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Revision 0

Results of Tritium Tracking and Groundwater monitoring at the Hanford Site 200 Area State Approved Land Disposal Site, Fiscal Year 2012

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

CH2MHILL
Plateau Remediation Company
P.O. Box 1600
Richland, Washington 99352

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J. P. McDonald
CH2M HILL Plateau Remediation Company

M. J. Tonkin
S. S. Papadopulos and Associates

M. Karanovic
S. S. Papadopulos and Associates

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CH2MHILL
Plateau Remediation Company
P.O. Box 1600
Richland, Washington 99352

APPROVED
By Julie Raymer at 7:29 am, Nov 20, 2012

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Executive Summary

The Hanford Site's 200 Area Effluent Treatment Facility processes contaminated aqueous wastes derived from Hanford Site facilities. The treated wastewater discharge contains tritium because it is not cost effective to remove this constituent from the waste stream. The wastewater is discharged to the soil column at the 200 Area State-Approved Land Disposal Site (SALDS), which is authorized to receive the discharge by *State Waste Discharge Permit Number ST 4500*[1] (Ecology, 2000) (hereafter referred to as the "Permit"). During the period from August 2011 through July 2012, 52.0 million L (13.7 million gal) of water containing 4.25 Ci of tritium were discharged to the SALDS. Groundwater monitoring for tritium and other constituents, as well as water-level measurements, are specified by the Permit. The objectives of the monitoring program are to evaluate constituent concentrations in the groundwater beneath the SALDS for compliance with limits specified in the Permit, and to track the migration of the tritium plume. The U.S. Department of Energy (DOE) has taken the position that its compliance with the Permit is a matter of intergovernmental comity and cooperation, and that the Permit has no jurisdiction over radionuclides, which are regulated by DOE under its *Atomic Energy Act of 1954*[2] authority.

The current monitoring network consists of two proximal (compliance) monitoring wells (699-48-77C and 699-48-77D) and eight tritium-tracking wells. The network formerly contained three proximal monitoring wells, but during the first quarter of fiscal year (FY) 2012, it was found that well 699-48-77A did not have enough water to sample. The Washington State Department of Ecology (Ecology) was notified that this well was dry. Ecology directed DOE to continue to sample the SALDS wells only as long as they produced representative results. Well 699-48-77A was declared dry and was removed from the sample schedule, but the well continues to be used for water-level measurements. Quarterly sampling of the proximal wells occurred in November/December 2011 and in January, April, and July 2012. During many of the sample events for well 699-48-77D, a full three-borehole volume purge was not performed because this well is nearly dry. The tritium-tracking wells were sampled in January, April, May, and June 2012.

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[1] Ecology, 2000, *State Waste Discharge Permit Number ST 4500*, Washington State Department of Ecology, Kennewick, Washington.

[2] *Atomic Energy Act of 1954*, 42 USC 2011, et seq.

Water-level measurements taken in the three proximal SALDS wells indicate that a small groundwater mound, resulting from operational effluent discharges, continues to be present beneath the facility. The mound declined slightly between 2011 and 2012 because of a reduced volume of effluent during FY 2012. Measurements also indicate that the water table is continuing to decline regionally at a rate of 0.25 m/yr (0.82 ft/yr), and this decline continues to affect well usability. The water table may increase somewhat from operation of the 200-ZP-1 Operable Unit final remedy pump-and-treat (P&T) system, because there are several injection wells located in the northern 200 West Area. This is expected to extend the useful life of some of the wells for a few years, but several SALDS monitoring wells are expected to become dry between 2015 and 2017, including the remaining shallow-screened proximal well, 699-48-77D.

There were no confirmed exceedances of a groundwater concentration limit in the proximal wells during FY 2012. Mercury (total) exceeded its 2.0 µg/L concentration limit during the November 2011 sampling of 699-48-77C, but it was concluded that this was due to laboratory error. Mercury was not detected in any other samples collected from this well during the year. Maximum tritium concentrations in the proximal wells were 170,000 pCi/L in 699-48-77C and 133,000 pCi/L in 699-48-77D. Compared to the previous FY, average tritium concentrations increased in 699-48-77C and declined in 699-48-77D. To date, tritium from the SALDS has not been detected in any of the tritium-tracking wells.

The numerical groundwater flow and contaminant transport model of the SALDS tritium plume was last updated in FY 2011. The modeling results showed that some locations along the northern margin of the 200 West Area are expected to exhibit measurable concentrations of SALDS-derived tritium by the year 2030, although the model indicates that concentrations would be below the drinking water standard of 20,000 pCi/L. The eastern end of the tritium plume is also predicted to migrate to the south toward the 200-ZP-1 P&T system extraction wells by 2030.

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Terms

CCU	Cold Creek unit
CP	Central Plateau
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
ERDF	Environmental Restoration Disposal Facility
ETF	Effluent Treatment Facility
FY	fiscal year
LERF	Liquid Effluent Retention Facility
LLBG	low-level burial ground
NAVD88	North American Vertical Datum of 1988
NTU	nephelometric turbidity unit
OU	operable unit
P&T	pump-and-treat
SALDS	State-Approved Land Disposal Site
VOA	volatile organic analyte

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1 Introduction

The Hanford Site's 200 Area Effluent Treatment Facility (ETF) processes contaminated aqueous wastes derived from Hanford Site facilities. Treated water from the ETF is discharged to the 600-211 State-Approved Land Disposal Site (SALDS), which is authorized to receive the discharge by *State Waste Discharge Permit Number ST 4500* (Ecology, 2000) (hereafter referred to as the "Permit"). The Permit allows disposal of ETF effluents to the SALDS drain field, located 360 m (1,200 ft) north of the 200 West Area (Figure 1-1). The Permit requires that groundwater samples be collected quarterly from the point of compliance monitoring wells 699-48-77A, 699-48-77C, and 699-48-77D (i.e., the proximal wells) located at the SALDS facility (although well 699-48-77A became dry during fiscal year [FY] 2012 and can no longer be sampled). It is required that the samples be analyzed for 17 constituents, 11 of which have groundwater limitations (i.e., concentration limits) specified in the Permit. Collection of water-level measurements is also required. The U.S. Department of Energy (DOE) has taken the position that its compliance with the Permit is a matter of intergovernmental comity and cooperation, and that the Permit has no jurisdiction over radionuclides, which are regulated by DOE under its *Atomic Energy Act of 1954* authority.

Much of the effluent disposed to the SALDS contains tritium because there is no cost-effective treatment technology to remove tritium from wastewater (DOE/RL-2009-18, *2009 Evaluation of Tritium Removal and Mitigation Technologies for Wastewater Treatment*). Thus, a tritium plume exists in groundwater beneath the SALDS, and the Permit requires that this plume be tracked. The wells used for this purpose are located farther from the facility than the proximal wells; they are referred to as the tritium-tracking wells. These wells are sampled either annually or semiannually. The Permit also requires that computer modeling of the tritium plume be performed, and that a groundwater monitoring and tritium-tracking report be submitted annually.

In addition to this annual report, the results of groundwater sampling and analysis of the proximal wells during 2012 were also reported in the following quarterly discharge monitoring reports:

- CHPRC-1200505, "Quarterly Discharge Monitoring Reports for the 200 Area Effluent Treatment and Treated Effluent Disposal Facilities Covering the October 2011 Through December 2011 Reporting Period"
- CHPRC-1201772, "Quarterly Discharge Monitoring Reports for the 200 Area Effluent Treatment and Treated Effluent Disposal Facilities Covering the January 2012 Through March 2012 Reporting Period"
- CHPRC-1203231, "Quarterly Discharge Monitoring Reports for the 200 Area Effluent Treatment and Treated Effluent Disposal Facilities Covering the April 2012 Through June 2012 Reporting Period"
- CHPRC-1204563, "Quarterly Discharge Monitoring Reports for the 200 Area Effluent Treatment and Treated Effluent Disposal Facilities Covering the July 2012 Through September 2012 Reporting Period"

Details of the SALDS groundwater monitoring program are described in the current groundwater monitoring plan (PNNL-13121, *Groundwater Monitoring and Tritium-Tracking Plan for the 200 Area State-Approved Land Disposal Site*).

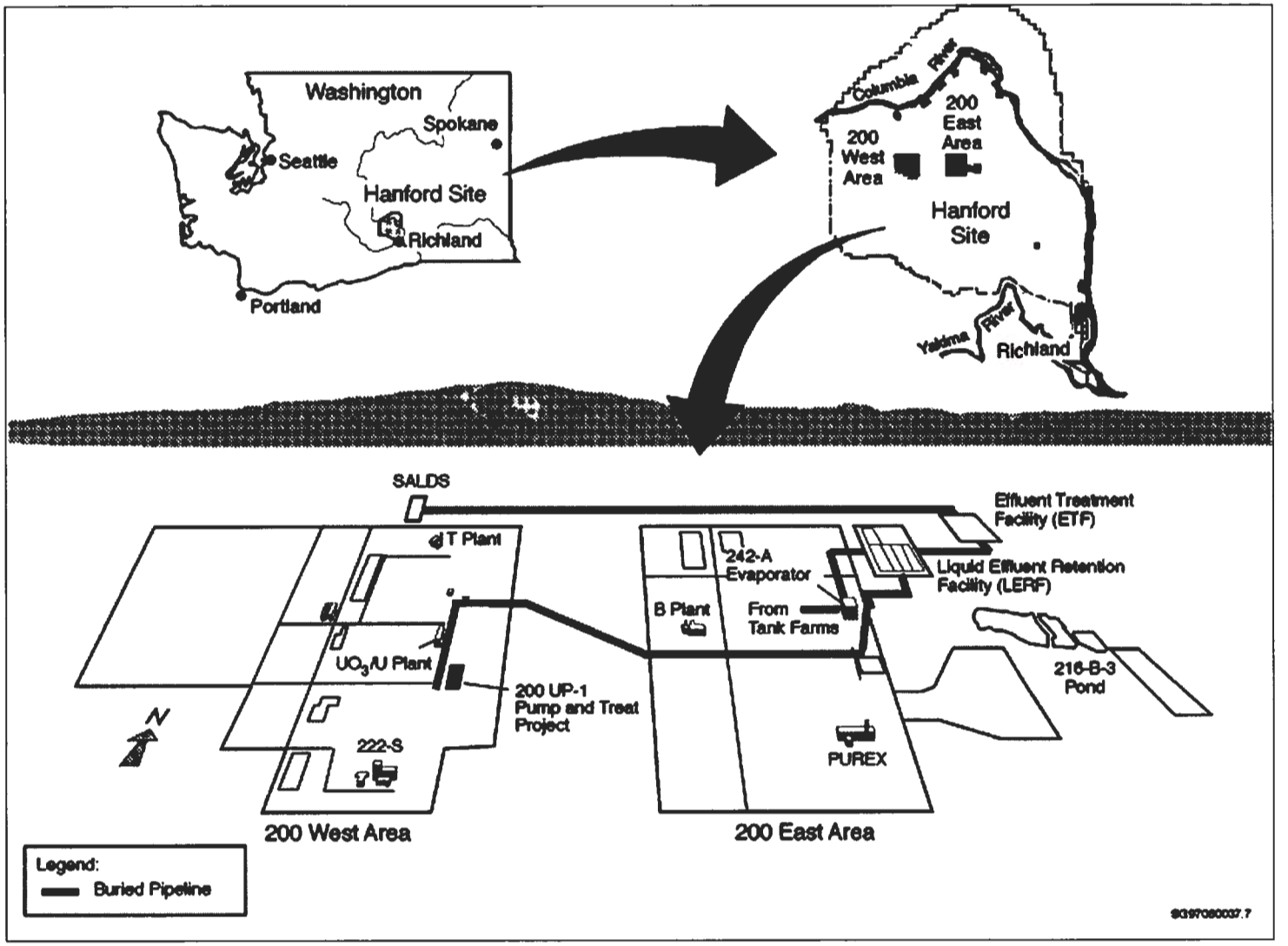


Figure 1-1. Location of the SALDS and Related Infrastructure

1.1 Objective and Scope

This report presents the results of groundwater monitoring of the proximal wells and tracking of the tritium plume from the SALDS facility during FY 2012. Because 30 days are required for the laboratory to analyze and report groundwater sampling results, this annual report addresses groundwater samples collected only up to August 31 of the reporting period so this report can be completed and submitted by the November 30 due date.

This report also contains a summary of the most recent update to the numerical groundwater flow and contaminant transport model of the tritium plume, which was performed during FY 2011. This model is required to be updated once per Permit cycle (i.e., once every 5 years). The FY 2011 model update is fully described in Appendix B of *Results of Tritium Tracking and Groundwater Monitoring at the Hanford Site 200 Area State-Approved Land Disposal Site, Fiscal Year 2011* (SGW-51085).

1.2 Background

Background information presented in this section is based on PNNL-13121. It addresses the conceptual model, the groundwater monitoring program, plume modeling, and the SALDS discharges.

1.2.1 Hydrogeologic Setting and Conceptual Model

The hydrogeologic setting and the conceptual model for the SALDS have been described in previous documents (e.g., SGW-38802, *Results of Tritium Tracking and Groundwater Monitoring at the Hanford Site 200 Area State-Approved Land Disposal Site Fiscal Year 2008*) and are not repeated here. Figure 1-2 shows the conceptual model and depicts effluent migration through the sediment profile to groundwater. A key aspect of this conceptual model is the lateral migration of the effluent in the vadose zone along the Cold Creek unit (CCU), which dips toward the south. Thus, much of the effluent is interpreted to enter the groundwater to the south of the drain field near monitoring well 699-48-77A.

1.2.2 Groundwater Monitoring Program

The primary objectives listed in the groundwater monitoring plan (PNNL-13121) are to compare groundwater sampling results in the proximal wells to the Permit concentration limits and to track the migration of the tritium plume from the SALDS facility. Other objectives listed in the monitoring plan include the following:

- Track changes in groundwater quality associated with SALDS discharges
- Determine why changes (if any) have occurred
- Compare model predictions with observed results to refine predictive model capability
- Correlate discharge events at SALDS with analytical results from groundwater monitoring
- Ensure that groundwater data are accurately interpreted
- Assess the hydraulic response of the aquifer to SALDS discharges

The groundwater monitoring well network (Figure 1-3) was designed to address these objectives using existing wells shared with other nearby facilities (e.g., the Low-Level Burial Grounds [LLBGs]) and dedicated wells drilled specifically to monitor SALDS (i.e., the proximal wells).

