2012*, Rev. 295.

ARHCO = Atlantic Richfield Hanford Company
HDW = Hanford Defined Waste
ILL = interstitial liquid level
SIM = Hanford Soil Inventory Model
REDOX = Reduction Oxidation
RSLTCK = R-Saltcake waste type

* ARH-1100-DEL, *200 Areas Operation Monthly Report January 1969*, page G-4.
** HW-83906 E RD, *Chemical Processing Department 200 West Area Tank Farm Inventory and Waste Reports July 1961 Through 1966.*

Table 4-2. Unplanned Releases Associated with 241-SX Tank Farm, Compiled from the Waste Information Database System.

WIDS Site Number	Location	Date	Release Type	Waste Type
UPR-200-W-114 UPR-200-W-50	Inside 241-SX Tank Farm and spread eastward beyond the fence	1/1/1958	Wind born particulates from 241-SX Tank Farm activities	Consolidated WIDS site containing UN-216-W-24 UN-200-W-114

WIDS = Waste Information Data System
Source: WIDS database.

- PNNL-13757-2, *Characterization of Vadose Zone Sediment: Borehole 299-W23-19 [SX-115] in the S/SX Waste Management Area*

- PNNL-13757-3, *Characterization of Vadose Zone Sediment: Borehole 41-09-39 in the S/SX Waste Management Area*

- RHO-ST-23, *Geology of the Separation Areas, Hanford Site, South-Central Washington*

- RPP-23748, *Geology, Hydrogeology, Geochemistry, and Mineralogy Data Package for the Single-Shell Tank Waste Management Areas at the Hanford Site*

- RPP-7613, *Moisture Distribution in the SX Tank Farm*

- WHC-EP-0883, *Variability and Scaling of Hydraulic Properties for 200 Area Soils, Hanford Site*.

The main source of information about geologic strata underlying the Hanford Site and the tank farms is data from the drilling of boreholes and the analyses of the sediments and contaminants within them.

Four major stratigraphic units underlie the 241-S, 241-SX, and 241-SY Tank Farms (in ascending order) include the following:

- Columbia River Basalt Group

- Ringold Formation (including members of Taylor Flats [Rtf] and members of Wooded Island [Rwi])

- Cold Creek unit (including subunits CCU_u and CCU_l)

- Hanford formation (including subunits H1 and H2)

- Backfill.

The general characteristics of these units are described in more detail in RPP-23748. The SSTs at WMA S-SX were emplaced within the Hanford formation sediments. All but the surface of the Hanford formation have a general tendency to dip west to southwest toward the axis of the Cold Creek unit. The vadose zone beneath WMA S-SX is as much as 65 meters (213 ft) thick and consists of the Hanford formation, the Cold Creek unit, and the upper part of the Ringold Formation. Both the water table and the unconfined aquifer reside entirely within the Ringold Formation; see Figures 4-2 and 4-3.

Sediments in the vadose zone vary from open-framework gravels of the gravel-dominated facies and interbedded sand and silt of the silt-dominated facies of the Hanford formation to calcium carbonate-rich deposits of the Cold Creek unit and cemented gravels of the Ringold Formation. These sediments are characterized by numerous lateral discontinuities, such as pinchouts, erosion truncations, and irregular flow patterns. If clastic dikes are present, they may enhance vertical flow patterns. Therefore, there are numerous possible avenues for contamination to migrate through the vadose zone (HNF-4936).

The following is an overview of the hydrology of the uppermost unconfined aquifer beneath WMA S-SX. More detailed information can be found in RPP-23748, RPP-7884, DOE/RL-2009-73, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area S-SX*, and DOE/RL-2011-118.

The current primary groundwater flow direction in the unconfined aquifer beneath WMA S-SX is to the east-southeast. The estimated hydraulic gradient in this region is 2.0×10^{-3}. The general groundwater flow velocity ranges from 0.013 to 0.31 meters/day (0.04 to 1.02 ft/day) (DOE/RL-2011-118).

Water level data collected from monitoring wells located near and inside WMA S-SX (299-W23-1, 299-W23-3, 299-W23-4) indicate that between the early 1950s and mid-1960s, the water table in the vicinity of WMA S-SX rose ~11 meters (~36 ft) in response to wastewater discharges to the 216-U-10 pond. The water table elevation remained fairly steady between 1965 and 1984. Water levels began to decline rapidly in 1985, when discharge to the 216-U-10 pond ceased. That decline continues today. Water levels have decreased by ~11 meters (~36 ft) in the WMA S-SX area since 1985, and have returned to levels consistent with those observed in the early 1950s.

The aquifer resides in partially cemented sands and gravels of the Ringold Formation member of Wooded Island (subunit E). Currently, the water table beneath WMA S-SX lies ~136 meters (~446 ft) above mean sea level, resulting in ~78 meters (~255 ft) of vadose zone (RPP-17209). The unconfined aquifer is ~67 meters (~219 ft) thick (RPP-23748), and hydraulic conductivity values reported for the aquifer in this area range from 0.15 to 17.2 meters/day (0.49 to 56.4 ft/day) (PNNL-14058, *Historical Vadose Zone Contamination from S and SX Tank Farm Operations*). Additional hydraulic property data from aquifer testing at wells near WMA S-SX are provided in RPP-23748 and DOE/RL-2011-118.

Figure 4-2. Location of Cross Sections Presented in RPP-23748.

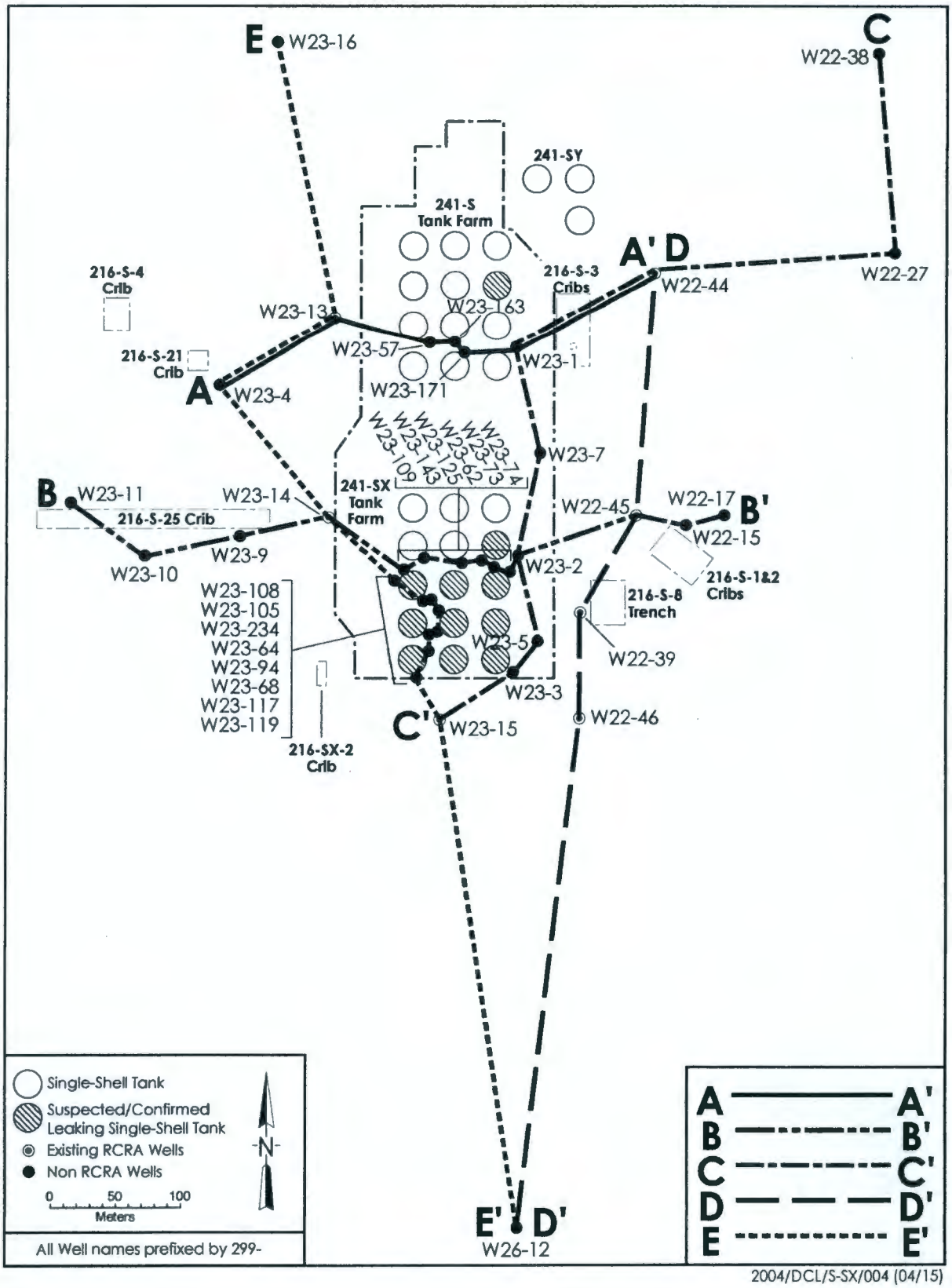
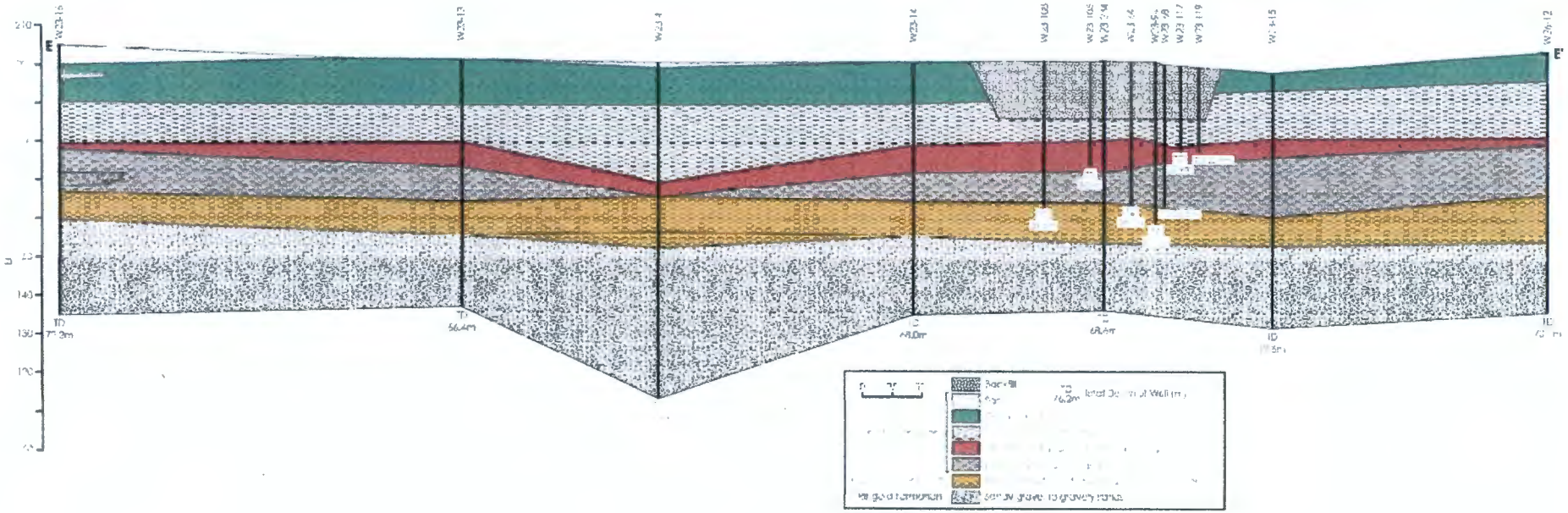


Figure 4-3. Geologic Cross-Section E-E' from the 241-S and 241-SX Tank Farms.



Groundwater beneath WMA S-SX was found to be contaminated with nitrate, ^{99}Tc, and hexavalent chromium attributed to two general source areas within the WMA (DOE/RL-2011-118). The nitrate plume data are attributed to one source area to the north in 241-S Tank Farm and one area to the south in SX Farm (Figure 3-6). Tritium and carbon tetrachloride plumes are also present in groundwater beneath the WMA, but their sources are thought to be further upgradient of the WMA.

4.2.3 Potential Soil Contamination

This section provides an overview of information on soil surface and vadose zone contamination in WMA S-SX as provided in HNF-SD-WM-ER-560, *Historical Vadose Zone Contamination from S and SX Tank Farm Operations*. A detailed description of contaminant occurrences and environmental conditions at the WMA S-SX is provided in HNF-4936.

The FIR for WMA S-SX (RPP-7884) provides an in-depth analysis of the history and vadose zone data collected through 2001. Based on this analysis, it was determined that three main areas of contamination exist in the vadose zone underlying the 241-S and SX Tank Farms. These three zones include the areas around the following tanks:

- Tanks 241-SX-107 (SX-107), 241-SX-108 (SX-108), 241-SX-109 (SX-109)
- Tanks 241-SX-113, 241-SX-115 (SX-115)
- Tank 241-S-104.

Evidence from the historical record suggests that the largest leaks in WMA S-SX came from these tanks or associated infrastructure. Comparison of gamma data within these three areas shows ^{137}Cs to be much more extensively distributed both horizontally and vertically in the area around tanks SX-107, SX-108, and SX-109. In the areas around tanks 241-SX-113, SX-115, and 241-S-104, ^{137}Cs is measured in one drywell very close to the side of each tank. Spectral gamma logging data also indicate the presence of generalized near-surface contamination across WMA S-SX. A number of surface and near-surface spills and UPRs were documented in and around WMA S-SX. Summary descriptions of these events are provided in HNF-SD-WM-ER-560. Most appear to have been minor releases that made relatively insignificant contributions to vadose zone contamination. Recent field characterization efforts for the WMA S-SX FIR (RPP-7884) were mostly directed toward the areas around larger known release events. Relatively small amounts of recent characterization data have been collected for the areas around minor release events.

The FIR indicates that waste from tanks in SX Farm has impacted groundwater with ^{99}Tc concentrations reaching over 80,000 pCi/L at the time of the study (2002). With no additional sources in the vicinity of the WMA it can be assumed that the contamination must have reached the groundwater via the soil column, resulting at least in residual contamination throughout the soil column, in addition to likely retention of non-mobile contaminants within the soil column.

Figure 4-4 presents results of a combined drywell geophysical gamma logging survey and soil analytical results from SX Farm and presented in RPP-7884 as a kriged contaminant distribution of ^{137}Cs at values above 5×10^3 pCi/g. Note the peak concentrations centered between

tank SX-109 and tank SX-108, with additional contamination present at tanks SX-107 and SX-115. Since the ^{137}Cs is relatively immobile, this information could be projected to assume deeper, more dispersed plumes of mobile contaminants originating from the same locations. The results of this kriging analysis seem to be consistent with the independently conducted 2008 SGE resistivity survey presented in Figure 4-5.

The WTW SGE survey conducted in August 2008 focused on the acquisition and analysis of electrical resistivity data to identify and locate low resistivity regions in and around the SX Farm area indicative of potential areas of high nitrate or sodium contamination (RPP-RPT-38322, *Surface Geophysical Exploration of the S and SX Tank Farms at the Hanford Site*). The initial part of the survey integrated GPR and electrical resistivity. High-resolution electrical resistivity data were collected in a WTW survey using 21 existing groundwater wells and 132 vadose zone wells in the SX Farm area. A correction factor was developed to correct the raw data to account for the area infrastructure, thereby adjusting the final interpretive results.

Figure 4-5 displays survey results for WTW resistivity measurements. Well-to-well measurements provide 2D results only and do not indicate depth. Resistivity anomalies less than 1.5 ohm-m are shown in red. Resistivity values between 1.5 and 3 ohm-m are shown in green. Low resistivity is an indicator of increased moisture or increased concentration of electrolytes compared to background conditions. The results of the modeling show lowest resistivity near tanks that have been designated as historically leaking. In particular, these include the tanks in the central to south portion of SX Farm. The low resistivity appears to be centered on tank SX-108. In general there is good agreement between the results of these two studies.

4.2.4 Previous Vadose Zone Results

In addition to the well logging, resistivity, and soil sample results presented in the preceding section, a 2009 follow-on soil sampling campaign was completed to further evaluate the potential for installation of an ISB (RPP-43548). Figure 4-6 displays the direct push soil sampling locations (green circles) combined with the highest nitrate analytical value for each direct push location, as well as an outline of the WTW resistivity results. Figure 4-6 includes nitrate results from two previous investigations, an angled boring completed under tank SX-108 (C3082) and vertical boring completed to the southwest of tank SX-115 (B8809). The highest nitrate value presented in Figure 4-6 is associated with the angled push investigation (C3082) at ~129 ft bgs. The sample was obtained under tank SX-108; as such, the symbol is drawn at the location of the sample rather than where the direct push originated. Table 4-3 presents a summary of moisture content, nitrate concentration, and ^{99}Tc concentration results with the associated depth for each direct push sampling location. The table specifically focuses on the locations from the area of interest (i.e., southern portion of the farm where the test will be performed). Nitrate is regulated as nitrogen in WAC 173-340, "Model Toxics Control Act – Cleanup," with a limit of 9.3 ppm. Nearly all of the samples associated with the SX Farm investigations have exceeded the 9.3 ppm WAC limit, with the highest concentrations observed between 100 and 140 ft bgs. The upper Cold Creek unit is located at approximately this depth and is believed to be providing a natural barrier restricting the progression of the subsurface contaminants to the water table.

Figure 4-4. 241-SX Tank Farm Geophysical Logging Plan and Cross Section View of Cesium-137 Contaminated Soil Above 5×10^3 pCi/g.