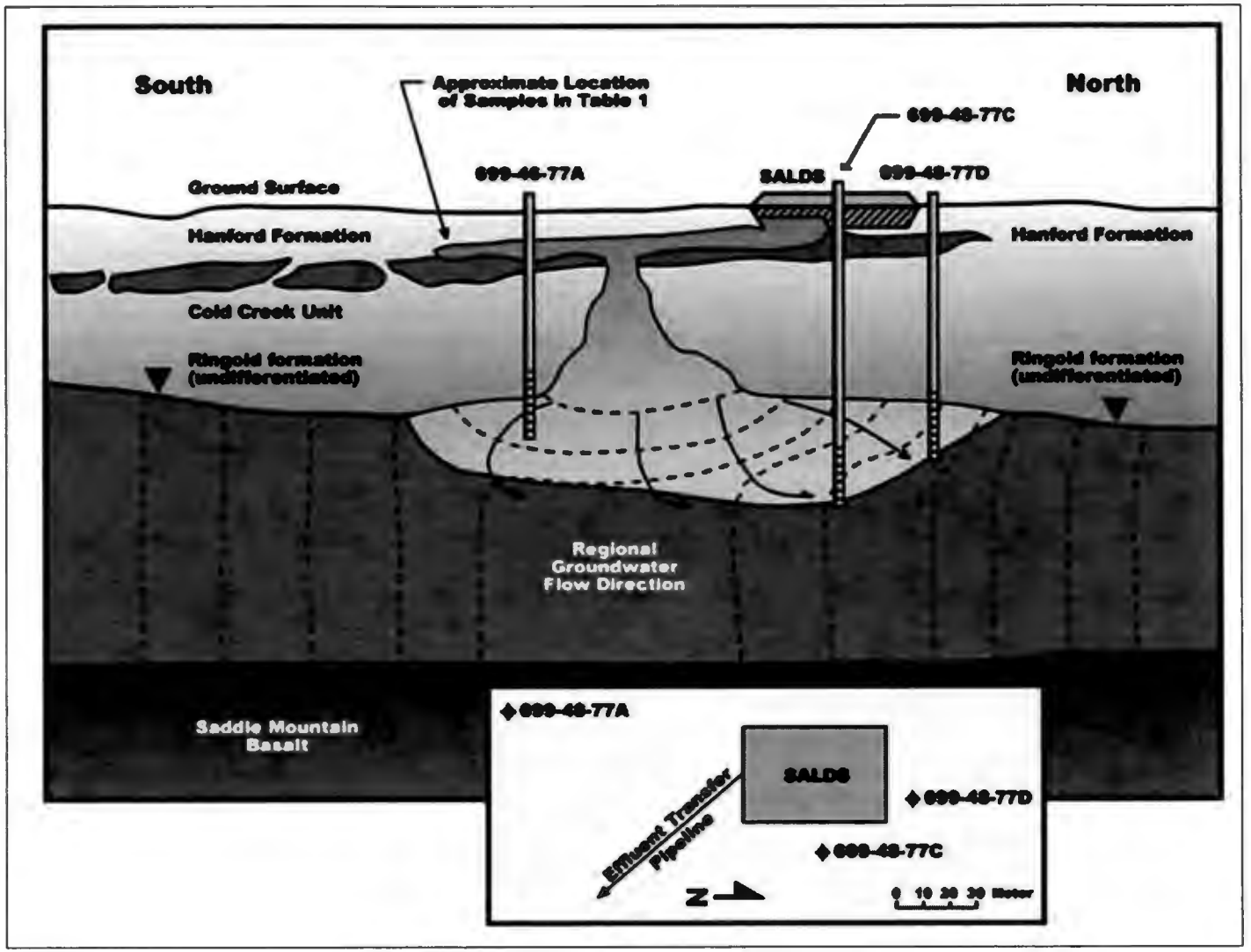


Figure 1-2. Conceptual Model Diagram of SALDS Operational Effects

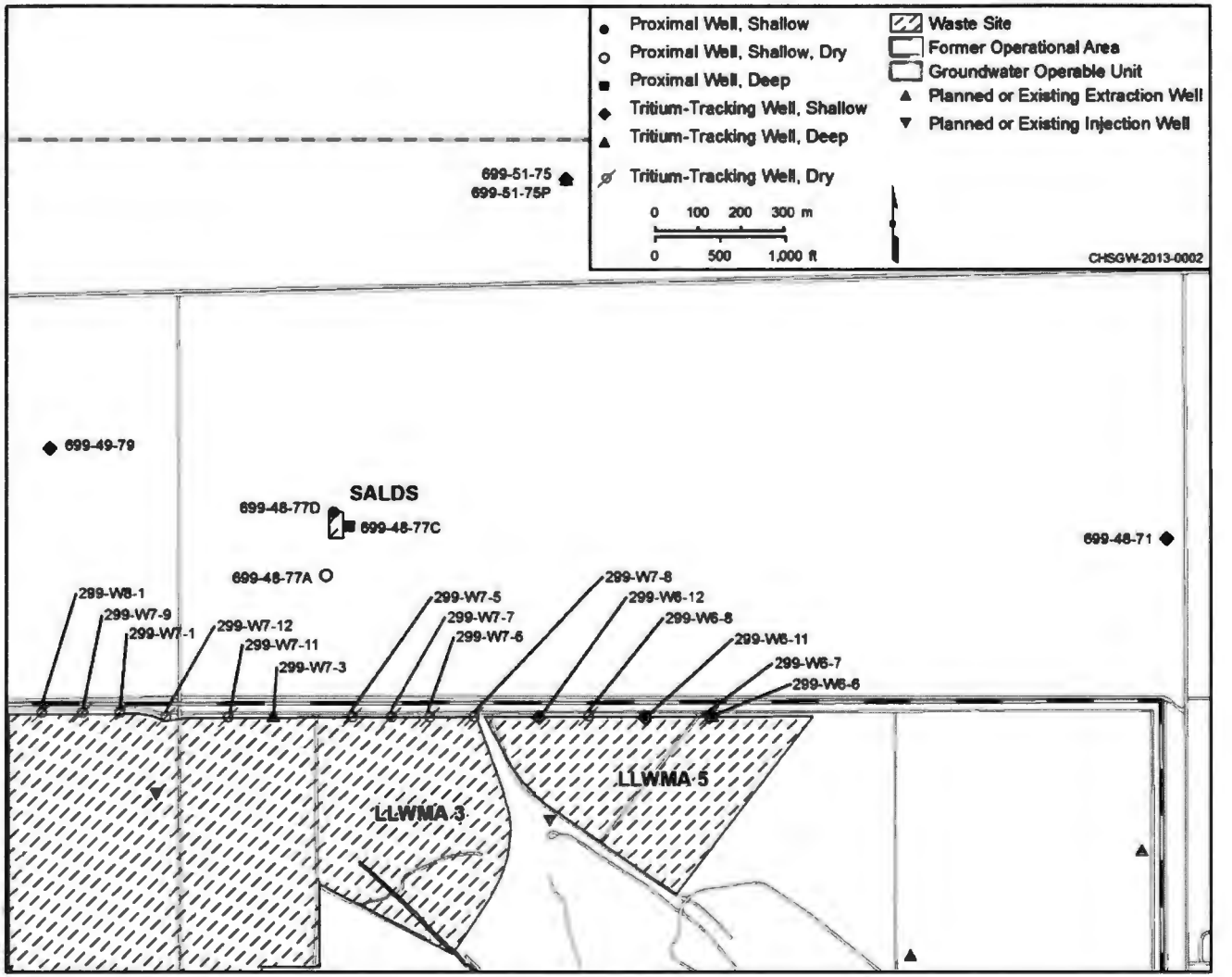


Figure 1-3. Locations of SALDS Groundwater Monitoring and Tritium-Tracking Network Wells

1.2.3 Groundwater Modeling

The Permit requires an update to the tritium groundwater plume numerical model at least once during a five-year Permit cycle to predict the distribution and movement of tritium in the aquifer as a result of SALDS discharges. The Permit also requires that the model be reapplied "within 6 months of detection of [the] tritium plume in a new monitoring well." This requirement indicates that the numerical model will be reapplied when the tritium plume associated with the SALDS is positively identified in a location not predicted by the most recent model run, or within a well not previously affected by SALDS-derived tritium. To date, no positive indications of SALDS-derived tritium have been detected in a new monitoring well.

The groundwater model was last updated in 2011, and Chapter 4 provides a summary of the results, including the predicted tritium concentrations in groundwater near the SALDS for the year 2030. The model incorporated recent refinements to the Central Plateau (CP) groundwater model (DOE/RL-2009-38, *Description of Modeling Analyses in Support of the 200-ZP-1 Remedial Design/ Remedial Action Work Plan*; CP-47631, *Model Package Report: Central Plateau Groundwater Model Version 3.3*) and included the SALDS discharge volume and tritium release information reported through June 2011. The model also included the latest information regarding the forecast operation of the 200-ZP-1 final remedy pump-and-treat (P&T) system. The P&T system began operating during July 2012, and future model updates will include actual P&T system operational parameters at the time the model update is performed. Appendix B of SGW-51085 provides a more detailed description of the modeling performed during 2011.

1.2.4 State-Approved Land Disposal Site Discharge Information

The SALDS effluent infiltration gallery (i.e., 619-A Crib) is a 35 m by 61 m (115 ft by 200 ft) rectangular drain field with 4 in. diameter porous pipe laterals coming from an 8 in. diameter header at 1.8 m (6 ft) intervals. The drain field pipes are 15 cm (6 in.) below the surface of a 1.8 m (6 ft) deep gravel basin. The gravel basin is covered by a minimum of 30 cm (12 in.) of natural, compacted cover soil.

Discharge of tritium-laden water to the SALDS began in December 1995, with 220 Ci of tritium released in the first 7 months (which amounted to approximately 52 percent of the total activity released to date). Discharge volumes until FY 2004 were about 95 million L (25 million gal) each year. Discharges between March 2005 and August 2007 were sporadic and included intermittent campaigns to treat 242-A evaporator process condensate and K Basins project waste streams, both of which supplied much of the tritium recently discharged to the SALDS. Discharge volumes increased in September 2007 when the ETF began treating wastewater from the interim action P&T system at the T Tank Farm; however, the tritium activity in this stream was low. Because the final action P&T system for the 200-ZP-1 OU began operating during July 2012, the interim action P&T system was shut down on June 5, 2012, and will no longer be operated. The final action system has its own treatment plant and returns water to the aquifer using injection wells, so the ETF/SALDS will not receive wastewater from this system.

During the period from August 2011 through July 2012, 52.0 million L (13.7 million gal) of water were discharged to the SALDS compared to 89.2 million L (23.6 million gal) during the previous one-year period. The primary source of FY 2012 effluent was from ETF treatment of the low-tritium-bearing groundwater stream from the T Tank Farm interim action P&T system. Prior to shutdown in June 2012, the pumping rate from this system during FY 2012 averaged 82 L/min (22 gal/min), excluding downtime when the pipeline was used to transfer batches of leachate from the Environmental Restoration Disposal Facility (ERDF) to the Liquid Effluent Retention Facility (LERF). In November 2011 and from June through August 2012, the ETF treated and discharged 8.89 million L (2.35 million gal) of a mixture of high-tritium-bearing wastes from K Basins and ERDF leachate. LERF Basin 44 has been used to store

these waste streams since 2002, and the accumulated water is treated in intermittent campaigns. Discharges from the ETF to the SALDS did not take place in August and September 2011 or in March 2012 due to maintenance outages. The total discharge volume to the SALDS since startup in December 1995 through July 2012 is approximately 1,168 million L (307 million gal) (Figure 1-4).

Figure 1-5 shows the monthly and cumulative activity of tritium discharged to the SALDS (not corrected for radioactive decay). The total quantity of tritium discharged during FY 2012 was calculated to be 4.25 Ci based on sampling at the ETF prior to discharge. Of this amount, 3.60 Ci were from treatment of K Basins/ERDF leachate and the remainder was from treatment of T Tank Farm groundwater. The 4.25 Ci discharged in FY 2012 is slightly less than the 4.70 Ci reported to have been released during FY 2011 (the FY 2011 value was thought to be biased high by an off-trend tritium sample result) (SGW-51085). Recent release activities are relatively small compared to historical releases (Figure 1-5). This reflects the relatively low concentration of tritium in the waste streams currently being treated. The total amount of tritium discharged to the SALDS from December 1995 through July 2012 is 425 Ci.

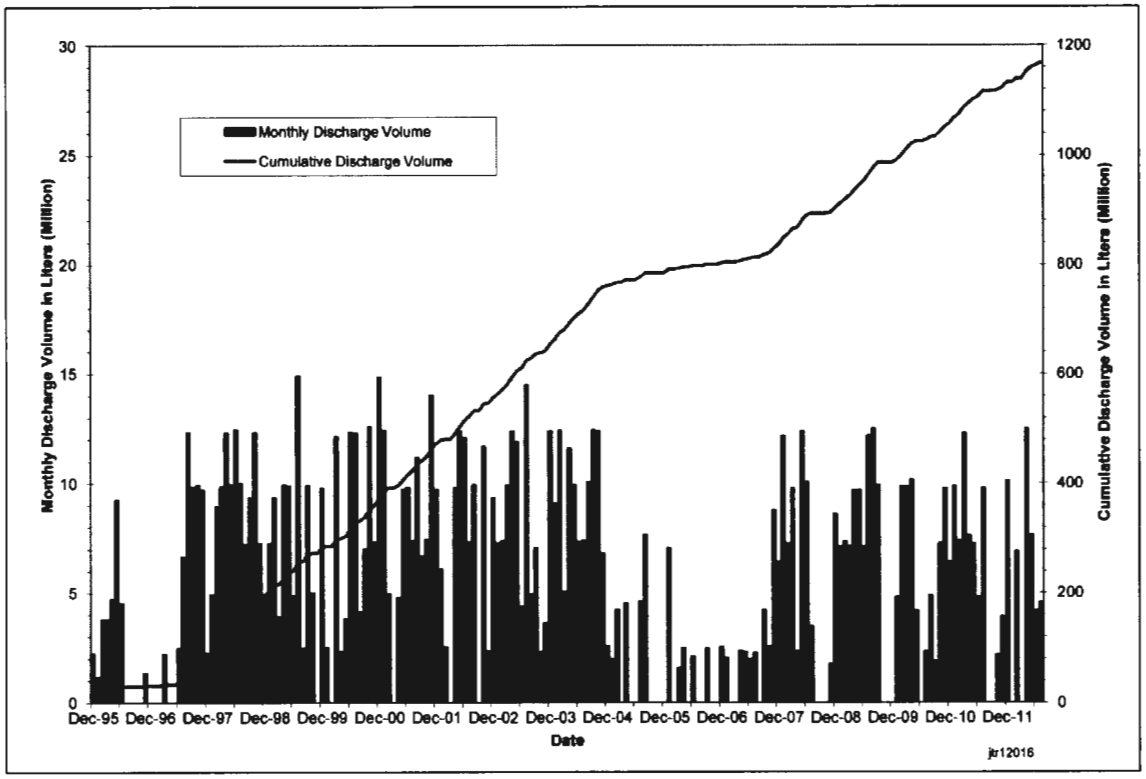
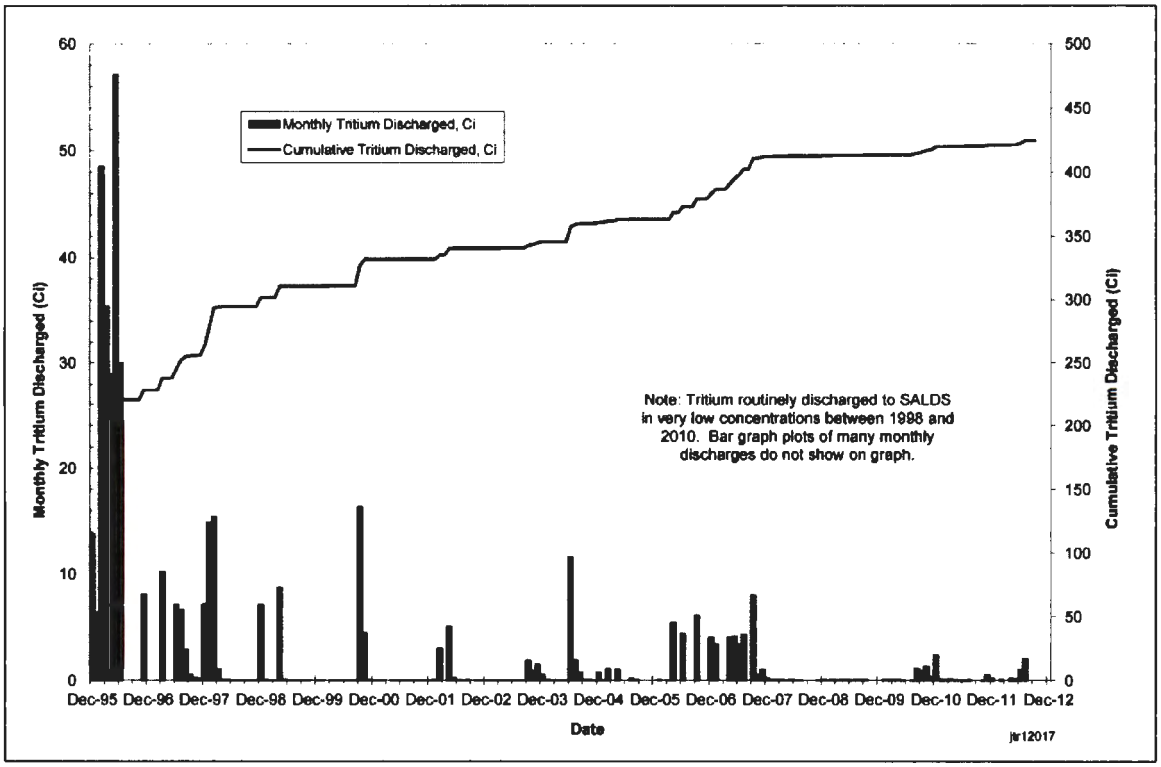


Figure 1-4. Monthly and Cumulative Discharge Volumes for the SALDS from Inception Through July 2012



Notes: Note that the activity listed in this figure has not been adjusted for decay.

Figure 1-5. Monthly and Cumulative Tritium Activity Discharged to the SALDS from Inception Through July 2012

2 Results of Fiscal Year 2012 Water-Level Monitoring

Measurements of water levels in wells surrounding the SALDS are necessary to assess the hydraulic response of the aquifer to SALDS discharges, to interpret local and regional water table elevation changes, and to determine the groundwater flow direction. These measurements are used in combination with groundwater chemistry analyses to update conceptual and predictive models and to forecast the movement of tritium from the SALDS facility.[3]

2.1 Water-Level Measurements

Water levels are measured in all wells prior to each sampling event, and additional measurements are collected monthly in the proximal wells (699-48-77A, 699-48-77C, and 699-48-77D) in accordance with the groundwater monitoring plan (PNNL-13121). The water table has declined in recent years to the point where a number of wells have become dry (Figure 1-3). As this occurs, water-level measurements and sampling in these wells are discontinued. Proximal well 699-48-77A had too little water remaining to be sampled during 2012, but water-level measurements continued to be collected from this well during the year.

Figures 2-1 through 2-6 present current hydrographs for the SALDS proximal and tritium-tracking wells. Wells depicted on these hydrographs are grouped by relative position to the SALDS. Water levels in all of the wells in the 200 West Area have generally exhibited declining trends since effluent discharges associated with process operations were terminated at U Pond in 1985 and later at all nonpermitted facilities in 1995. The water table in the 200 West Area is up to 10 m (33 ft) higher than the estimated pre-Hanford Site water table elevation. However, water levels are expected to decline only another 3 to 5 m (10 to 16 ft) before stabilizing, because the water table is being affected by offsite irrigation activities to the west that were not occurring in pre-Hanford Site times (DOE/RL-2011-118, *Hanford Site Groundwater Monitoring for 2011*). However, the water table in the northern 200 West Area is expected to be substantially altered by the final remedy 200-ZP-1 P&T system that began operating in July 2012 (SGW-50907, *Predicted Impact of Future Water-Level Declines on Groundwater Well Longevity Within the 200 West Area, Hanford Site*).

Water-level measurements across the 200 West Area are normally collected during March of each year; however, during 2012, these measurements were delayed until April. Using measurements in both the proximal and tritium-tracking wells, the average decline of water levels in the SALDS area for the 13-month period from March 2011 to April 2012 was 0.24 m (0.79 ft), which is an annual rate of decline of 0.22 m/yr (0.73 ft/yr), as shown in Table 2-1. Because water levels in the proximal wells experience fluctuations in response to SALDS discharges, the average decline in all of the SALDS monitoring network wells may not be representative of the regional water-level decline. Also, well water-levels are commonly affected by barometric pressure fluctuations, which may mask the average rate of decline when this rate is determined using only two measurements from a well. A more representative regional water table rate of decline was determined by performing linear regression on all water-level measurements collected over the past 3 years (i.e., FYs 2010, 2011, and 2012) for each well. The results are shown in Table 2-1. The best estimate of the regional average annual rate of water table decline is the result that excludes the proximal wells, which is 0.25 m/yr (0.82 ft/yr).

[3] All elevations in this document are in the North American Vertical Datum of 1988.

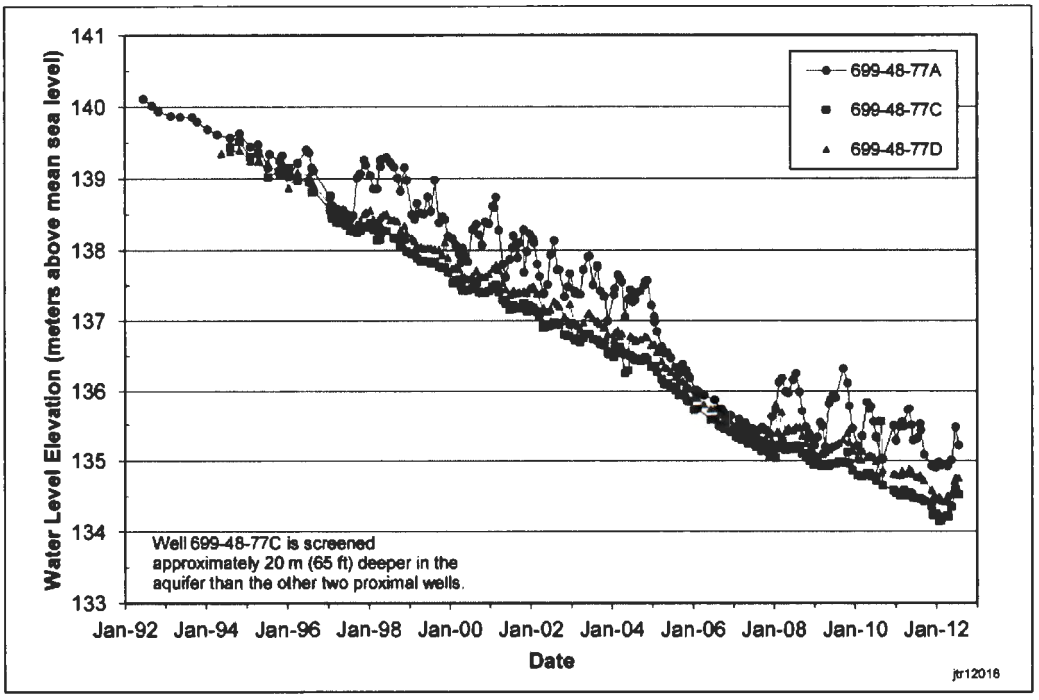


Figure 2-1. Water Levels in the SALDS Proximal Wells

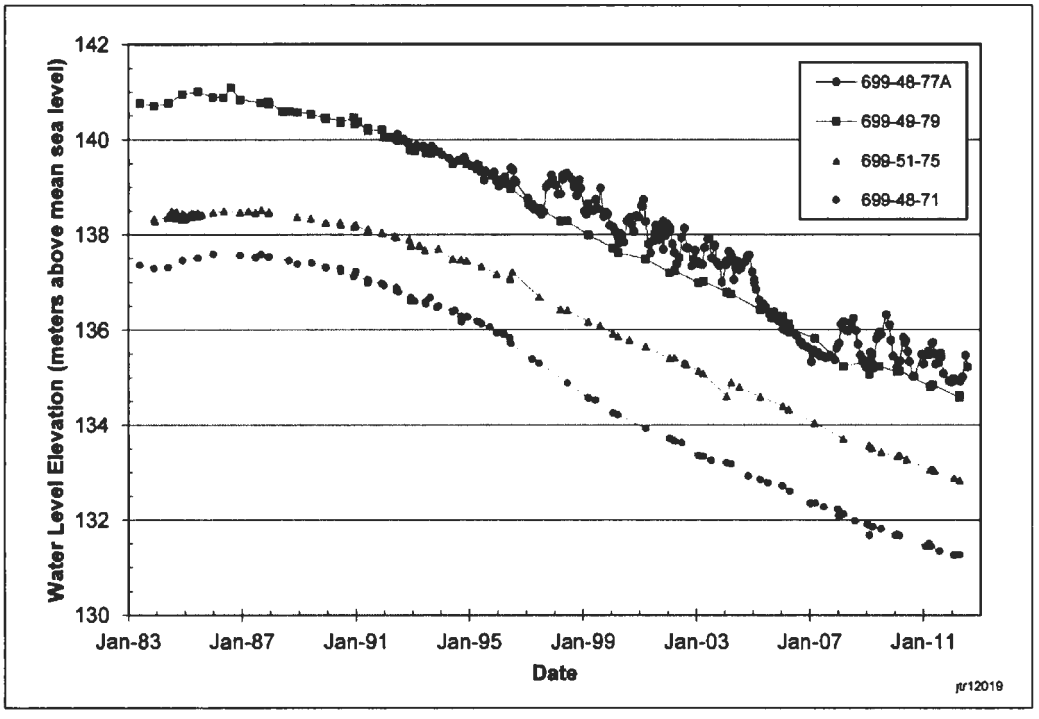


Figure 2-2. Water Levels in the Tritium-Tracking Wells North, Northwest, and East of the Site Compared with Well 699-48-77A

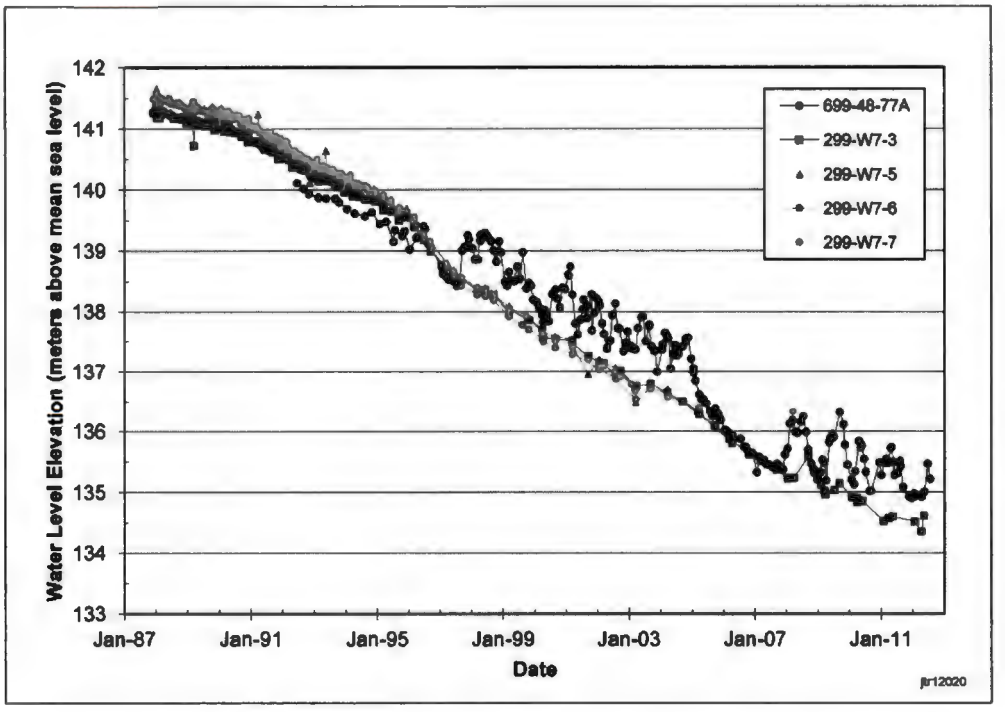


Figure 2-3. Water Levels in the Tritium-Tracking Wells South of the SALDS Compared with Well 699-48-77A

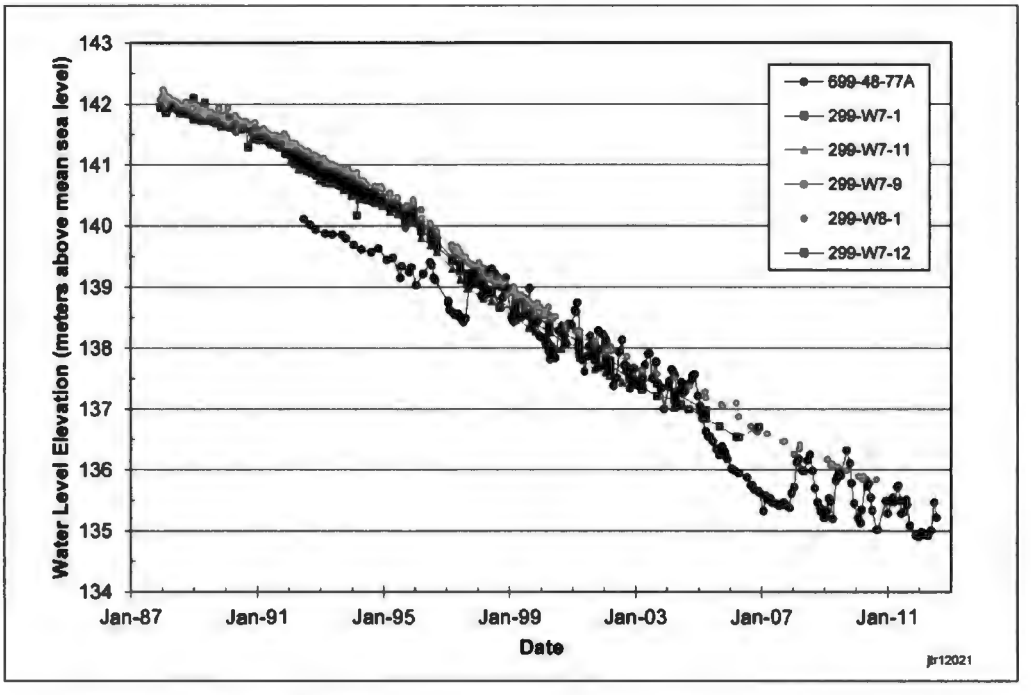


Figure 2-4. Water Levels in the Tritium-Tracking Wells Southwest of the SALDS Compared with Well 699-48-77A

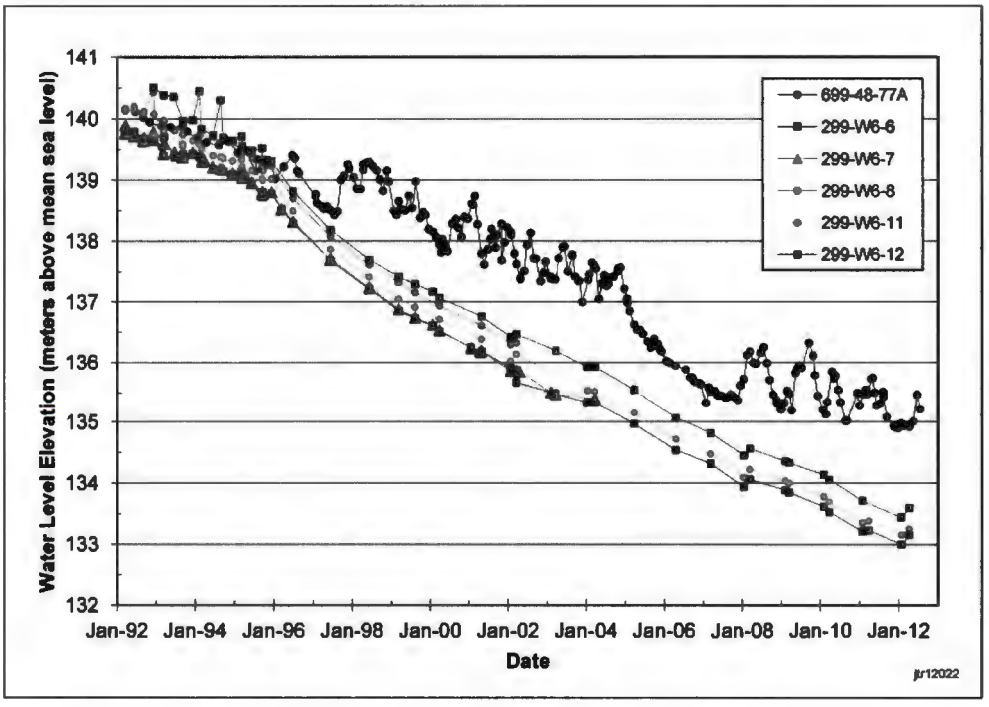
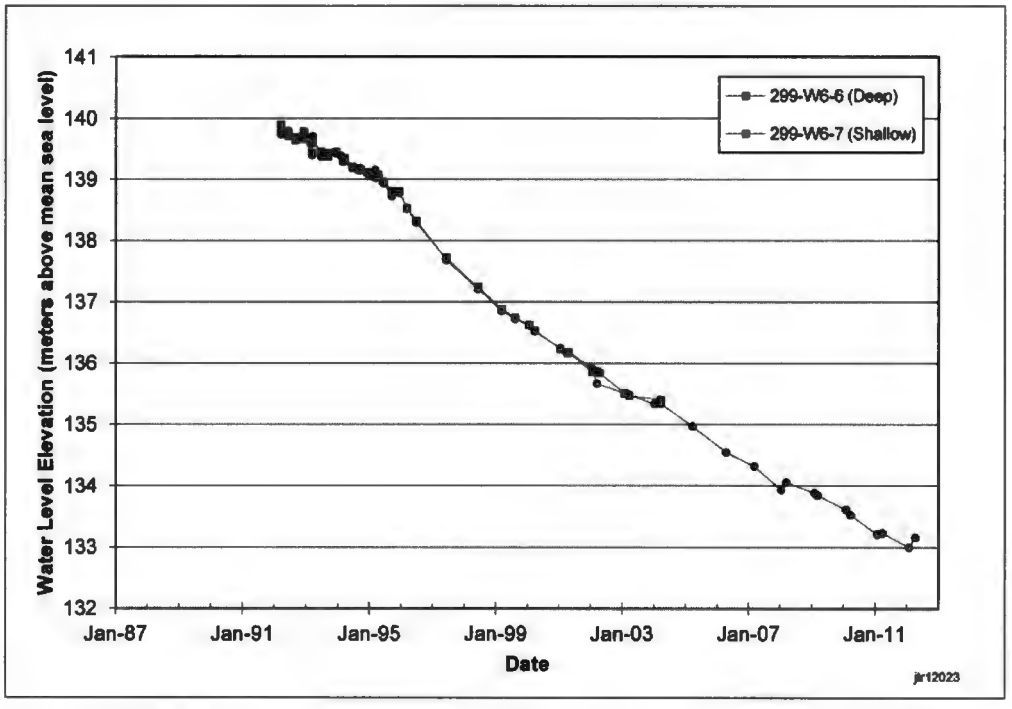


Figure 2-5. Water Levels in the Tritium-Tracking Wells Southeast of the SALDS Compared with Well 699-48-77A



Notes: Well 299-W6-6 is completed approximately 51 m (167 ft) deeper in the aquifer than Well 299-W6-7.