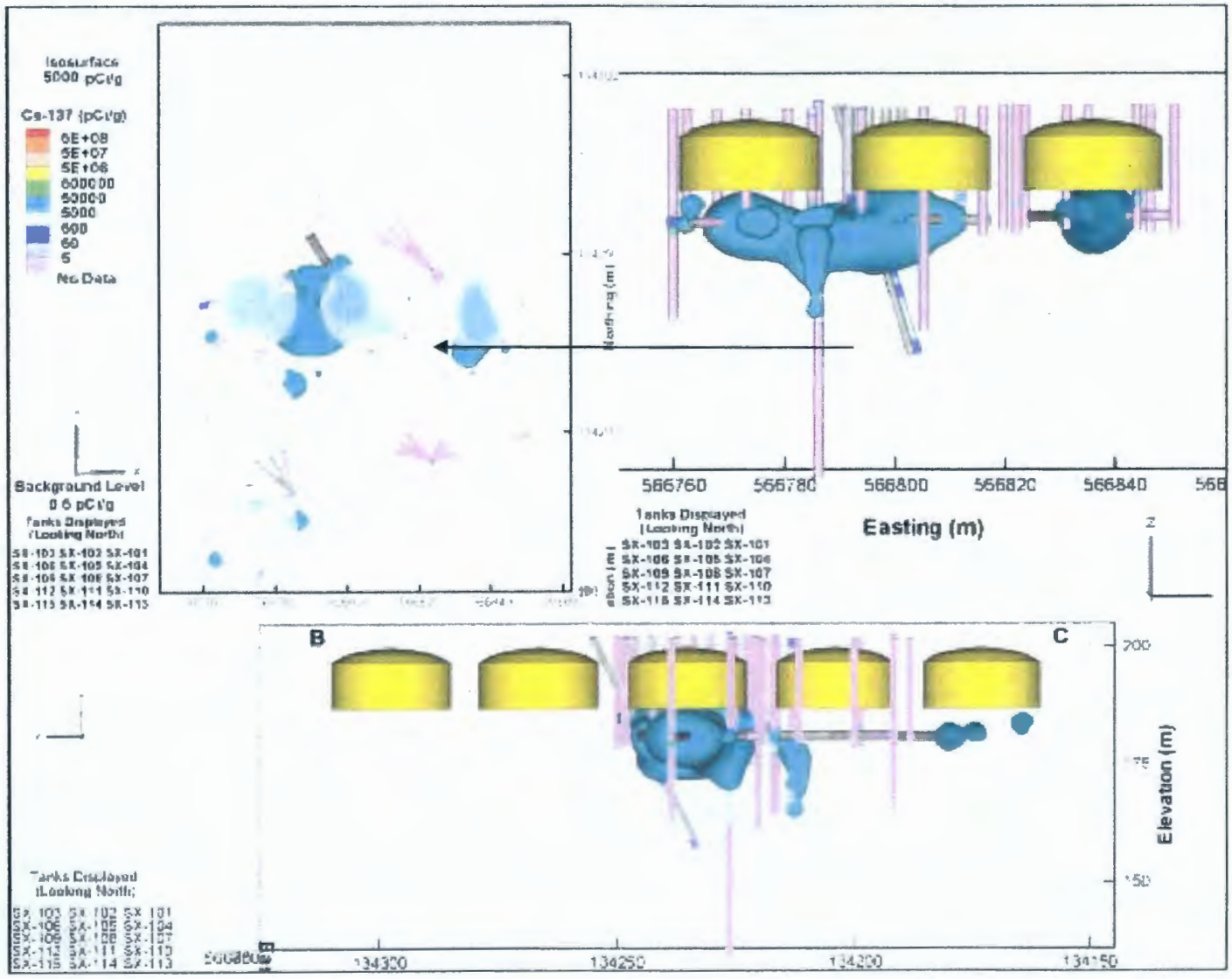


Figure 4-5. 241-SX Tank Farm Surface Geophysics Exploration Results.

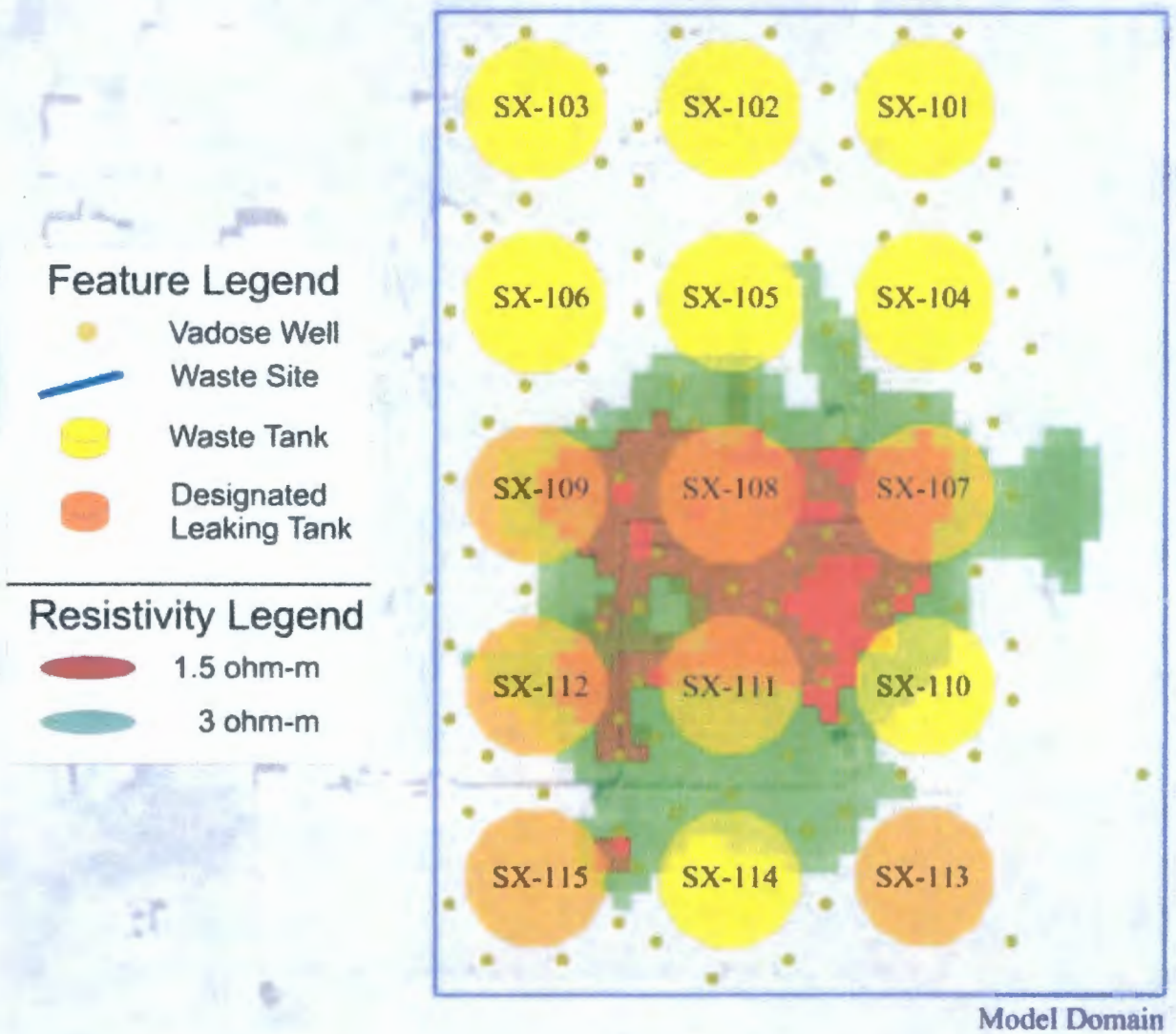
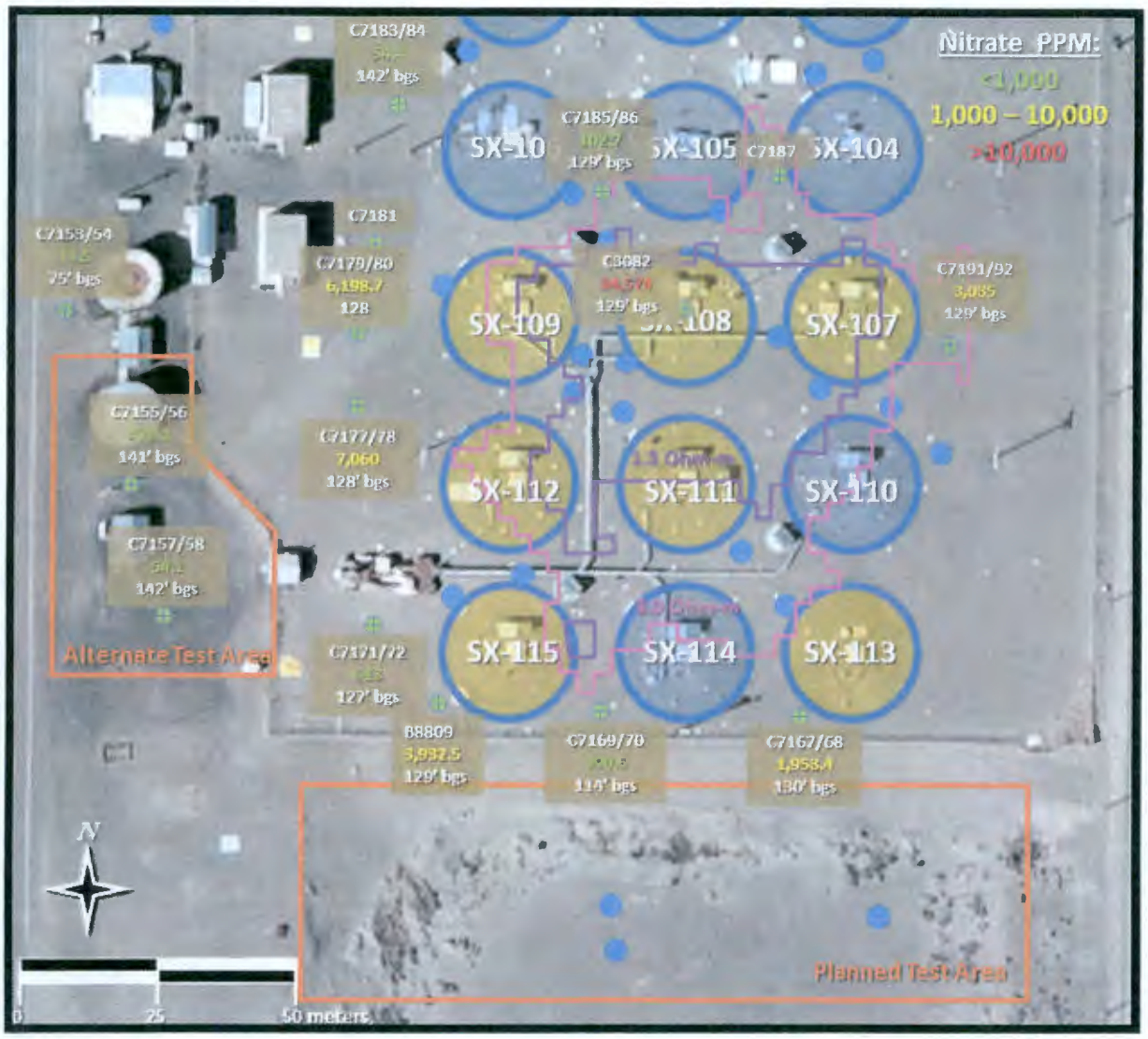


Figure 4-6. Direct Push Sampling Locations, with Maximum NO_3 and 2006 Well-to-Well Resistivity Anomalies at 3.0 Ohm-meters (pink) and 1.5 Ohm-meters (purple).



1.5 Ohm-m (WTW Resistivity 2008, RPP-RPT-38322) — soil sample location

3.0 Ohm-m (WTW Resistivity 2008, RPP-RPT-38322) — groundwater well

Note: The highest concentration for each boring and associated depth are listed. The WAC limit for nitrate in soil is 9.3 PPM as nitrogen. This map suggests that both investigation areas are well above the WAC limits.