Figure 2-6. Water Levels in a Deep/Shallow Well Pair Southeast of the SALDS

Table 2-1. Change in Water Table Elevation

Well	March 2011 Elevation (m)	April 2012 Elevation (m)	Annual Rate of Change, 2011 to 2012 (m/yr)[a]	Average Annual Rate of Change, FY 2010 to FY 2012 (m/yr)[b]
699-48-77A[c]	135.480	134.923	-0.514	-0.190
699-48-77C[c]	134.579	134.229	-0.323	-0.253
699-48-77D[c]	134.808	134.452	-0.329	-0.261
299-W6-11[d]	133.381	133.250	-0.121	-0.259
299-W6-12[d]	133.706[e]	133.592	-0.105	-0.281
299-W7-4[d]	134.604	134.438	-0.153	-0.264
299-W12-1[d]	131.938	131.656	-0.260	-0.258
699-48-71[d]	131.506	131.269	-0.219	-0.203
699-49-79[d]	134.808	134.624	-0.170	-0.247
699-51-75[d]	133.057	132.833	-0.207	-0.242
Average – all wells (m/yr)			**-0.222**	**-0.246**
Average – excluding proximal wells (m/yr)			**-0.163**	**-0.251**
Average – proximal wells only (m/yr)			**-0.359**	**-0.235**

a. The difference in the water-level elevations between March 2011 and April 2012 (or other dates as indicated below) normalized to a 12-month period.

b. Determined by linear regression of the water-level measurements collected during FY 2010 through FY 2012.

c. Proximal well.

d. Distal well.

e. Measured during January 2011.

FY = fiscal year

Groundwater mounding near the SALDS creates a downward hydraulic gradient in the aquifer in the vicinity of the mound. However, this downward gradient is localized to the SALDS vicinity. Water-level measurements from a deep and shallow monitoring well pair (299-W6-6 and 299-W6-7) located 1 km (3,300 ft) southeast of the SALDS did not indicate any substantial vertical gradient in this area during the 1990s and early 2000s (Figure 2-6). The shallow well, 299-W6-7, became dry in 2005.

2.1.1 Well Longevity

Most of the tritium-tracking wells located south of the SALDS were constructed with 6.1 m (20 ft) screens, and many have gone dry due to the declining water table. Previous annual reports (e.g., SGW-51085) used trend analyses to predict when the remaining monitoring wells would become dry based on the historical rate of water-level decline in the wells. Thus, it was assumed that the historical rate of decline would be representative of future water table changes. However, this approach did not account for future operation of the 200-ZP-1 final remedy P&T system, which is expected to substantially alter the water table in the northern portion of the 200 West Area. At least some of the SALDS network monitoring wells will be affected by this system that began operating in July 2012.

A groundwater modeling study was conducted during 2011 to assess the effect that both the regional water table decline and operation of the P&T system would have on well water levels within the 200 West Area and vicinity (SGW-50907). This study represents the best forecast of well longevity through the year

2020 for 200 West Area monitoring wells. The results of this study for the shallow-screened SALDS network monitoring wells is shown in Table 2-2. Wells 299-W6-6, 299-W7-3, and 699-51-75P were excluded from the study because they are screened deep within the aquifer and will not become dry.

The results of the modeling study indicated that water levels will increase in some of the shallow-screened wells between 2011 and 2013 in response to the P&T system (Table 2-2). This is because there are several P&T system injection wells located in the northern 200 West Area, including three within 1 km (3,300 ft) of the SALDS (Figure 1-3). The increases are predicted to range from 0.3 to 0.9 m (1 to 3 ft). Water levels are not expected to increase in wells 699-48-71 and 699-51-75, which are farther from the injection wells. Thus, some of the wells that are becoming dry will be usable a few years longer than if the P&T system did not operate.

Only three of the shallow-screened SALDS monitoring wells are predicted to have more than 0.3 m (0.98 ft) of water after the year 2016 (Table 2-2). These are tritium-tracking wells 699-48-71, 699-49-79, and 699-51-75. Proximal well 699-48-77A was predicted to have less than 0.3 m (0.98 ft) of water at the end of 2011, and this well was indeed found to be sample dry at that time and has been removed from the sample schedule. The water level is predicted to increase in this well, but not higher than 0.6 m (1.97 ft) above the bottom of the screen (Figure 2-7). This well should be usable for water-level monitoring until 2014. Wells 299-W6-11, 299-W6-12, and 699-48-77D are predicted to have less than 0.3 m (0.98 ft) of water above the screen in 2015 or 2016 (Figures 2-8, 2-9, and 2-10, respectively). However, these wells could become sample dry earlier because the amount of water needed for sampling varies from well to well. The effect of the final remedy 200-ZP-1 P&T system on the water table elevation will continue to be evaluated in the future to determine if any of the now dry tritium-tracking wells may become usable again.

2.2 Groundwater Flow

The water-level measurements collected within the 200 West Area and vicinity during April 2012 were used to construct a water table map of the SALDS area (Figure 2-11). Water levels continue to be elevated at well 699-48-77A compared to the other proximal wells, forming a mound on the water table. The hydraulic head is higher in this well than the surrounding wells due to movement of the discharge water to the south along the CCU and subsequent infiltration to the aquifer near this well. The effluent discharge rate during the period from October 2011 through July 2012 averaged 5.2 million L (1.4 million gal) per month. This is smaller than the average monthly discharge rate of 8.2 million L (2.2 million gal) from October 2010 through July 2011 (SGW-51085). This reduction in the average monthly discharge resulted in a smaller groundwater mound beneath the facility. For instance, the water-level elevation difference between the proximal wells 699-48-77A and 699-48-77D was 0.2 m (0.6 ft) less during April 2012 than one year earlier in March 2011. During March 2011, the water level in 699-48-77A was 0.7 m (2.2 ft) higher than the water level in 699-48-77D, but it was only 0.5 m (1.6 ft) higher during April 2012. The decline in the water table mound also explains the relatively high water-level decline rate in the proximal wells between March 2011 and April 2012 compared to the other SALDS network wells (Table 2-1).

The regional groundwater flow direction in the SALDS vicinity is toward the east-northeast, although radial flow occurs in a small area beneath the facility due to the groundwater mound (Figure 2-11). The groundwater flow rate at the nearby Low-Level Waste Management Area 3 has been estimated to range from 0.04 to 0.15 m/d (15 to 55 m/yr) (DOE/RL-2011-118), and this is assumed to be representative of the flow rate in the SALDS vicinity in areas away from the mound. Flow rates are expected to be higher in the local vicinity of the mound because of a higher hydraulic gradient magnitude.

Table 2-2. Well Open-Interval Bottom Elevations Compared to Predicted Water Levels

Well	Open-Interval Bottom Elevation (m)	Predicted Water Levels by Year (m NAVD88)									
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
299-W6-11	131.71	133.27	134.22	133.86	133.56	132.50	132.07	131.76	131.51	131.28	131.07
299-W6-12	132.71	133.61	134.51	134.22	133.95	133.26	132.85	132.54	132.29	132.07	131.85
299-W8-1	136.1	135.50	136.12	136.11	135.96	135.76	135.49	135.23	135.01	134.80	134.56
699-48-71	124.5	131.32	130.88	130.40	130.04	129.77	129.48	129.24	129.02	128.82	128.75
699-48-77A	135.1	135.24	135.72	135.61	135.42	135.05	134.73	134.45	134.22	134.00	133.78
699-48-77D	134.2	134.98	135.80	135.23	135.04	134.69	134.38	134.11	133.88	133.67	133.44
699-49-79	125.8	134.65	134.89	134.86	134.73	134.52	134.28	134.04	133.83	133.63	133.42
699-51-75	127.72	132.93	132.94	132.80	132.62	132.32	132.03	131.78	131.56	131.35	131.17

Source: SGW-50907, *Predicted Impact of Future Water-Level Declines on Groundwater Well Longevity Within the 200 West Area, Hanford Site.*

Notes: Values are highlighted yellow for years in which a well is forecast to have less than 0.9 m (3 ft) of water above the bottom of the open interval and highlighted in red when the water level is within 0.3 m (1 ft) of the open-interval bottom.

NAVD88 = North American Vertical Datum of 1988

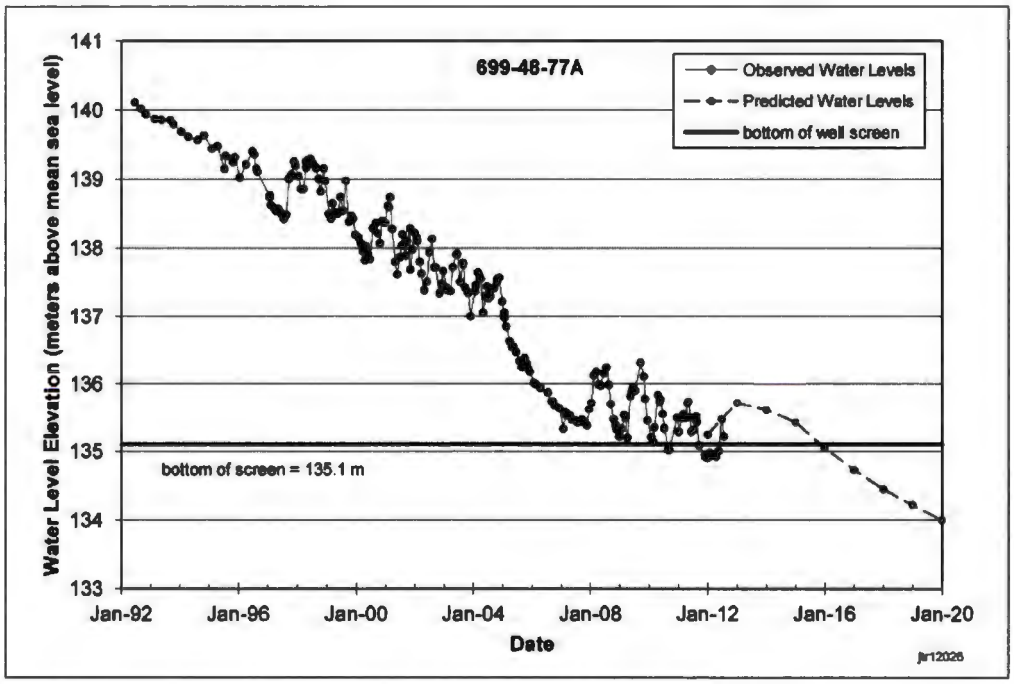


Figure 2-7. Water Remaining in Proximal Well 699-48-77A

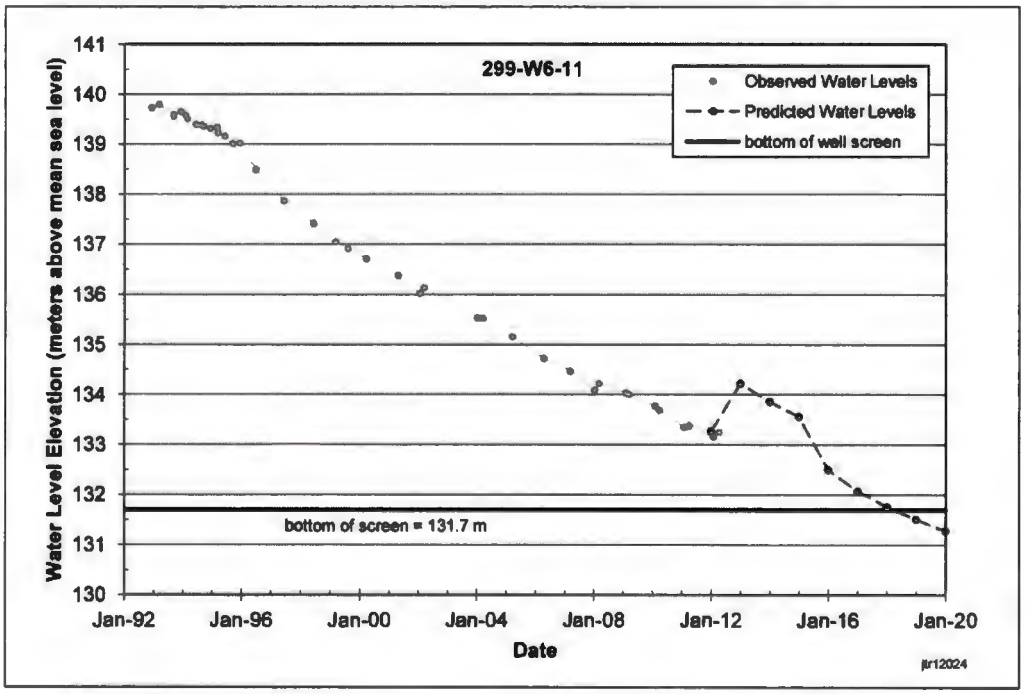


Figure 2-8. Water Remaining in Tritium-Tracking Well 299-W6-11

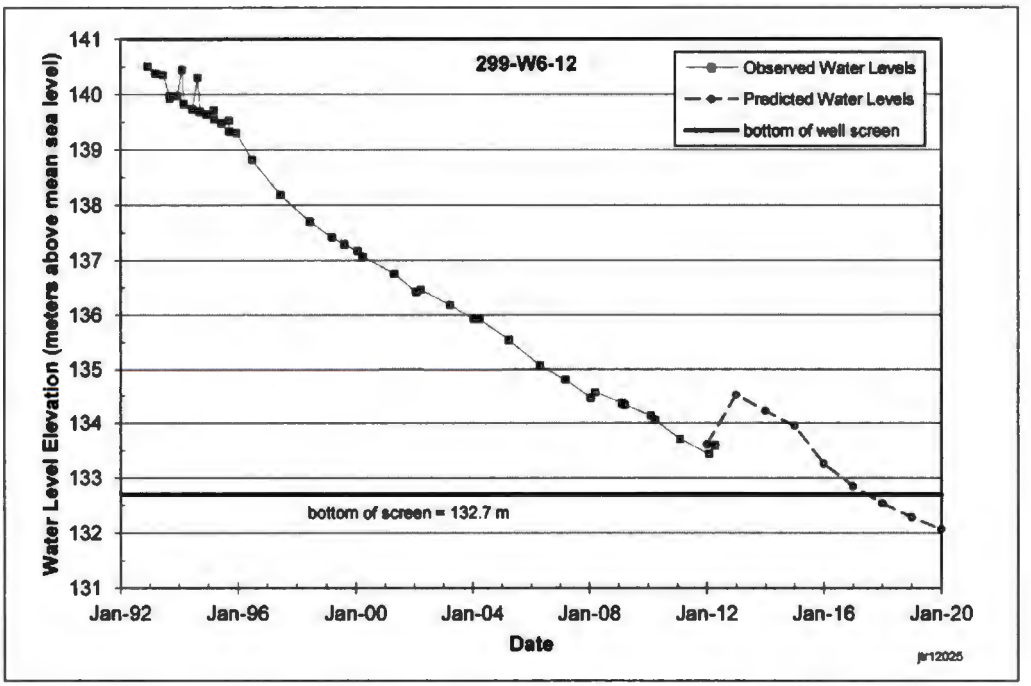


Figure 2-9. Water Remaining in Tritium-Tracking Well 299-W6-12

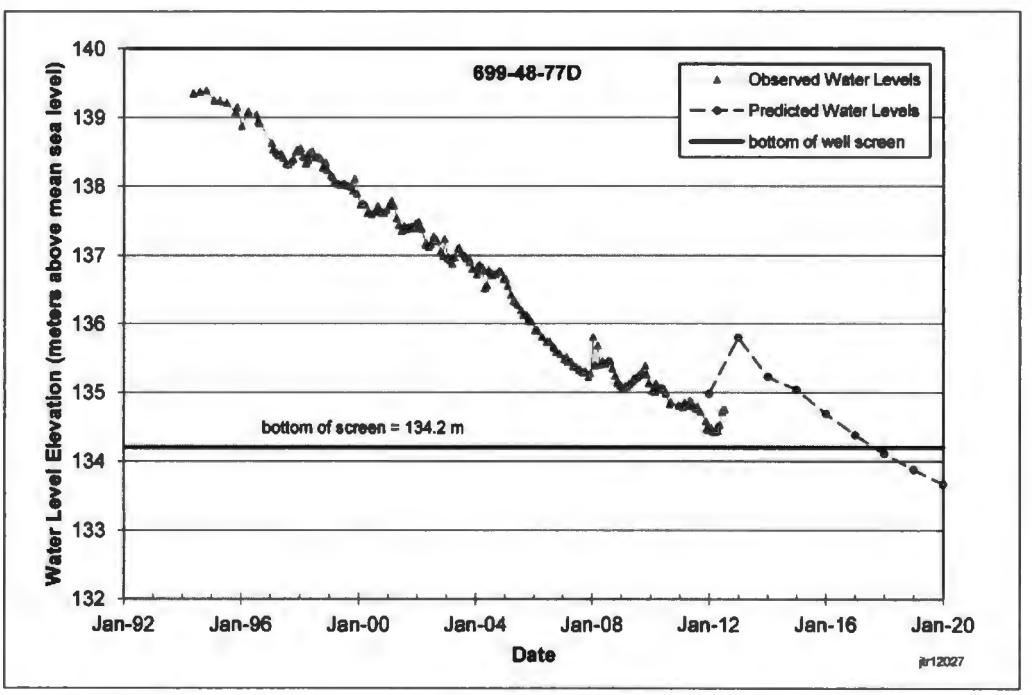


Figure 2-10. Water Remaining in Proximal Well 699-48-77D

The arrows shown in Figure 2-11 denoting the interpreted groundwater flow paths indicate that effluent from the SALDS should approach wells located southeast of the facility and may actually reach these wells if dispersion is taken into account. The maximum distance that effluent may travel from the SALDS to the south before turning east is not known precisely; however, based on both past and current model predictions, the distance by advection only (i.e., without considering dispersion) is assumed to be relatively short (i.e., approximately 300 to 350 m [1,000 to 1,150 ft]). Interpretation of the flow paths shown in Figure 2-11 indicates that wells 699-51-75 and 699-48-71 (located 1 km [3,300 ft] northeast and 1.9 km [6,200 ft] east of the SALDS, respectively) are regionally downgradient of the facility and are in reasonable locations for intercepting SALDS effluent.