PPM = parts per million WAC = *Washington Administrative Code* WTW = well-to-well

Results of the previous soil investigations at SX Farm indicate the presence of contamination within the vadose zone. One way to mitigate the risk associated with this contamination is to restric groundwater recharge and reduce soil moisture by installing one or more ISBs. Previous work completed at T and TY Farms resulted in the installation of ISBs to reduce soil moisture.

The work planned in this document evaluates the potential to reduce the subsurface soil moisture and contaminant inventory through pore-water and vapor extraction.

Table 4-3. Direct Push Analytical Results from Area of Interest.

Sample Hole (Logging Hole in Parentheses)	Depth (feet below ground surface)	Sample ID #	$\%H_2O$	Nitrate (µg/g)	^{99}Tc (pCi/g)
C7172 (C7171) (~40 feet northwest of tank 241-SX-115)	46-48	B206Y1	13.84	5.51	<0.0656(U)*
	75.5-77.5	B206Y3	14.28	51.8 (E)	1.02
	97.5-99.5	B206Y5	18.96	266	50.3
	126-128	B20H52	20.33	613	115
C7170 (C7169) (~20 feet southeast of tank 241-SX-115)	81.5-83.5	B206X4	2.75	174	14.3
	113-115	B206X6	5.22	990	76.8
	133-135	B206X8	15.69	27.0	0.530
	150-152	B20H47	18.67	41.2	0.0296 (J)
C7158 (C7157) (150 feet west of tank 241-SX-115)	87-89	B206R8	2.16	2.12	<0.0711(U)*
	124-126	B206T0	14.08	17.3	0.456 (J)
	141-143	B206T2	13.89	54.1	4.01*
C7168 (C7167) (~10 feet southwest of tank 241-SX-113)	81-83	B206W8	10.86	958	65.8
	129-131	B206X0	13.94	1.95E+03	137
	145-147	B206X2	17.03	66.2	2.48

(J) – Result is below quantitation limit and is considered estimated (E) – Exceeded the calibration range (U) – not detected
Information derived from RPP-RPT-47008, *Final Analytical Report for Soil Samples in Support of an Interim Barrier at SX Farm*. Values marked with an asterisk (*) were corrected to fix a typographical error in RPP-RPT-47008.

4.3 DESCRIPTION OF PLANNED WORK

The description of the planned work is discussed in the following subsections:

- Background on Contaminant Removal and Desiccation Testing at 241-SX Tank Farm
- Purpose of Test
- Test Stage Information.

4.3.1 Background on Contaminant Removal and Desiccation Testing at 241-SX Tank Farm

The following Hanford Site field and laboratory studies of soil desiccation and/or soil water extraction are relevant to the proposed work at SX Farm:

- the BC Cribs and Trenches soil desiccation tests
- the 216-Z-9 Crib testing of soil vapor extraction
- recent and ongoing laboratory studies undertaken by PNNL.

In addition to the work mentioned above, there are ongoing efforts to remove contaminated pore-water from the vadose zone north of 241-B Tank Farm (B Farm) in Hanford's 200 East Area. The similarity between the work described in this Work Plan and the work being conducted north of B Farm is very limited. The pore-water being removed north of B Farm occurs in a perched layer and flows freely into the well, where it is pumped to the surface for treatment and disposal, similar to a classic pump-and-treat operation.

While conducting soil desiccation tests near the BC Cribs and Trenches in the 200 East Area of the Hanford Site, DOE, Richland Operations Office (DOE-RL) and its contractor, CH2M HILL Plateau Remediation Company (CHPRC) found that unexpectedly high nitrate, chloride, sulfate, sodium, calcium, magnesium, and ^{99}Tc concentrations were in extracted pore-water (DOE/RL-2009-119). It was concluded that this was the result of extraction of water droplets, rather than evaporated water as was expected (DOE/RL-2009-119). This testing showed that under certain conditions, soluble contaminants (including nitrate, technetium, and other cations and anions) could be removed from the soil in addition to water. The result was attributed to the high velocity air flow during the test. The flow rate of ~390 ft^3/min was estimated to provide soil gas velocity exceeding 80 km/h (50 mi/h). The presence of significant contamination suggests that the high air flow entrained a mist of pore-water droplets in addition to vapor phase water (DOE/RL-2009-119). It was further concluded that it was doubtful this phenomenon could be maintained, because imposed soil gas velocity would decrease as a function of distance-from-the-well squared (DOE/RL-2009-119). Testing at SX Farm will support a determination about whether this is a valid conclusion.

The testing at BC Cribs and Trenches was performed using wide diameter boreholes. A test of soil vapor extraction using narrow diameter direct push holes was also performed by CHPRC to extract carbon tetrachloride from the vadose zone in the Hanford 200 West Area near the 216-Z-9 Crib (HNF-41053-VA, *Use of Narrow-Diameter, Direct-Push Wells to Characterize and Remediate Carbon Tetrachloride in the 200 West Area, Hanford Site, Washington*). In this test, carbon tetrachloride was successfully extracted from holes with an exterior diameter of ~1.5 in., screened between ~58 and 64 ft bgs.

More recently, PNNL has conducted laboratory experiments and numerical modeling to demonstrate the effects of multiple variables on the process of pore-water extraction from soil media similar to sediments at SX Farm (PNNL-20507, *Pore-Water Extraction Intermediate-Scale Laboratory Experiments and Numerical Simulations* and PNNL-21882/ RPT-DVZ-AFRI-011, *Pore-Water Extraction Scale-Up Study for the SX Tank Farm*). Test variables included imposed negative pressure, as well as soil media hydraulic properties, grain size, and packing. The PNNL studies demonstrate that, in principle, pore-water extraction from unsaturated porous media is possible. The studies suggest optimal volumetric moisture contents and vacuum pressure for successful pore-water extraction from media similar to that in the SX Farm target area. The studies also indicate that the success of pore-water (and mobile contaminant) removal field testing will be influenced by the rate at which a vacuum is applied to the soil medium, as well as by extraction system design.

Discussions among ORP and Ecology personnel concerning the testing at BC Cribs and Trenches and near the 216-Z-9 Crib resulted in the creation of an HFFACO milestone for

conducting a contaminant removal/soil desiccation test in the area of the SX Farm in the 200 West Area. Milestone M-045-20 requires that a work plan be submitted describing the plan for initial proof-of-principle testing of contaminant removal testing at the SX Farm for purposes of determining whether more extensive testing is warranted. Target Date M-045-22-T03 requires that a report documenting the results of this field testing be submitted which includes a recommendation for further soil desiccation/contaminant removal for tank farm contamination or for performing ISB construction.

The SX Farm pore-water extraction test will be a proof-of-principle test of a contaminant removal technology using tank farm-deployable equipment. The general location of the test at SX Farm was specified in Milestone M-045-20. The general location of the test area was chosen due to the presence of relatively shallow moist geologic layers containing mobile contaminants such as ^{99}Tc and nitrates. The specific area south of SX Farm was chosen for the test to allow greater operational flexibility than would be possible working within the tank farm itself.

4.3.2 Purpose of Test

The purpose of this test is to determine if soil water extraction using tank farm-deployable equipment is a viable technology for soil remediation within a tank farm. To this end, this test will use small-diameter (~ 1.75-in. inside diameter) holes placed with a direct push hydraulic hammer. Direct push technology is used throughout the tank farms for subsurface investigations that include geophysical logging, equipment placement, and sample collection activities. Direct push technology is used at tank farms due to its low cost, rapid hole placement, and the fact that it does not produce excavated soil that can lead to worker exposure and increased waste disposal costs. In addition, the direct push hydraulic hammer is a relatively small unit compared to other drilling equipment and can be placed in locations where placement of a larger drill rig would be problematic.

Questions to be answered include:

1. Can soluble contaminants in liquid phase pore-water be removed using narrow diameter direct push holes?

2. What equipment configuration and operating parameters are required to extract liquid phase pore-water containing contaminants through a direct push hole?

3. If liquid phase water containing contaminants cannot be removed, can vapor phase moisture be removed using the narrow diameter probe holes placed with the direct push unit?

4.3.3 Test Stage Information

Staff from Ecology, ORP, DOE-RL, WRPS, and PNNL met on October 30, 2012 to discuss the planned proof-of-principle testing near SX Farm. Minutes from this meeting are contained in Appendix D. As discussed at the meeting, the testing will be performed in three stages as illustrated in Figure 4-7.

- The first stage proof-of-principle testing will be field activities to obtain additional information about three prospective test locations south of the SX Farm fence line. This first stage will involve pushing and logging these three test locations to determine if the locations have good moisture peaks (i.e., adequate moisture content) as determined by reviewing neutron log data collected from the borehole.