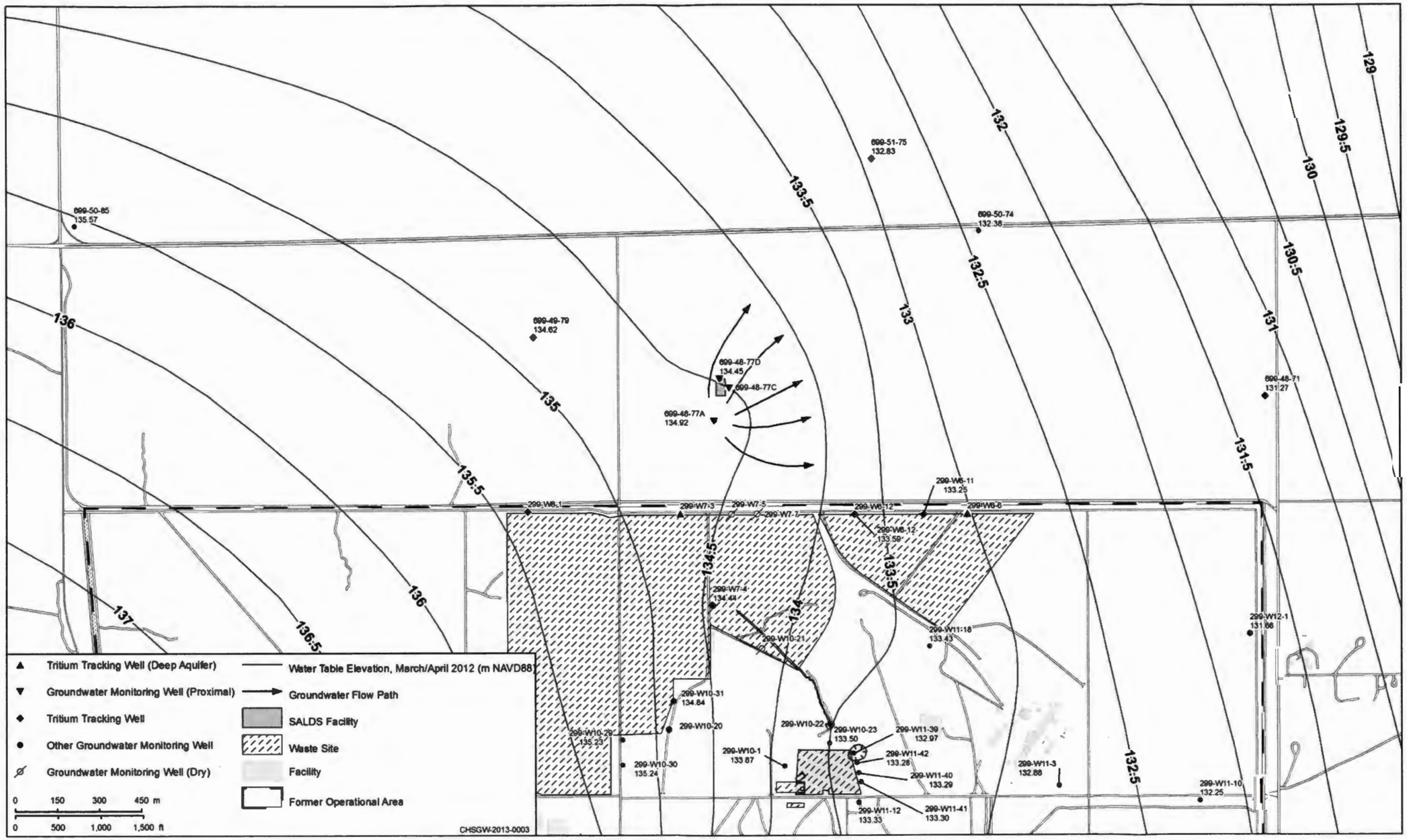


Figure 2-11. Water Table Map and Interpreted Groundwater Flow Directions in the SALDS Area, April 2012

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3 Results of Fiscal Year 2012 Groundwater Sampling

Groundwater sampling was scheduled quarterly in the SALDS proximal wells (699-48-77A, 699-48-77C, and 699-48-77D) and annually to semiannually in the tritium-tracking wells located in the vicinity of the SALDS. Table 3-1 shows the FY 2012 sampling schedule. During the first quarter of FY 2012, proximal well 699-48-77A was found to not have enough water to sample. The Washington State Department of Ecology (Ecology) was notified of this noncompliance in December 2011. Ecology then directed that sampling of the SALDS wells should continue only until they no longer produce representative data (Ecology, 2012). Ecology also agreed that no replacement wells are needed because monitoring of the ETF effluent would provide assurance that the Permit discharges limits would not be exceeded (Ecology, 2012). Well 699-48-77A was not sampled at all during FY 2012 and has been removed from the sample schedule. During the second, third, and fourth quarters of the FY, both remaining proximal wells had to be resampled for selected constituents because either the laboratory did not analyze the required practical quantitation limit standard at the same time as the samples, or because required hold times were exceeded.

Section 3.1 summarizes the FY 2012 groundwater sampling results for the remaining two proximal wells. Section 3.2 discusses the results of the tritium analyses (including the tritium-tracking wells), which are provided in Appendix A.

Table 3-1. Sampling Schedule for FY 2012

Well	Sampling Frequency/Months*	Other Sampling Programs	Comments
299-W6-6	A / January	200-ZP-1 OU	Deep well. FY 2012 sample date: January 2012.
299-W6-11	A / January	200-ZP-1 OU	FY 2012 sample date: January 2012.
299-W6-12	A / January	--	FY 2012 sample date: January 2012.
299-W7-3	S / January, May	200-ZP-1 OU	Deep well. FY 2012 sample dates: January and May 2012.
699-48-71	A / January	200-ZP-1 OU	FY 2012 sample date: January 2012.
699-48-77A	Q / October, January, April, July	--	Attempts to sample during November and December 2011 were not successful. Well is dry; removed from schedule. Formerly sampled for 17 constituents/parameters required by the Permit, including tritium.
699-48-77C	Q / October, January, April, July	--	Sampled for 17 constituents/parameters required by the Permit, including tritium. FY 2012 sample dates: November 2011 and January (anions resampled in March), April (VOAs resampled in June), and July (anions resampled in August) 2012.
699-48-77D	Q / October, January, April, July	--	Sampled for 17 constituents/parameters required by Permit, including tritium. FY 2012 sample dates: December 2011 and January, (anions resampled in April), April (VOAs resampled in June), and July (anions resampled in August) 2012.

Table 3-1. Sampling Schedule for FY 2012

Well	Sampling Frequency/Months*	Other Sampling Programs	Comments
699-49-79	A / January	--	FY 2012 sample date: April 2012.
699-51-75	S / January, May	--	FY 2012 sample dates: January and June 2012.
699-51-75P	A / January	--	Deep piezometer in well 699-51-75. FY 2012 sample date: January 2012.

* Actual months of sampling may vary slightly due to equipment failure, winter weather conditions, or accessibility restrictions caused by fire hazard; however, the sampling frequency is generally maintained.

A = annually
FY = fiscal year
OU = operable unit
Q = quarterly
S = semiannually
VOA = volatile organic analyte

3.1 Proximal Well Sampling and Analyses for Fiscal Year 2012

Quarterly samples from the two remaining proximal wells were analyzed for tritium and the other 16 constituents/parameters required by the ST 4500 Permit, Special Condition S2(B) (Ecology, 2000). The Permit sets enforcement limits for acetone, benzene, cadmium (total), chloroform, copper (total), lead (total), mercury (total), field pH, sulfate, tetrahydrofuran, and total dissolved solids. Gross alpha, gross beta, strontium-90, and tritium are required by the Permit but are not assigned enforcement limits; they are reported for informational purposes. Specific conductance and temperature are also required by the Permit, and the results for all of these parameters are reported quarterly in discharge monitoring reports. Additional parameters (i.e., alkalinity, dissolved oxygen, and turbidity) are used to determine general groundwater characteristics and to verify the quality of analytical results. Table 3-2 lists the maximum concentrations for these constituents in the proximal wells and the corresponding sampling months for FY 2012.

Table 3-2. Constituent Maximum or Range of Concentrations in Groundwater and Corresponding Sampling Month for the Proximal SALDS Wells, FY 2012

Constituent (Permit Limit)	Well 699-48-77C	Well 699-48-77D
Constituents with Permit Limits		
Acetone (160 µg/L)	<1.0 (U)[a]	<1.0 (U)[a]
Benzene (5 µg/L)	<1.0 (U)[a]	<1.0 (U)[a]
Cadmium, total (10 µg/L)	<0.1 (U)[a]	0.15 (B); December 2011[b]
Chloroform (6.2 µg/L)	<1.0 (U)[a]	<1.0 (U)[a]

Table 3-2. Constituent Maximum or Range of Concentrations in Groundwater and Corresponding Sampling Month for the Proximal SALDS Wells, FY 2012

Constituent (Permit Limit)	Well 699-48-77C	Well 699-48-77D
Copper, total (70 µg/L)	1.1; November 2011	36.3; December 2011[b]
Lead, total (50 µg/L)	0.37 (B)	10.9; December 2011[b]
Mercury, total (2 µg/L)	<0.1 (U)[c]	<0.1 (U)[a]
Field pH, pH units (6.5 to 8.5)[d]	7.9 to 8.1	8.1 to 8.2
Sulfate (250,000 µg/L)	4,290; March 2012	20,100; August 2012
Tetrahydrofuran (100 µg/L)	<2.0 (U)[a]	<2.0 (U)[a]
Total dissolved solids (500,000 µg/L)	157,000; July 2012	198,000; January 2012
Other Constituents Required by the Permit		
Gross alpha, pCi/L	<1.9 (U)[a]	3.01; December 2011
Gross beta, pCi/L	5.1; July 2012	7.5; December 2011
Strontium-90, pCi/L	1.2; July 2012	3.8; July 2012
Tritium, pCi/L	170,000; July 2012	133,000; December 2011
Field specific conductance, µS/cm[d]	188 to 194	177 to 276
Field temperature, °C[d]	18.2 to 21.6	14.9 to 22.7
Additional Constituents Not Required by the Permit		
Alkalinity, mg/L	89 to 143	110 to 138
Dissolved oxygen, mg/L[d]	8.76 to 8.98	9.12 to 12.3
Turbidity, NTU[d]	0.4 to 9.5	12.3 to 200

Notes: All concentrations in µg/L, unless otherwise indicated.

a. Not detected in any sample.

b. Result affected by high turbidity; not representative of the aquifer.

c. The maximum reported mercury result was 2.4 µg/L in well 699-48-77C during November 2011, but this result was not confirmed by subsequent sampling and was interpreted to be a laboratory error. Mercury was not detected in any other sample from this well.

d. Four analyses performed per sample event (except for some sampling events at well 699-48-77D). Values reported in this table are the averages of the four analyses.

B = detected at a value less than the contract-required detection limit but greater than or equal to the instrument detection limit/method detection limit, as appropriate (i.e., a low-level detection).

NTU = nephelometric turbidity unit

U = not detected; detection limits (for nonradionuclides) or minimum detectable activity (for radionuclides) are indicated, as applicable.

There were no confirmed exceedances of a Permit limit during FY 2012. Acetone, benzene, cadmium, chloroform, and tetrahydrofuran were reported below detection limits in both proximal wells for each of the samples collected during FY 2012. Mercury was detected at 2.4 µg/L in an unfiltered sample from well 699-48-77C during November 2011, which was above the Permit limit of 2 µg/L. The sample was re-analyzed, yielding a result of 1.8 µg/L. However, these sample results were deemed invalid and not representative of the aquifer for the following reasons:

- Mercury was not detected in the filtered sample.
- Mercury was not detected in either of the filtered and unfiltered duplicate samples collected at the same time for quality assurance purposes.
- Sample results of effluent from the ETF indicate little or no mercury present in the water discharged to the SALDS. The maximum historical effluent sample result was 0.090 µg/L (November 2008), but mercury has not been detected in most of the effluent samples.
- The reported result of 2.4 µg/L is similar to the practical quantitation limit check standard of 2.0 µg/L, which is analyzed at the same time, suggesting a possible mix up in labeling sample bottles at the analytical laboratory.
- Mercury was not detected in any subsequent samples collected from this well during FY 2012.

There were also issues associated with the unfiltered metals results from well 699-48-77D. This well is nearly dry (Figure 2-10), and during purging, the water level frequently declined to near the same level as the pump intake, making it difficult to purge the required three borehole volumes. Many of the samples were aerated because air was drawn into the pump intake. Also, the samples had high turbidity because of the inability to fully purge the well, and potentially because aeration agitated the water and entrained particles that are not normally mobile during the sampling process.

High turbidity adversely affects sample results for some metals. Metal samples are preserved with nitric acid to prevent alteration of the sample chemistry by chemical and biological processes prior to sample analysis (*Soil Water and Groundwater Sampling* [Wilson, 1995]). Acid is also added to metals samples at the laboratory in preparation for analysis. However, when the turbidity is high, the acid causes metals adsorbed or precipitated on the sediment to become dissolved, resulting in elevated metals results that are not representative of the aquifer. For instance, the turbidity averaged 200 nephelometric turbidity units (NTU) for the December 2011 sampling, which resulted in elevated results for cadmium, copper, and lead in the unfiltered samples (Table 3-2). Under these conditions, the filtered sample results are more representative of aquifer conditions. During December 2011, the filtered samples had copper and lead concentrations of 0.63 µg/L and 0.25 µg/L, respectively, which is much lower than the unfiltered results of 36.3 and 10.9 µg/L. Cadmium was not detected in any of the filtered samples collected from well 699-48-77D during FY 2012.

Field pH measurements were within the 6.5 to 8.5 criterion in all samples collected from the proximal wells during FY 2012. The minimum and maximum pH values of 7.9 and 8.2 occurred in well 699-48-77D. The maximum sulfate concentration was 20,100 µg/L in 699-48-77D, well below the Permit limit of 250,000 µg/L. The maximum total dissolved solids value was 248,000 µg/L in 699-48-77D, below the 500,000 µg/L Permit limit.

During FY 2012, gross beta results ranged from below detection limits to a maximum of 7.5 pCi/L in the proximal wells, which is below the Hanford Site background value of 8.96 pCi/L (95 percentile value provided in DOE/RL-96-61, *Hanford Site Background: Part 3, Groundwater Background*). Strontium-90 results ranged from below detection limits to a maximum of 3.8 pCi/L. The maximum value is above the

Hanford Site background value of 0.020 pCi/L, but is below the 8 pCi/L drinking water standard. Gross alpha analyses in the proximal wells yielded results ranging from nondetects to 3.01 pCi/L. There are no Permit limits associated with gross alpha, gross beta, or strontium-90.

3.2 Results of Tritium Analyses (Tritium Tracking)

The proximal wells are sampled quarterly for a suite of constituents that includes tritium, but the other SALDS network monitoring wells are sampled annually or semiannually for tritium only (i.e., the tritium-tracking wells). Eight tritium-tracking wells were sampled between January and June 2012. Due to generally declining water levels throughout the 200 West Area, 11 of the 19 tritium-tracking wells listed in the monitoring plan (PNNL-13121) have gone dry and are no longer in use. Five of the wells that were successfully sampled are screened in the upper portion of the aquifer near the water table; the other three wells are screened at greater depths, including one well (699-51-75P) that is a piezometer nested within well 699-51-75 but is completed 41 m (135 ft) deeper in the aquifer. Four of the tritium-tracking wells are also sampled as part of monitoring for the 200-ZP-1 OU (Table 3-1). The tritium results for this program, as well as the results collected specifically for the SALDS well network, are provided in Appendix A.

3.2.1 Tritium in the Proximal Monitoring Wells

Groundwater in the proximal wells has been affected by tritium discharges since 1996 (Figure 3-1). From FY 2011 to FY 2012, the average tritium activity changed by 20 percent or more in both proximal wells, 699-48-77C and 699-48-77D, indicating substantial changes in concentration (Figure 3-2). The average concentration increased from 101,000 pCi/L to 156,000 pCi/L in 699-48-77C between FY 2011 and FY 2012, and the average concentration decreased from 138,000 pCi/L to 110,000 pCi/L in 699-48-77D. The maximum tritium concentrations in the proximal wells during FY 2012 and the associated sampling dates are shown in Table 3-2.