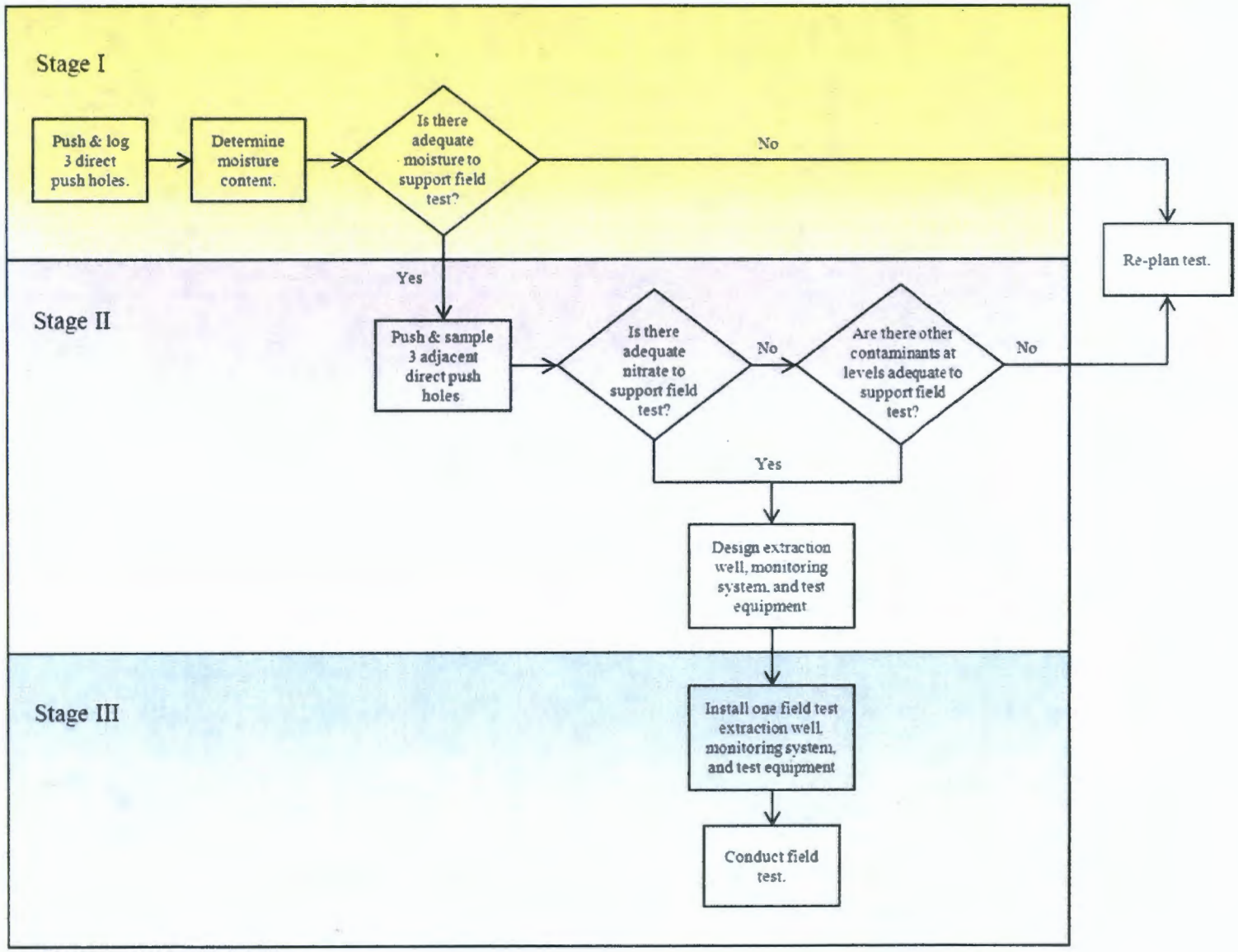
- The second stage of proof-of-principle testing will be pushing boreholes adjacent to the first boreholes, collecting samples, identifying a preferred test location, and designing the test equipment and associated monitoring system.

- The third stage of the proof-of-principle testing will be to procure equipment, install the test and monitoring equipment including a direct push hole at the selected test location, and conduct the water extraction test itself.

Stage I of the proof-of-principle testing will be field activities to obtain moisture information about three prospective test locations south of the SX Farm fence line. The general location for the three prospective test locations is shown in Figure 4-6. Ground penetrating radar and electrical ground scans will be performed before probe holes are pushed, to identify sub-surface infrastructure and support citing of the test holes. The combination of sub-surface infrastructure and surface accessibility will determine the exact location of each test hole. Holes will be pushed and logged at each of the three prospective test locations to determine moisture content. Moisture content will be determined by reviewing neutron log data collected from the direct push hole. Although the determination of the prospective test location's viability based on moisture content will be primarily qualitative, work performed by PNNL and documented in PNNL-21882/RPT-DVZ-AFRI-011 indicates that a minimum moisture content of 20% by volume should be targeted. However, additional PNNL testing is ongoing, and it is possible that a lower moisture content may be acceptable at the selected test location based on site-specific soil conditions. Existing data shows that high moisture zones should be found at these prospective test locations.

During Stage II of the test, the prospective test locations with adequate moisture content will be characterized for the presence of nitrate. A second direct push hole will be pushed adjacent to each of the first boreholes placed in Stage I. Each of these second direct push holes will be sampled at two sample intervals. Sample intervals will be selected based on the logging results and other information available about the location. The samples will be analyzed on a "quick-turnaround" basis for moisture content, nitrate, and technetium. Based on nitrate concentrations from each location, a location will be chosen for the proof-of-principle test. If a location cannot be chosen based on nitrate, other contaminants may be considered and could form the basis for the selection of one of the three prospective test locations for the proof-of-principle test. Note that if no location is deemed appropriate for the test, then replanning of the test will be initiated.

Figure 4-7. Decision Process for Borehole Placement and Determining the Acceptability of a Potential Test Location.



Also in Stage II, the design of the extraction well, monitoring system, and test equipment will be completed, and a procedure will be developed for conducting the test. Specific equipment design, test configuration, and operating plans will be developed as a part of the test design. It is anticipated that the test configuration will include a vacuum pump to facilitate extraction of the pore-water and a micro pump to transfer the pore-water to the surface.

In Stage III, an extraction well, monitoring system, and test equipment will be installed and operated to complete the test, data will be gathered and analyzed, and a test report will be prepared to document test results. Conceptually, testing will determine if water containing mobile contaminants can be extracted using direct push holes. Additionally, equipment configurations and operating parameters may be varied during testing to determine effects on factors such as the radius of influence, efficiency of contaminant removal, and length of time required for well equilibration. Per HFFACO Target Date M-045-22-T03, a test report will be developed and will include a recommendation for further soil desiccation/contaminant removal or for performing ISB construction.

In addition to the work covered under this plan, deployment of a field beta detector may occur if deemed feasible. This work will be purely opportunistic and will be dependent upon project timing, opportunity, risk, and budget. It is mentioned here for information purposes only.

4.4 KEY DELIVERABLES AND SCHEDULE

Section 5.0 provides the schedule for the activities associated with contaminant removal proof-of-principle testing at SX Farm. This schedule is based on identifying a suitable test location from the three prospective test locations discussed in Section 4.3 of this Work Plan. If a suitable test location cannot be identified, additional Stage I activities will be required, which will impact follow-on activities. The anticipated deliverables are as follows.

- Field test location decision: an informal report (provided as a briefing to Ecology) that describes the results of the Stage I direct push hole logging, provides the quick turnaround analysis results of any samples analyzed in Stage II, and identifies the location for the proof-of-principle test.

- Field test protocol: a formal report describing the equipment to be used in the proof-of-principle test and the test activities.

- Contaminant removal proof-of-principle test report: a secondary document (M-045-22-T03) describing the results of the contaminant removal proof-of-principle testing at SX Farm that will include a recommendation for further soil desiccation/ contaminant removal for tank farm contamination or for performing ISB construction.

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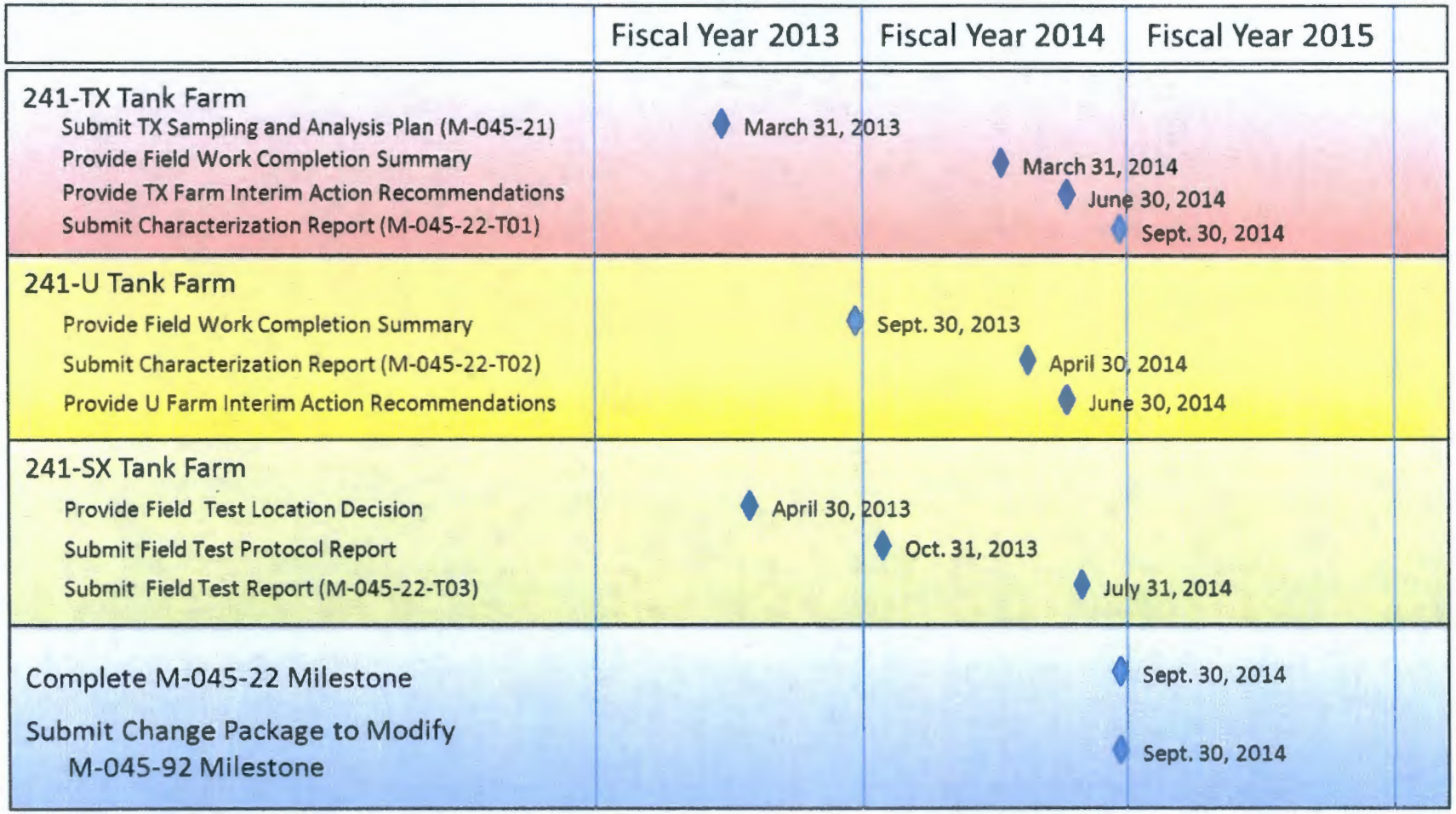
5.0 SCHEDULE

The schedule provided in this section of the Work Plan (Figure 5-1) addresses key deliverables discussed in Sections 2.4, 3.4, and 4.4 of this Work Plan. Deliverables identified on the schedule include documents required under HFFACO Milestones M-045-21 and M-045-22 and HFFACO Target Dates M-045-22-T01, M-045-22-T02, and M-045-22-T03. Additional and less formal deliverables (e.g., field work completion summaries) are also included on the schedule.