3.2.1.1 Long-Term Trends

Figure 3-1 shows tritium concentrations in the proximal wells compared to the amount of tritium released at the SALDS. Peak tritium concentrations occurred in September 1997 (2,000,000 pCi/L) and February 1998 (2,100,000 pCi/L) in wells 699-48-77A and 699-48-77D, respectively, in response to initial discharges to the SALDS between December 1995 and June 1996. The tritium concentration trend in well 699-48-77C is attenuated and time-lagged compared to the other wells. The peak concentration in this well occurred in February 2001, which is 3 years after the peak occurred in 699-48-77D, and the concentration was lower at 980,000 pCi/L. This is because 699-48-77C is screened approximately 20 m (65 ft) below the water table, and it took longer for the plume front to migrate to this depth, which allowed for more dispersion of the plume. Radiological decay would also have been a factor in the reduced concentration because tritium has a relatively short half-life (12.3 years), but dispersion was the primary factor.

Since the time of peak concentrations in the proximal wells, the tritium concentration trends have been generally downward. However, from 1999 to 2005, concentration changes in well 699-48-77A were irregular (Figure 3-1), with periodic highs and lows of significant amplitude (sometimes two order-of-magnitude changes). These fluctuations were likely caused by the annual campaigns of the 242-A evaporator wastewater during that time, which was high in tritium. In April 2008, the 820,000 pCi/L tritium concentration was the highest level seen in well 699-48-77A in a decade (Figure 3-2). This was likely due to several intermittent ETF campaigns in 2006 and 2007 to treat wastewater from the K Basins project, which had tritium levels similar to those of 242-A evaporator wastewater.

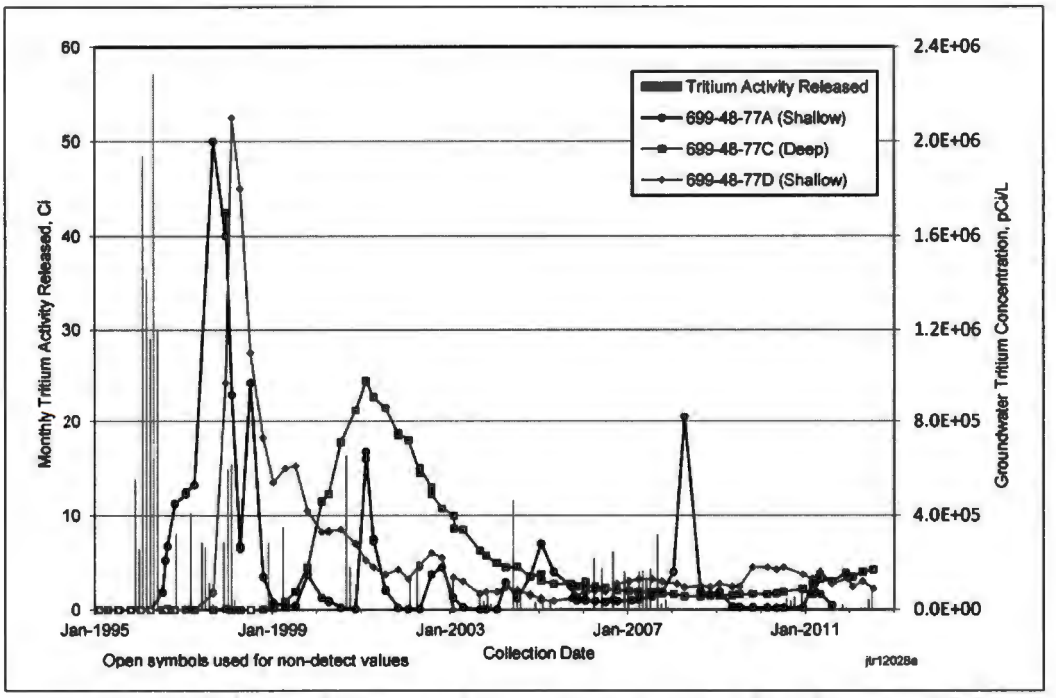

Figure 3-1. SALDS Tritium Releases and Concentration Trends in SALDS Proximal Wells from 1995 Through July 2012

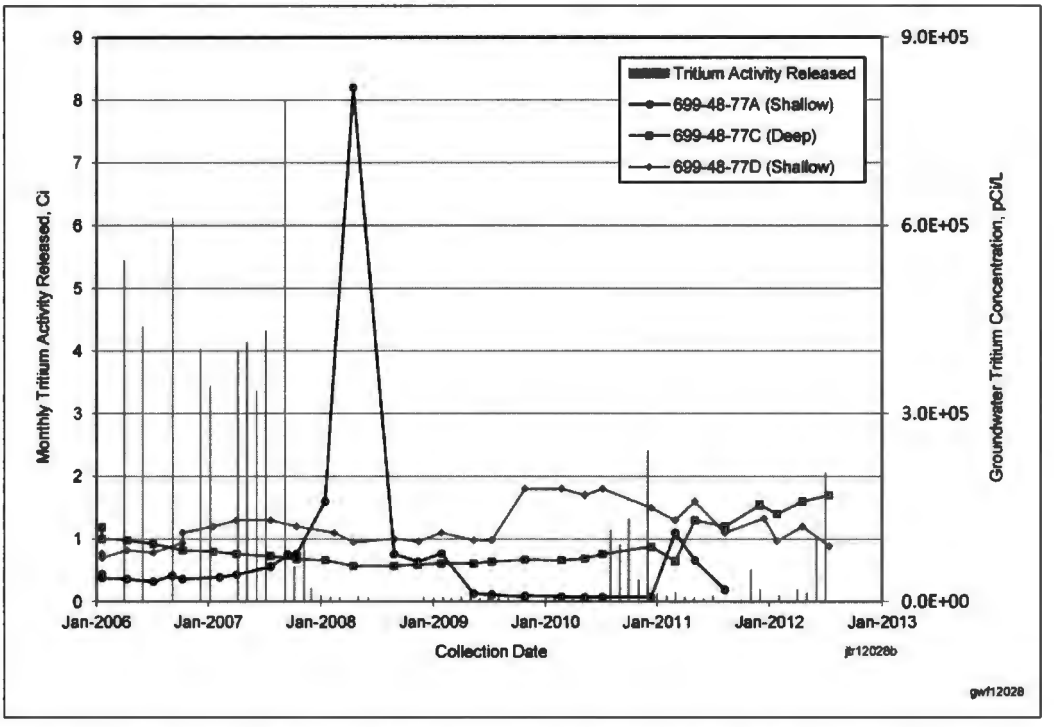

Figure 3-2. SALDS Tritium Releases and Concentration Trends in SALDS Proximal Wells from 2006 Through July 2012

These intermittent campaigns restarted in FY 2010, with the ETF again treating wastewater from the K Basins project, which may explain the slight upward trend in tritium results observed during FY 2011. Well 699-48-77A has too little water remaining for sampling and has been removed from the sample schedule.

Well 699-48-77D is located nearest to the SALDS, yet the well showed a tritium concentration increase starting in September 1997, more than one year later than more distant well 699-48-77A. The two causes for this delay are (1) the SALDS drain field fills from the southern end of the facility farthest away from 699-48-77D; and (2) discharged water in the vadose zone moves to the south along the CCU, which has a southward dip (Section 1.2.1). These two conditions direct the subsurface flow of effluent away from 699-48-77D, so the effluent actually reaches the groundwater closer to well 699-48-77A. This interpretation is consistent with the low specific conductance values that have been measured in 699-48-77A (ranging from 89 to 98 μS/cm during FY 2011), which indicates that a substantial portion of SALDS effluent, which is very low in specific conductance, has mixed with groundwater at this location.

3.2.1.2 Current Trends

The current tritium concentration trends at the two remaining proximal wells are mixed. The trend is increasing in 699-48-77C and declining in 699-48-77D. Increases at 699-48-77C, screened deeper in the aquifer, may be the attenuated, time-lagged response to the ETF treatment of wastewater from the K Basins project, released to the SALDS during 2006 and 2007. The declines in 699-48-77D may be in response to the reduced amount of tritium released to the SALDS from 2008 until 2010, at which time processing of K Basins wastewater began again.

3.2.2 Tritium-Tracking Wells

Sample results during FY 2012 continued to indicate that the tritium plume from the SALDS has not reached any of the tritium-tracking wells. Tritium was not detected in wells 699-49-79 and 699-51-75, located west and northeast of the SALDS, respectively (Figure 3-3). In addition, tritium was not detected in the three deep tritium-tracking wells 299-W6-6, 299-W7-3, and 699-51-75P.

Wells located southeast of the SALDS exhibited elevated tritium concentrations during FY 2012, but this is caused by migration of tritium from past wastewater disposal sites in the 200 West Area. Average FY 2012 concentrations in the two shallow-screened wells in this area were 185 pCi/L in 299-W6-12 and 1,600 pCi/L in 299-W6-11. Many of the wells along the northern margin of the 200 West Area exhibited elevated tritium concentrations prior to the start of SALDS discharges (Figures 3-4 and 3-5), further supporting the interpretation that the tritium originates from the 200 West Area.

Well 699-48-71, located 1.9 km (1.2 mi) to the east of the SALDS crib, continued to show an increase in tritium concentration, from 1,170 pCi/L in FY 2011 to 1,400 pCi/L in FY 2012. Tritium concentrations have been increasing in this well since 2004. Although this well is located downgradient of the SALDS crib, the distance suggests that discharges from the SALDS are not the source of tritium in groundwater at this location. This is also supported by the tritium modeling results, which predict that the SALDS plume should not reach this well prior to the year 2030 (Figure 4-3 in Chapter 4). The tritium at well 699-48-71 is part of the same plume that has impacted the wells along the northern margin of the 200 West Area and originated from past wastewater disposal sites (Figure 3-3).

3.3 Results of Other Constituent Analyses

After discharges began at the SALDS, several anions and metals increased in concentration in the proximal wells and then rapidly declined. The specific conductance (a measure of total ions in solution) at well 699-48-77A clearly shows a well-defined spike in the months after SALDS discharges began in

December 1995 (Figure 3-6), with values peaking at approximately 845 µS/cm in August 1996. This was likely due to transport of dissolved soluble mineral species in the vadose zone during initial percolation of SALDS effluents (PNNL-11633, *Origin of Increased Sulfate in Groundwater at the ETF Disposal Site*; PNNL-11665, *Tritium Monitoring in Groundwater and Evaluation of Model Predictions for the Hanford Site 200 Area Effluent Treatment Facility*). This spike in dissolved constituents was a temporary effect associated with the initial wetting of the vadose zone sediments beneath the facility.

Currently, specific conductance in the proximal wells is related to the volume of effluent releases from the SALDS. The SALDS effluent is very low in specific conductance. For example, the average value for June 2012 was 1.98 µS/cm (CHPRC-1203231). The Hanford Site groundwater background for specific conductance has a geometric mean of 348 µS/cm (DOE/RL-96-61). Thus, mixing of SALDS effluent with groundwater reduces the specific conductance in the monitoring wells because of dilution, and the amount of reduction depends on the volume of effluent released. Conversely, during periods of reduced discharges, specific conductance in the monitoring wells increases because of less dilution. This occurred between 2005 and 2007, when pumping ceased and a rebound study was conducted at the 200-UP-1 P&T system, resulting in reduced effluent volumes released from the SALDS (Figure 3-6). Specific conductance in shallow proximal wells 699-48-77A and 699-48-77D increased during this time and peaked in late 2007 and early 2008. A slight peak in specific conductance was observed during early 2011 in deep proximal well 699-48-77C, which is likely the attenuated, time-lagged response to the 2005 to 2007 period of reduced effluent discharges. A map showing the low specific conductance values in the proximal wells compared to other wells in the SALDS vicinity is shown in Figure 3-7.

During FY 2012, the maximum field conductivity readings in the proximal wells were 194 µS/cm in 699-48-77C and 276 µS/cm in 699-48-77D. The trend has been relatively stable in 699-48-77D since 2009, although a slight increasing trend is evident during FY 2012 (Figure 3-6). This may be in response to the reduced effluent discharges between August 2011 and July 2012 (52.0 million L [13.7 million gal]) compared to the previous one-year period (89.2 million L [23.6 million gal]). Specific conductance exhibits a slight declining trend in 699-48-77C, which is likely the attenuated, time-lagged response to the increase in SALDS discharges during 2007.

During FY 2012, the maximum total dissolved solids in the proximal wells was 157 mg/L in 699-48-77C and 198 mg/L in 699-48-77D. Concentrations are generally stable in 699-48-77C, but a slight upward trend has been occurring at 699-47-77D since 2006 (Figure 3-8). The reason for this trend is unknown, but it is not caused by SALDS discharges. During the same time, a decreasing trend occurred at 699-48-77A, which is the well most impacted by the effluent releases. Similar to specific conductance, total dissolved solids in the proximal wells are diluted compared to other nearby wells (Figure 3-7) because of the very low total dissolved solids in the SALDS effluent (e.g., less than 2 mg/L during June 2012 [CHPRC-1203231]) compared to natural background in the aquifer (geometric mean of 201 mg/L [DOE/RL-96-61]).

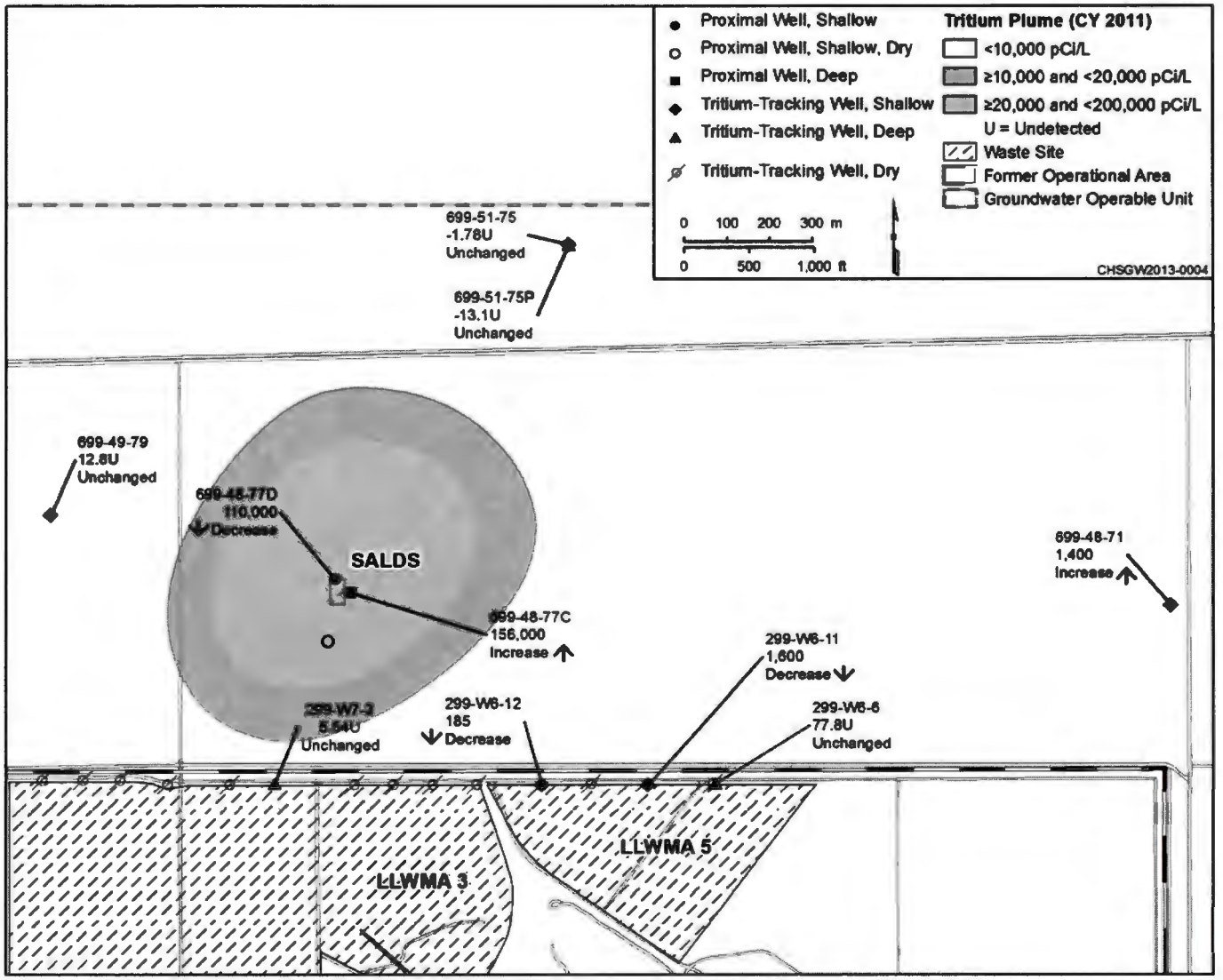

Figure 3-3. Average Tritium Activities in Groundwater for SALDS Tritium-Tracking Network for FY 2012