Figure 5-1. Schedule of Key Deliverables for 200 West Area Tank Farms Interim Measures Preliminary Investigation Work Plan.



6.0 PROJECT MANAGEMENT

6.1 ORGANIZATIONS AND RESPONSIBILITIES

All work performed for this Work Plan is managed by the ORP Federal Project Director for Retrieval and Closure. The Federal Project Director may delegate specific personnel to oversee and report on aspects of the work as required. Contractor support for this Work Plan is provided by WRPS Single-Shell Tank Retrieval and Closure. The manager of the Closure and Corrective Measures organization is responsible for overall performance and reporting of the work. Specific sub-contractors will be assigned to perform specific tasks, coordinated and integrated through the Closure and Corrective Measures organization.

6.2 WORK CONTROL

The primary goals of work control are to provide methods for planning, authorizing, integrating and controlling work so tasks can be performed on schedule and within budget. Work control will be performed through the use of WRPS procedures that implement the requirements of DOE Order 430.1B, *Real Property Asset Management*. The Closure and Corrective Measures manager or delegate is responsible for ensuring that the appropriate work control procedures are applied.

6.3 MEETINGS AND PROGRESS REPORTS

Monthly progress will be reported under the associated HFFACO milestone or target at the monthly HFFACO Project Managers Meeting.

Additional meetings will be held among ORP, WRPS, and Ecology to discuss technical issues that require decisions (for example, selection of sampling depths for the soil samples in TX Farm). For any meeting that requires a decision:

- A meeting agenda will be distributed prior to the meeting
- Meeting notes will be generated, summarizing the technical discussions and identifying each decision and action item
- Following review and finalization of the meeting notes, a copy signed by the ORP and Ecology project managers will be entered into the HFFACO administrative record.

6.4 RECORDS MANAGEMENT

Formal documents, designs, and data produced under this Work Plan will be managed through WRPS Records Management Process. Primary and secondary documents required by HFFACO

milestones and targets will be formally submitted and managed through the applicable HFFACO document processes. Any revisions to this Work Plan or the associated primary and secondary documents, once finalized, will be in accordance with Section 9.3 of the HFFACO.

6.5 QUALITY ASSURANCE

Work described in this Work Plan will be performed under TFC-PLN-02, "Quality Assurance Program Description" and its implementing procedures. This document flows down requirements from DOE Order 414.1C and ASME NQA-1, *2008 Quality Assurance Requirements for Nuclear Facility Applications (QA)*, as applicable to the work scope. Any work performed by sub-contractors to WRPS is subject to the same quality assurance requirements.

6.6 SAFETY AND HEALTH

Work performed under this Work Plan will be governed by TFC-PLN-47, "Worker Safety and Health Program," which flows down the requirements of 10 CFR 851, "Worker Safety and Health Program." Work that involves radioactive materials will also be governed by HNF-5183, "Tank Farms Radiological Control Manual," which flows down the requirement of 10 CFR 835, "Occupational Radiation Protection."

6.7 COMMUNITY RELATIONS

Community relations activities will be conducted in accordance with the *Hanford Site Tri-Party Agreement Public Involvement Community Relations Plan* (DOE/RL 2002). All community relations activities associated with the Work Plan will be conducted per this community relations plan.

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APPENDIX A

MEETING MINUTES: FUTURE CHARACTERIZATION SITES FOR POTENTIAL INTERIM MEASURE AT 241-TX TANK FARM SEPTEMBER 6, 2012

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Meeting Notes

Data Requirements for 241-TX Farm Direct Push Logging and Sampling

Meeting Date:	Thursday September 6, 2012
Location:	Ecology Building, room 3A
Purpose:	Discuss data requirements for the direct push logging and sampling that will be performed at 241-TX tank farm to evaluate potential interim measures
Attendees:	Joe Caggiano (Ecology), Maria Skorska (Ecology), Jared Mathey (Ecology) , Chris Kemp (ORP), Mark Triplett (PNNL), Mike Connelly (WRS), Susan Eberlein (WRPS), Harold Sydnor (WRPS)

Topics of Discussion:

- Mike Connelly discussed the general approach to defining data requirements for a direct push field activity (State the problem, Identify the decision, Identify inputs to the decision, Define study boundaries, Develop a decision rule, Optimize the direct push locations).
- It was noted that the purpose of this direct push campaign is to determine if an interim surface barrier or other interim measure would be beneficial at TX farm. Future characterization will be required for a complete Phase 2 RCRA Facility Investigation/Corrective Measures Study, beyond the scope of the current activity.
- Mike summarized the body of information that led to the conclusion that TX tank farm contains vadose zone contaminants (see attachment 1 for summary information from previous studies).
- Joe Caggiano noted that although many of the TX farm tanks are designated as "assumed leakers", the designation may be the result of an overfill or other loss, rather than a loss of tank integrity.
- Joe noted that the TX tanks served as feed and receiver tanks for the 242-T evaporator, with the result that there were many transfers of waste through pipelines, which could have resulted in undocumented losses.
- Mark Triplett raised a question about the soil inventory estimate used in the draft Tank Closure and Waste Management (TC&WM) Environmental Impact Statement (EIS). Mark subsequently confirmed that in the publicly available draft, TX farm has the highest estimated leak inventory for Tc-99 and Nitrate of all of the farms. (See Table D-26 in the draft.) They used an inventory of 107 Ci of Tc-99. T Farm was 2nd with 67 Ci and C farm 3rd with 56 Ci. The estimate may be revised in the final.

- Joe noted that the depth of plumes and the mobility of the contaminants will determine how effective an interim surface barrier would be.
- Joe recommended that we review history of any large liquid releases (e.g. water line leaks) in the area.
- The approach to direct push logging and sampling was briefly summarized:
    - A first direct push bore hole is pushed to refusal, and is logged for gamma and moisture.
    - The logging results are used to select appropriate sampling depths. Mobile contaminants are likely to accumulate in the same regions as the higher moisture.
    - The first probe hole is decommissioned, placing multiple electrodes for use in subsequent resistivity work if needed.
    - A second direct push probe hole is pushed adjacent to the first (a few feet away). Approximately 3 samples are taken during pushing of the second probe hole. Each sample is approximately 18 inches in length, and about 600-700 g of soil.
    - Sample analysis is performed on a "quick turnaround" basis (about 1 week) for a few key analytes. A more complete suite of analyses is performed over a longer time period.
- It was proposed that the direct push sites be selected in 2 phases. In the first phase, about 8 locations should be identified to get the approximate outline of the area of interest. Based on the results of logs and quick-turnaround samples from the first locations, an additional 4 locations should be chosen to better define the area of interest.
- The group selected 8 tentative locations for the first round of direct push (see page 17 of attachment 1 – red triangles indicate proposed locations). Each proposed location will have a logging probe hole and a sampling probe hole.
- The proposed locations will be subject to some adjustment once ground penetrating radar is completed, to avoid contact with sub-surface structures.
- The final 4 locations will be selected based on results from the first 8 locations. It was agreed that the details for the final 4 would not be included in the work plan, but only a general outline of potential areas (see attachment 1, page 17, areas noted as "Round 2").
- The group will meet again in approximately 2 weeks, following opportunities to review additional information and address questions. At that meeting, the proposed 8 locations will be reviewed again to determine if any changes are needed.
- Proposed analytes for the sample analysis were discussed. Pages 18 and 19 include tables of analytes that had been included for the interim surface barrier investigation at S farm. Attendees were asked to review the tables to identify if any changes were needed before the next meeting.

Actions:

1. Provide meeting notes with summary of proposed direct push locations (Eberlein)
2. Review historic records to determine if any large liquid releases (e.g. water line leaks) occurred in the area of TX farm (Connelly).
3. Review notes and background information (as needed) to determine if any changes should be proposed for the initial 8 locations, shown on attachment 1 page 17 (all attendees).
4. Review tables of proposed analytes (attachment 1, pages 18-19) to determine if any changes are warranted (all attendees).
5. Schedule field trip and follow-on meeting to finalize plans, tentatively the week of September 17 (Eberlein)

Concurrence:

CJ Kemp 10-23-12		Mark W Beck 10-30-12	
C.J. Kemp, ORP	Date	Jeff Lyon, Ecology	Date

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APPENDIX B

MEETING MINUTES FROM 241-TX TANK FARM INTERIM SURFACE BARRIER DIRECT PUSH SAMPLE LOCATIONS SEPTEMBER 18, 2012 MEETING

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Meeting Notes

TX Field Trip to Verify Direct Push Locations with Follow-On Confirmation Meeting

Meeting Date:	Tuesday September 18, 2012
Location:	TX Tank Farm in the Morning Ecology Building, room 3A in the Afternoon
Purpose:	Verify selected locations for the direct push logging and sampling that will be performed at 241-TX Tank Farm to evaluate potential interim measures
Attendees:	Field Trip: Joe Caggiano (Ecology), Jared Mathey (Ecology), Chris Kemp (ORP), Jim Lynch (ORP), Doug Hildebrand (RL), Harold Sydnor (WRPS), Mike Connelly (WRPS), Marcel Bergeron (WRPS), Dan Glaser (WRPS) Follow-On Meeting: Joe Caggiano (Ecology), Jared Mathey (Ecology), Jeff Lyon (Ecology), Marysia Skorska (Ecology), Mark Triplett (PNNL), Doug Hildebrand (RL), Harold Sydnor (WRPS), Mike Connelly (WRPS), Dan Glaser (WRPS)

Topics of Discussion:

- Mike Connelly provided the field trip participants with a topographic map of TX-Tank Farm. There were labeling errors on the map, and Mike said he would provide an updated map with the labeling errors corrected (attached with these meeting notes).