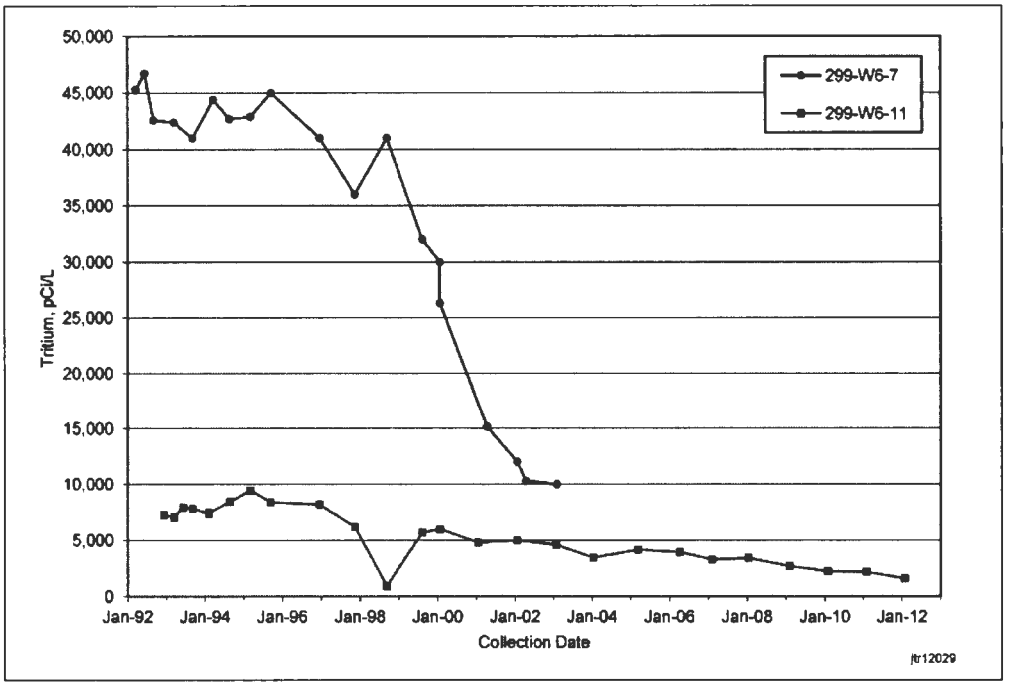

Figure 3-4. Tritium Activity Trends in Wells Southeast of the SALDS Showing Remnant Effects of the Tritium Plume from the 200 West Area

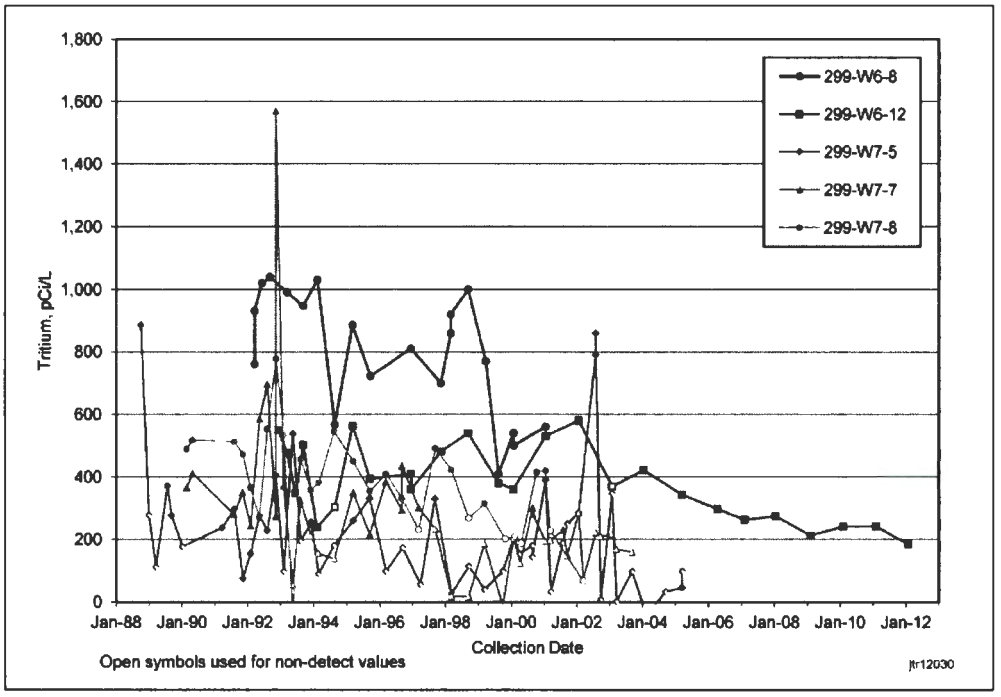

Figure 3-5. Tritium Concentrations in Wells South of the SALDS Showing Remnant Effects of the Tritium Plume from the 200 West Area

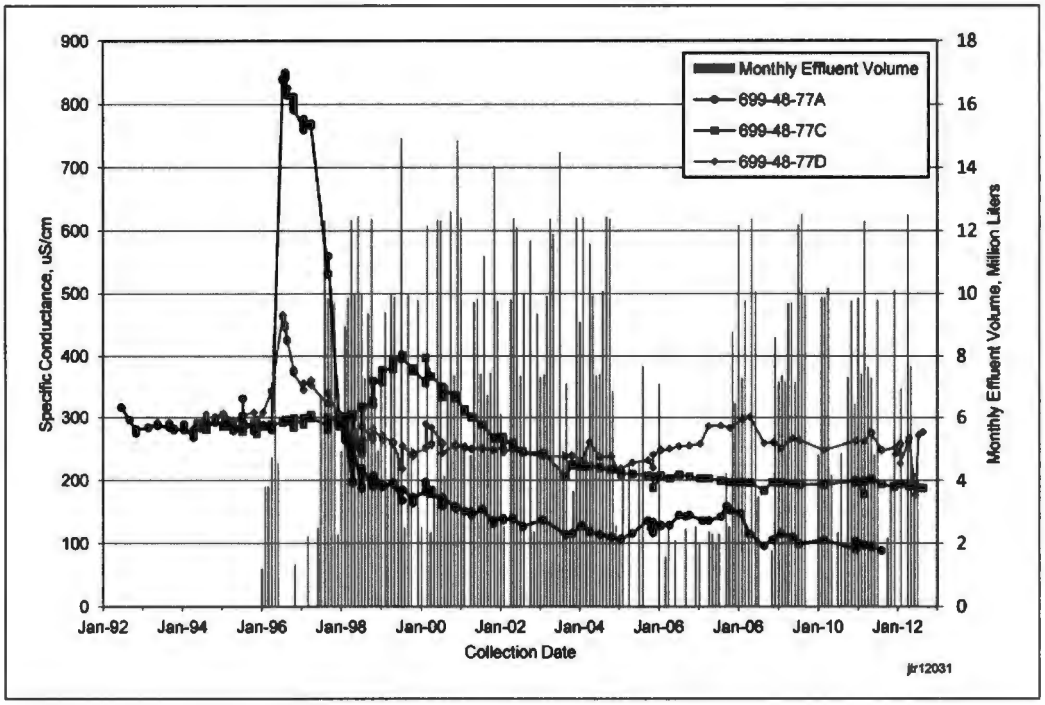

Figure 3-6. Specific Conductance in the SALDS Proximal Wells

Figures 3-9 through 3-12 provide trend plots for chloride, sulfate, calcium, and sodium in the proximal wells. These constituents are leached from the soil and they are naturally present in groundwater, so the sample results are not directly representative of ETF effluent. However, these constituents do provide useful information regarding the effect of SALDS discharges on groundwater. Chloride, sulfate, and calcium exhibit the same trends as described previously for specific conductance. Sharp increases were observed in concentrations in the shallow proximal wells (699-48-77A and 699-48-77D) shortly after discharges began in 1995 due to leaching from the soil column. More recent trends exhibit an inverse relationship, with discharge volume indicating dilution in the aquifer by SALDS discharges. The trends at deep well 699-48-77C exhibit the same attenuated, time-lagged response that was observed for specific conductance. The sodium trends also exhibit an increase in concentration shortly after the start of effluent discharges, but the relative increase was lower than for the other constituents (Figure 3-12). More recent sodium concentrations do not appear to trend with the other constituents, and there is no obvious relationship with effluent discharge volumes. This suggests that the effluent is continuing to leach sodium from the soil column so the concentration in the leachate is similar to the concentration in groundwater.

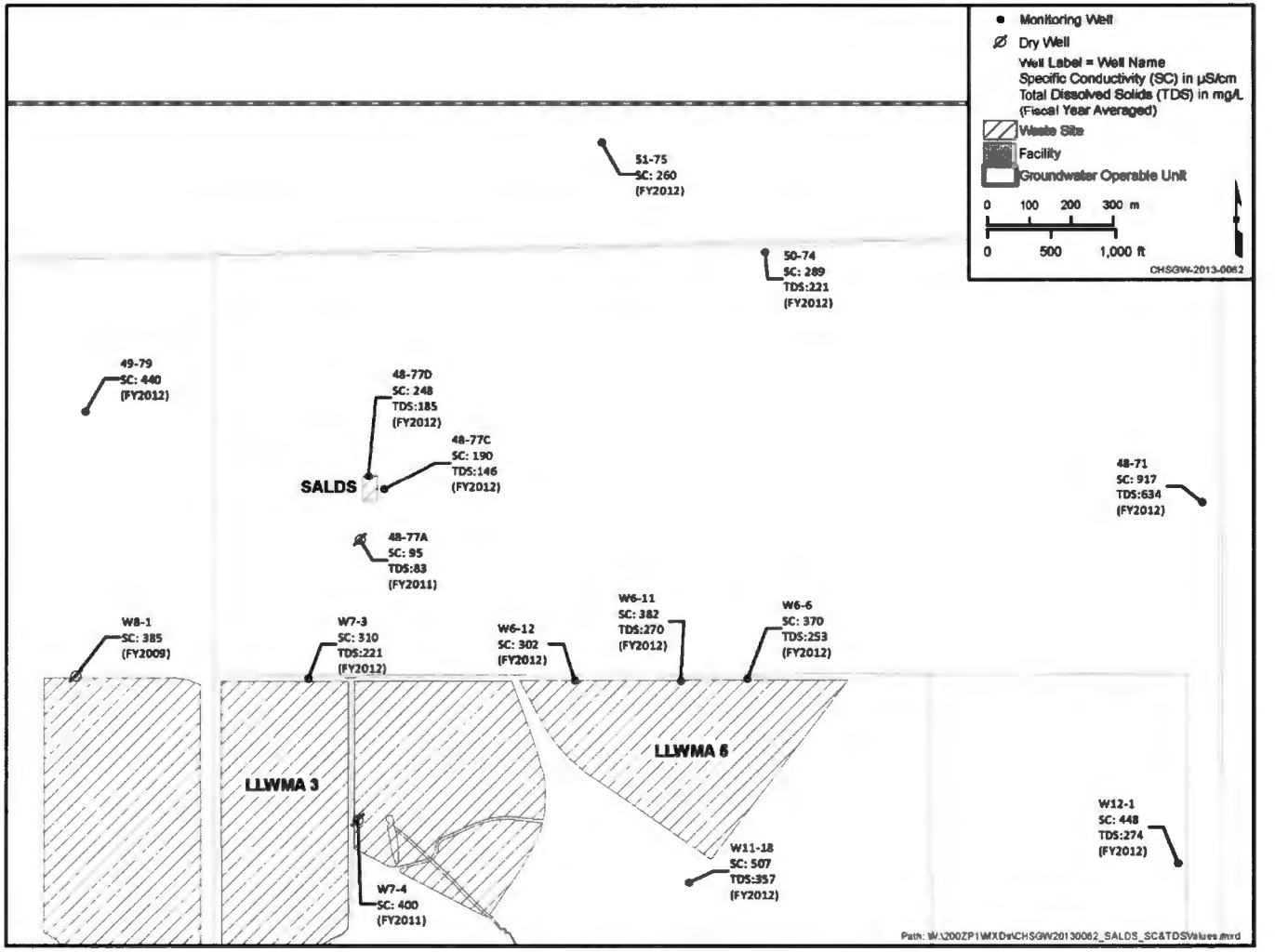

Figure 3-7. Average Specific Conductance and Total Dissolved Solids in the SALDS Vicinity