- Field trip participants met on the southeast side of TX tank farm. It was recognized by everyone that the suggested direct push location on the SE side of TX-105 would not work. It was located on top of a hill close to the 241-TXR-152 and 241-TXR-153 diversion boxes. Harold indicated that he would not be able to get the direct push rig up the hill because of the limited space on top of the hill. It was also noted that space south and below the hill was limited due to chained off WIDS sites and the location of diversion box 241-TX-153. The chained off areas were due to two underground miscellaneous storage tanks (241-TX-302A and 241-TX-302XB). Both of these are catch tanks which are connected to the 241-TX-153 diversion box. WIDS reports are attached to these meeting notes. Since, the location on top of the hill was not accessible; a new location approximately 60 ft SSE of the original location was selected. This location is just to the NW of diversion box 241-TX-153. Since, the underground infrastructure will not be known until ground penetrating radar is completed over the area, two alternative locations were identified; one approximately 140 ft south of the original location (preferred alternative) and one approximately 100 ft ESE of the original location. All locations are shown on the updated topographic map.

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- The field participants then walked around the farm and surveyed all other proposed locations. It appears that all other locations would be accessible to the direct push with one caveat there is an overhead power line for the location close to 241-TX-115 and 241-TX-118 tanks. Harold will check with the appropriate people and if that location has to be modified, the participants of the field trip and follow-on meeting will be notified. All locations are subject to relocation pending the outcome of GPR surveys to detect and locate underground structures that must be avoided.

- The follow-on meeting at Ecology's offices. In that meeting, the participants reviewed the observations at the tank farm and concurred with the direct push locations (see map on the following page).

Actions:

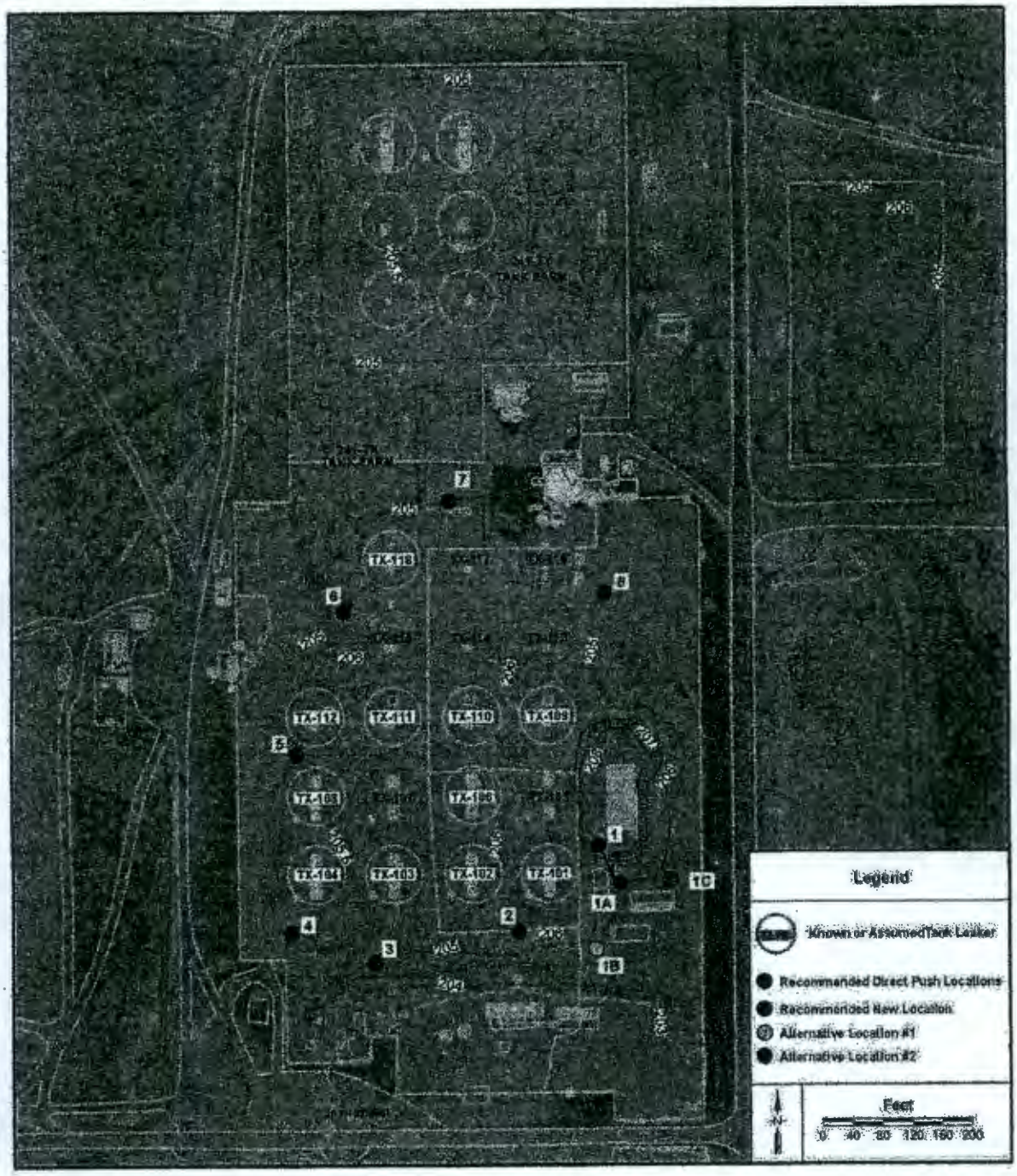
1. Provide Meeting Notes for both the field trip and follow-on meeting (Connelly)
2. Provide update map showing the direct push locations and alternative sites if underground infrastructure interfered with the direct push location (Connelly). See following page for updated map.

Concurrence:

CJ Kemp 10-23-12		Mike W Barn 10-30-12	
C.J. Kemp, ORP	Date	Jeff Lyon, Ecology	Date

1

Proposed Direct Push Locations Supporting Interim Measures at TX Tank Farm



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APPENDIX C

SOIL SAMPLING REQUIREMENTS FOR 241-TX TANK FARM

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Table C-1. Soil Sampling Requirements for 241-TX Tank Farm[a] (2 sheets)

Analysis Type	Primary Analysis	Constituent	Holding Time
"Quick Turn"	ICP/MS	Technetium-99	6 months
	9056 Ion chromatography	Nitrate	28 days/48 hours after digestion
	9045	pH	As soon as possible
	9050	Conductivity	28 days
Standard	6010 ICP/AES	Aluminum, Barium, Beryllium, Calcium, Chromium, Copper, Iron, Lead, Lithium, Manganese, Magnesium, Molybdenum, Phosphorous, Potassium, Sodium, Strontium, Zinc, Boron, Bismuth, Cerium, Europium, Lanthanum, Neodymium, Niobium, Palladium, Praseodymium, Rubidium, Rhodium, Ruthenium, Samarium, Silicon, Tin, Sulfur, Tantalum, Tellurium, Thorium, Titanium, Tungsten, Yttrium, Zirconium	6 months
	6020 ICP/MS	Antimony, Arsenic, Cadmium, Cobalt, Nickel, Selenium, Silver, Thallium, Uranium[b], Vanadium	6 months
	7471 Cold vapor atomic absorption	Mercury	28 days
	9056 Ion chromatography	Fluoride, Nitrite, Nitrate, Chloride, Sulfate, Acetate, Formate, Glycolate, Oxalate, Bromide, Phosphate	28 days/48 hours
	Ion chromatography EPA 300.7	Ammonium	7 days to distillation/28 days for preserved distillate
	9215 Ion selective electrode	Sulfide	7 days
	9014 Spectrophotometric	Cyanide	14 days

Table C-1. Soil Sampling Requirements for 241-TX Tank Farm[a] (2 sheets)

Analysis Type	Primary Analysis	Constituent	Holding Time
Standard	Gamma energy analysis	Cesium-137, Cobalt-60, Antimony-125, Europium-152, Europium-154, Europium-155, Thorium-228, Thorium-234	6 months
	Low energy gamma counting	Iodine-129	6 months
	ICP/MS	Techenetium-99, Tin-126, Uranium-233, Uranium-234, Uranium-235, Uranium-236, Uranium-238, Neptunium-237, Thorium-230, Thorium-232	6 months
	Liquid scintillation	Carbon-14, Tritium, Nickel-63, Selenium-79	6 months
	Alpha energy analysis	Plutonium-238, Plutonium-239/240, Americium-241, Curium-242, Curium-243/244	6 months
	Beta proportional counting	Strontium-90	6 months
	Gravimetric	Percent solids	None
	Gravimetric	Percent water	None
	Gravimetric	Bulk density	None

[a]Samplers will place the shoe material in a 500 mL glass bottle. The samples will be cooled to ≤ 6 °C. Available material from the shoe and liners (A, B, and C) are composited by the laboratory and the composited material is used in the "quick turn" and standard analysis.

[b]Uranium analysis will be met through the uranium-238 analysis.

EPA = U.S. Environmental Protection Agency
ICP/AES = inductively coupled plasma/atomic emission spectroscopy
ICP/MS = inductively coupled plasma/mass spectroscopy

Reference: EPA 600/4-86-024, 1986, *Development of Standard Methods for the Collection and Analysis of Precipitation*, "Method 300.7, Dissolved Sodium, Ammonium, Potassium, Magnesium, and Calcium in Wet Deposition by Chemically Suppressed Ion Chromatography," U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Office of Research and Development, Cincinnati, Ohio.

APPENDIX D

MEETING MINUTES FROM 241-SX TANK FARM INTERIM MEASURES PROOF-OF-PRINCIPLE TEST PLANNING OCTOBER 30, 2012 MEETING

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Meeting Notes:
SX Farm Interim Measures Proof of Principle Test Planning

Meeting Date:	October 30, 2012
Location:	Ecology Building, room 3B
Purpose:	Discuss plan for SX Farm interim measure soil contamination removal proof-of-principle test, and define next steps in completing work plan.
Attendees:	Jeff Lyon (Ecology), Michelle Hendrickson (Ecology), Joe Caggiano (Ecology), Marysia Skorska (Ecology), Jim Alzheimer (Ecology), Mike Barnes (Ecology), Chris Kemp (ORP), Doug Hildebrand (DOE), Dan Parker (WRPS), Dan Glaser (WRPS), Harold Sydnor (WRPS), Mike Connelly (WRPS), Dan Glaser (WRPS), Mark Triplett (PNNL)

Topics of Discussion:

- Dan Parker described the stages of the SX farm contaminant removal test (see Figure 1).
    - The purpose of the test is to determine if contaminants can be removed using direct push boreholes.
    - Three direct push locations south of the farm will be pushed and logged.
    - Logs will be reviewed to determine sample depths.
    - Samples will be analyzed for moisture and a few mobile contaminants to determine if the location is feasible to perform the test.
    - Minimum moisture content for testing will be based on lab and modeling work performed by PNNL, but will be a qualitative call.
    - Nitrate is considered an important indicator for the ability of the process to remove dissolved chemicals – other soluble contaminants will behave similarly to nitrate.
    - The work plan will include a schedule for design of the field monitoring and test equipment, set-up, and test performance.
    - The work plan will not include the details of the field test configuration because the initial stages must be performed first, to obtain the needed information to design the test.
    - The work plan will include a schedule for the later proof-of-principle test activities and deliverables, including the recommendation on whether further testing or implementation of the method should be planned.
- Joe Caggiano asked if extraction through the narrow direct push borehole was feasible. Dan responded that the test will help answer that question. Dan noted that it is unclear how successful contaminant removal can be given the need to maintain air/water velocities in the formation as the radius impacted by the test increases, but we want to find out.
- Marysia Skorska asked if the test would employ only vacuum or a combination of vacuum and air injection. Dan responded that a decision had not yet been made, but multiple configurations were being considered. Conceptually vacuum could be used to pull water into the well from the formation, and a small diameter bladder pump could be used to carry the water from the well to the ground surface.
- Marysia requested a high level schedule of the activities associated with the SX test and other elements of the work plan.

- The group discussed the process for review of draft work plan sections prior to formal submittal. The purpose of advance review is to address questions, ensure that the deliverable does not contain surprises, and make the review process easier.
- Susan Eberlein indicated that her goal was to provide enough advance information that, after receiving the formal submittal, Ecology would consider it possible to provide provisional approval to start field work while completing detailed review of the work plan.
- The written work description section for each of the work plan activities (SX test, U farm resistivity work and TX farm direct push work) will be extracted and provided to Ecology as a draft for review. The draft will be provided by email, and a follow up meeting will be held if there are questions or comments that need discussion.
- Each work plan section (SX, U, TX) will be provided in a separate email to the entire group, over the next 2 weeks.
- Ecology may decide to appoint a lead to coordinate review and response for the various sections.

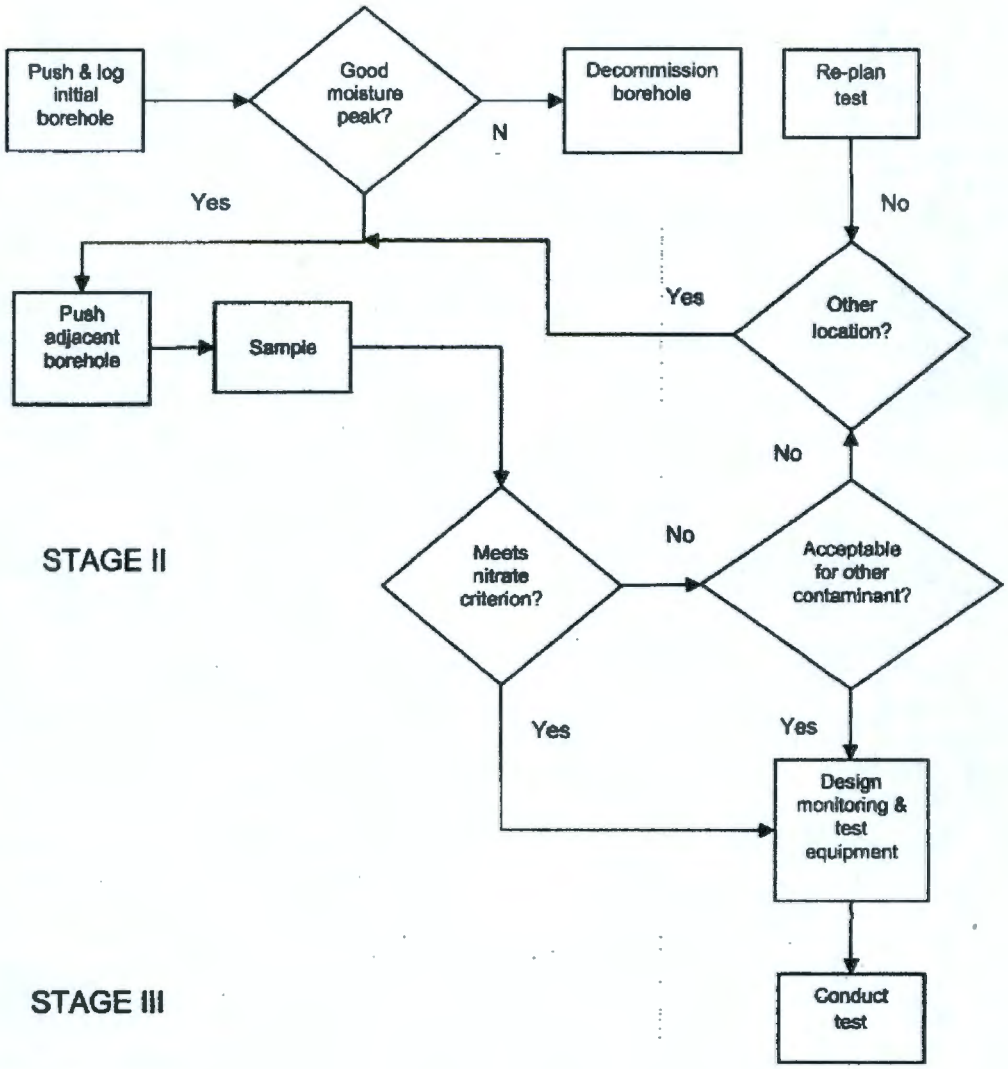
Actions:

1. Provide summary schedule of activities associated with each element of the work plan (Eberlein)
2. Provide U Farm work description section (Glaser)
3. Provide TX Farm work description section and draft TX data requirements document (Connelly)
4. Provide SX farm work description section (Parker)
5. Appoint Ecology lead/point of contact for each section as appropriate (Lyon)

Concurrence:

CJ Kemp	11-13-12	Mike W Barnes	11-13-12
C.J. Kemp, ORP	Date	Jeff Lyon, Ecology	Date

Figure 1. SX Farm Contaminant Removal Proof of Principle Test Phases



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ATTACHMENT 2

13-TF-0014

TPA CHANGE FORM M-45-12-05; REVISE MILESTONE M-045-22 AND ASSOCIATED TARGETS TO PROVIDE DUE DATES

Change Number	Federal Facility Agreement and Consent Order Change Control Form Do not use blue ink. Type or print using black ink.	Date
M-45-12-05		03/04/2013

Originator
T. W. Fletcher, DOE-ORP

Phone
(509) 376-3434

Class of Change
[ ] I - Signatories [X] II - Executive Manager [ ] III - Project Manager

Change Title
Revise milestone M-045-22 and associated targets to provide due dates.

Description/Justification of Change

Interim milestone M-045-22 requires submittal of deliverables with currently undefined dates. Interim milestone M-045-20 requires submittal of an interim measures investigation work plan, which would include a schedule defining the dates for the M-045-22 deliverables. This change provides those dates.

Impact of Change

This change provides the completion dates for M-045-22, and three associated targets, M-045-22-T01, M-045-22-T02, and M-045-22-T03.

Affected Documents

The HFFACO, as amended, and Hanford Site internal planning, management, and budget documents (e.g., River Protection Project System Plan, Baseline Control documents, and related work authorizations and directives).

Approvals

DOE	3/18/13 Date	X Approved_____Disapproved
N/A EPA	Date	_____Approved_____Disapproved
Ecology	Date	_____Approved_____Disapproved

Specific changes to Tri-Party Agreement Appendix D are displayed with double underline to indicate addition of text and by ~~strikeout~~ to indicate deletion of text.

M-045-22	DOE and Ecology will review the report generated in M-045-22-T03 and determine whether to continue with soil desiccation/contaminant removal testing and other interim measures. If DOE and Ecology agree to modify the remaining work in Milestone M-045-92, to construct two (2) barriers at SX farm, and design and construct interim surface barriers 3 and 4, DOE will propose a modification to Milestone M-045-92. ~~Due date to be established in TPA change control form submitted for M-045-20.~~	~~TBD~~ 09/30/2014
M-045-22-T01	Submit to Ecology as a secondary document the results of the vadose zone characterization in the 241-TX Farm per the schedule in M-045-20. ~~Due date to be established in TPA change control form submitted for M-045-20.~~	~~TBD~~ 09/30/2014
M-045-22-T02	Submit to Ecology as a secondary document the results of the vadose zone characterization in the 241-U farm per the schedule in M-045-20. ~~Due date to be established in TPA change control form submitted for M-045-20.~~	~~TBD~~ 04/30/2014
M-045-22-T03	Submit to Ecology as a secondary document the results of the initial field testing of soil desiccation/contaminant removal technology in SX tank farm, per the schedule in M-045-20. Include a recommendation for further soil desiccation/contaminant removal for tank farm contamination or for performing interim barrier construction. ~~Due date to be established in TPA change control form submitted for M-045-20.~~	~~TBD~~ 07/31/2014