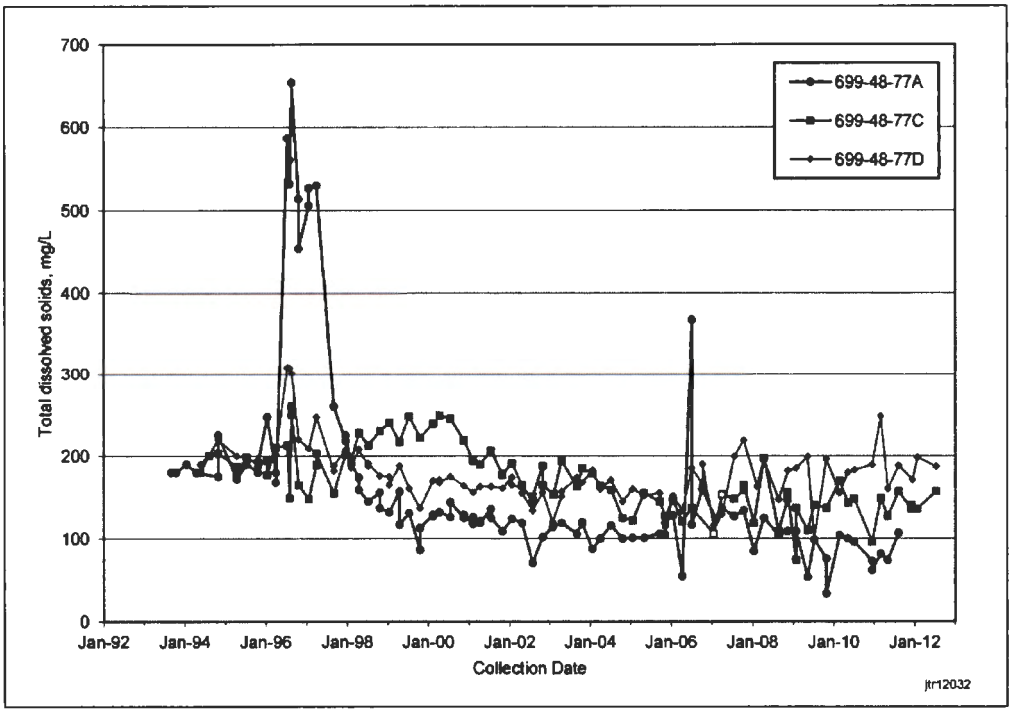

Figure 3-8. Total Dissolved Solids in the SALDS Proximal Wells

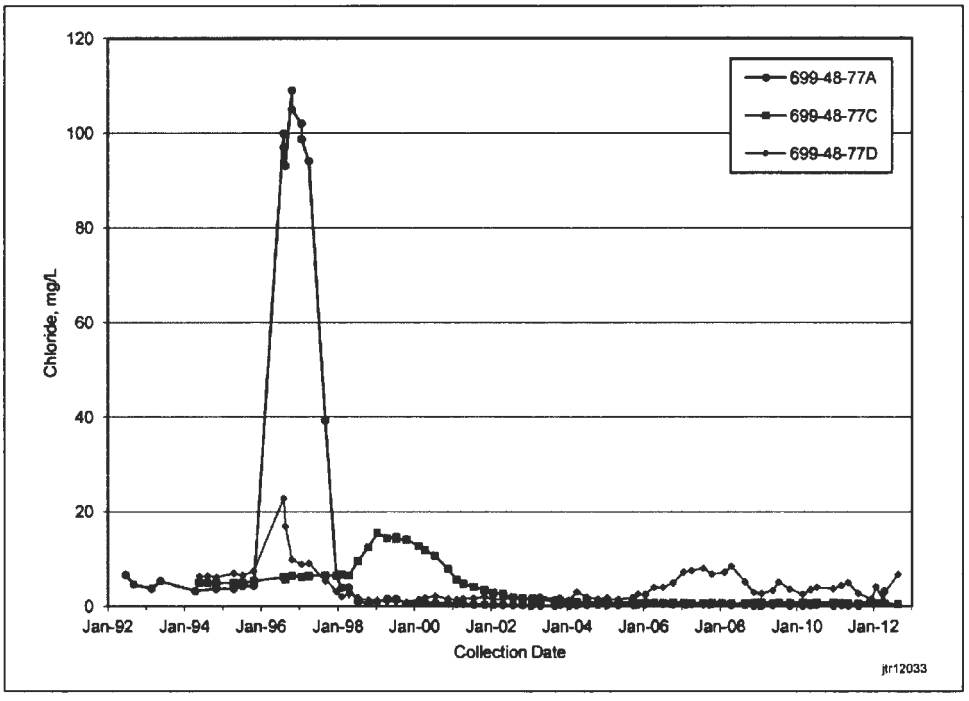

Figure 3-9. Chloride Concentrations in the SALDS Proximal Wells

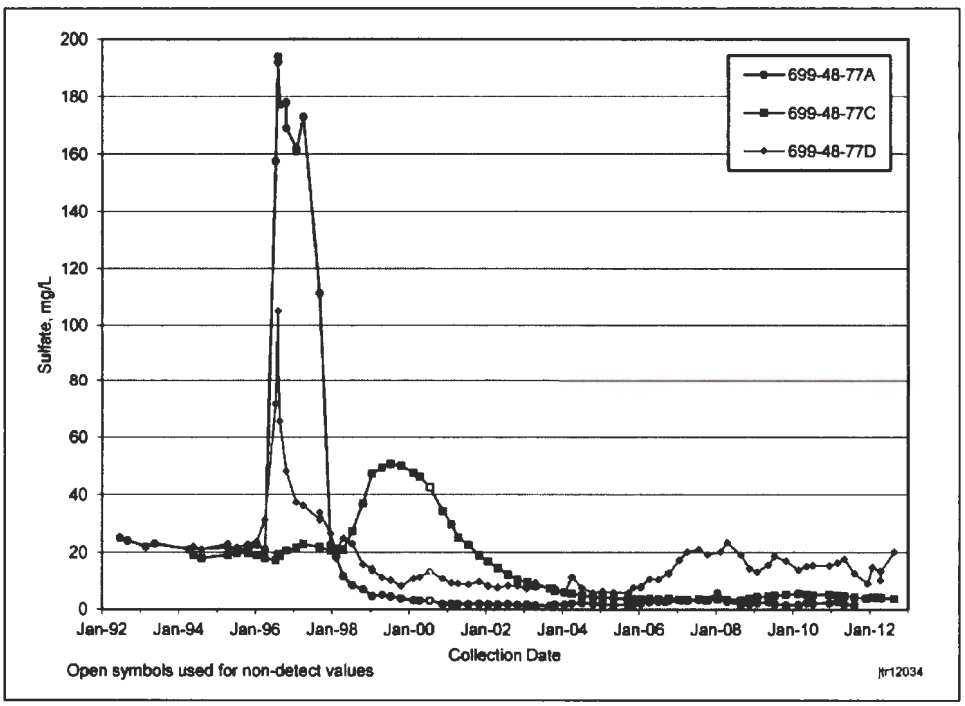

Figure 3-10. Sulfate Concentrations in the SALDS Proximal Wells

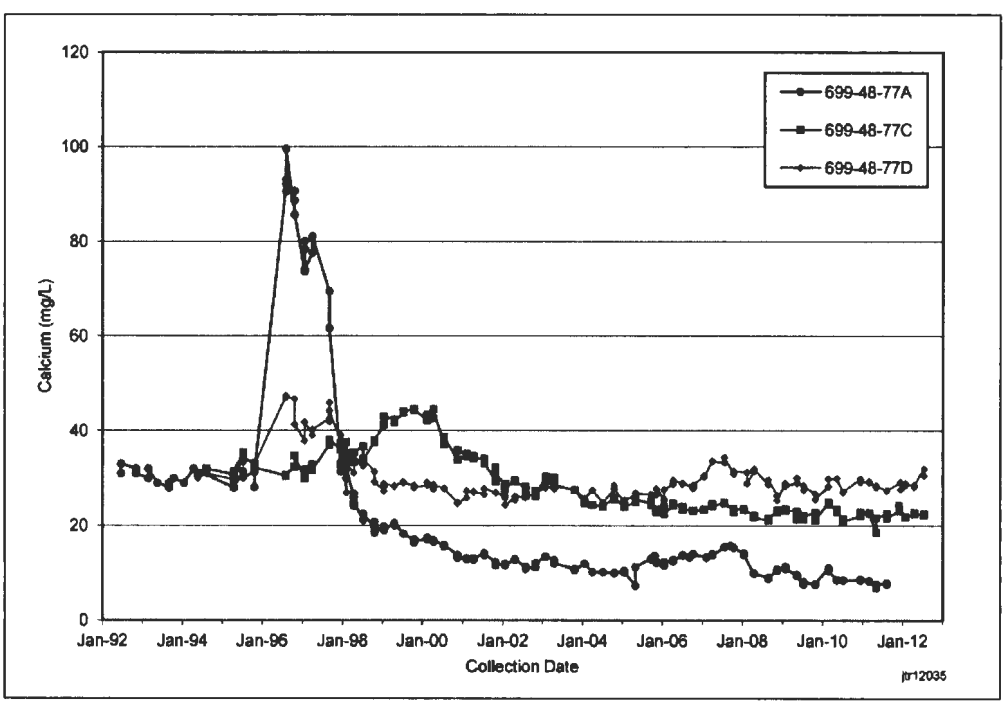

Figure 3-11. Calcium Concentrations in the SALDS Proximal Wells

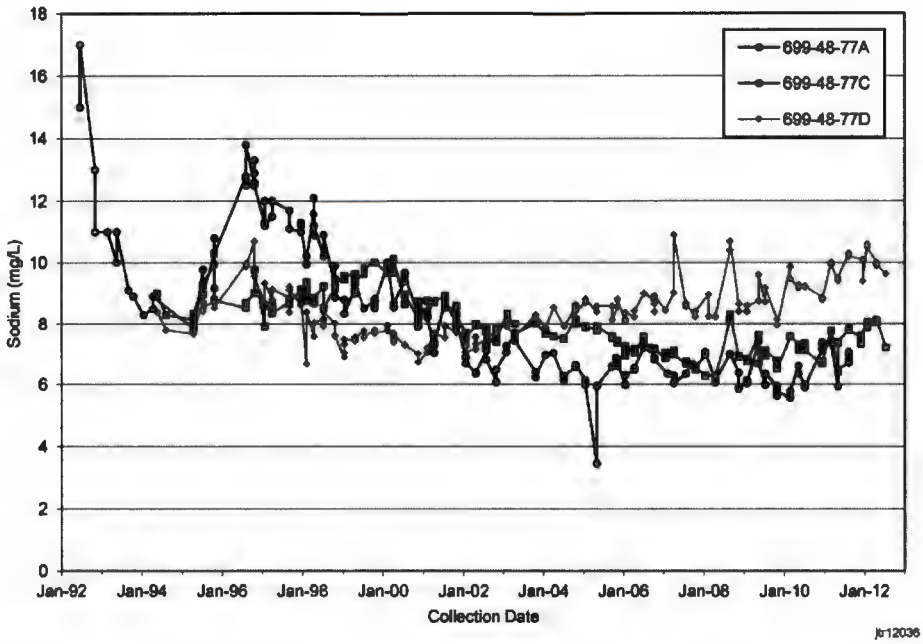

Figure 3-12. Sodium Concentrations in the SALDS Proximal Wells

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4 Groundwater Modeling and Site Analysis

Groundwater modeling and site analysis are required to be performed once per Permit cycle, which is every 5 years. The model was last updated during FY 2011 (SGW-51085) and included tritium migration and fate predictions based on both the latest calibration of the groundwater model and the latest information regarding the forecast operation of the final remedy 200-ZP-1 P&T system. For convenience, the summary description of the modeling update that was provided in last year's report (SGW-51085) is repeated in the remainder of this section. Additional details regarding the modeling are presented in Appendix B of SGW-51085.

4.1 Analysis Approach

The modeling was performed using the CP groundwater model that was first described in *200-West Area Pre-Conceptual Design for Final Extraction/Injection Well Network: Modeling Analyses* (DOE/RL-2008-56). The CP Model simulates conditions from the 1940s through the present (calibration period) and is then used to simulate likely future conditions under assumed extraction and injection rates for the final remedy 200-ZP-1 groundwater P&T system. The CP Model was updated in 2010 (ECF-HANFORD-10-0371, *Central Plateau Version 3 MODFLOW Model*; CP-47631) and included an improved calibration of the flow field to historical water-level measurements compared to previous versions of the model. The migration and fate of the SALDS tritium plume were simulated using historical tritium releases from the start of facility operation through June 2011, along with future projected tritium releases.

In addition to the model simulations, analyses were completed using a water-level mapping and particle-tracking technique to verify that the flow field simulated by the CP Model in the SALDS vicinity was in reasonable agreement with actual field conditions determined using water-level measurements. The mapping and particle-tracking analysis was performed using the program KT3D_H2O Version 3 ("KT3D_H2O: A Program for Kriging Water Level Data Using Hydrologic Drift Terms" [Karanovic et al., 2009]). This software uses kriging to generate gridded maps of water-level elevations taking the SALDS effluent discharges into account, and then uses the maps to compute particle movement paths. The analysis used 17 sets of water-level maps, from 1995 through 2011.

4.2 Groundwater Flow

Figure 4-1 compares the results of conservative particle-tracking analyses through the year 2030, calculated using the CP Model and the water-level mapping technique. The two methods of evaluating the flow field yielded similar results; both techniques indicate a generally eastward movement of groundwater in the SALDS vicinity. The eastern end of the particle tracks differ in that the CP Model indicates a component of flow toward the south in later years. The model simulated the expected future effects of the final remedy 200-ZP-1 P&T system in which flow turns southward toward the extraction wells, whereas for future projections, the water-level mapping technique used the 2011 water-level map that does not include future P&T system effects.

The particle tracks shown in Figure 4-1 are based on advection without dispersion. The software used for the water-level mapping particle tracks can simulate dispersion using a random-walk technique, and the results are shown in Figure 4-2. This figure suggests that when dispersion is taken into account, groundwater from the SALDS could reach wells located along the northern boundary of the 200 West Area by the year 2030. Using either method of particle-tracking analysis, the SALDS effluent is not predicted to reach well 699-51-75 (located 800 m [2,600 ft] to the northeast of the SALDS) or well 699-48-71 (located 1.9 km [1.2 mi] to the east) by the year 2030.

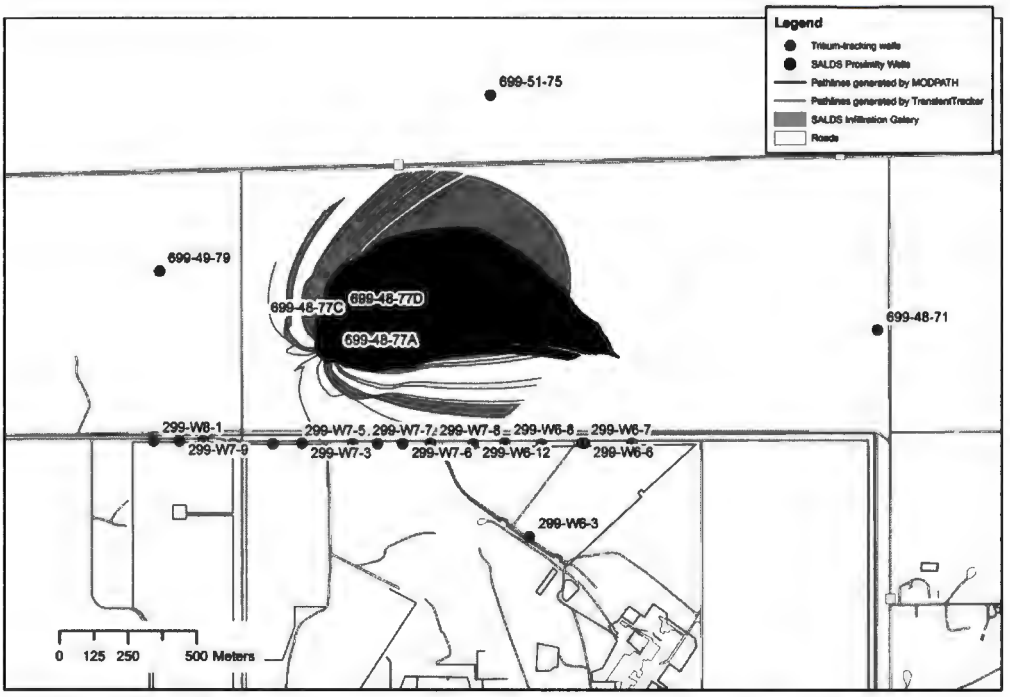

Figure 4-1. Particle Tracks through Year 2030 Calculated Using the CP Model and the Water-Level Mapping Technique

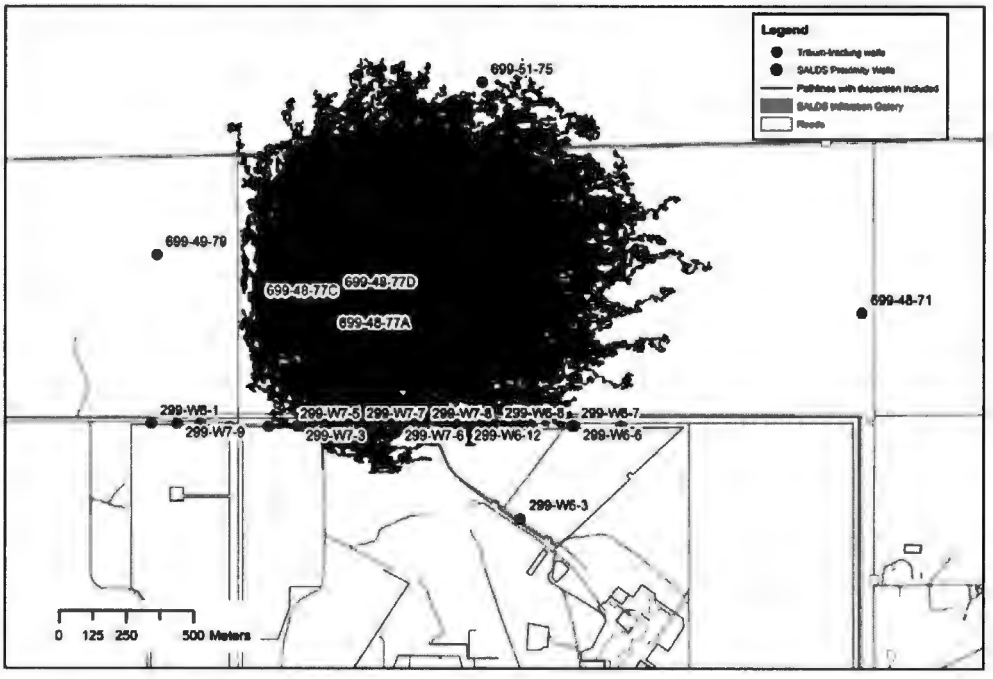

Figure 4-2. Particle Tracks with Dispersion Produced by the Water-Level Mapping Technique

4.3 Tritium Plume Migration and Fate

The CP Model was used to simulate the migration and fate of the SALDS tritium plume. Figure 4-3 shows the results for the year 2030 (Appendix B in SGW-51085 shows the results for 2000 through 2030 at 5-year intervals). The modeling was completed using two effective porosity assumptions, 0.13 and 0.18, and results for both are shown in Figure 4-3. Under either assumption, the tritium plume is not anticipated to reach tritium-tracking wells 699-51-75 or 699-48-71 by the year 2030. However, some locations along the northern margin of the 200 West Area are expected to exhibit measurable concentrations of SALDS-derived tritium by 2030, although the model indicates that concentrations would be below the drinking water standard of 20,000 pCi/L.

The results in Figure 4-3 differ slightly from results presented in the earlier model update performed in FY 2010 (SGW-47923, *Results of Tritium Tracking and Groundwater Monitoring at the Hanford Site 200 Area State-Approved Land Disposal Site, Fiscal Year 2010*) in that the distal end of the tritium plume is now simulated to migrate toward the south by the year 2030. The reason for this difference can be seen in Figure 4-4, which compares the FY 2010 and FY 2011 model update results for the year 2030 (for an effective porosity of 0.13) and shows the assumptions used for each update regarding the predicted operation of the final remedy 200-ZP-1 P&T system extraction and injection wells. The FY 2010 model update assumed uniform flow rates for all extraction and injection wells (depicted in Figure 4-4 by the uniform symbol size for the extraction and injection wells). The extraction and injection rates used for the FY 2011 model update resulted from an optimization analysis of the P&T system to maximize the recovery of carbon tetrachloride (the principal contaminant being remediated) from the aquifer (SGW-50390, *FY 2011 Simulation-Optimization of the 200-ZP-1 Remedy Using the Central Plateau Model*). The optimized flow rates are predicted to be higher in the eastern extraction wells compared to the western wells, resulting in a larger area of water table drawdown along the eastern margin of the 200 West Area, toward which the tritium plume is predicted to migrate.

It should be emphasized that the 200-ZP-1 extraction and injection rates used in both the FY 2010 and FY 2011 model updates are conjecture based upon current knowledge of the individual well and total system capacity of the 200-ZP-1 P&T system. As such, actual flow rates are expected to differ from those presented in either of these model updates. However, the modeling results do indicate that the ultimate fate of the SALDS tritium plume will be affected by operation of the P&T system, as shown in Figure 4-4.

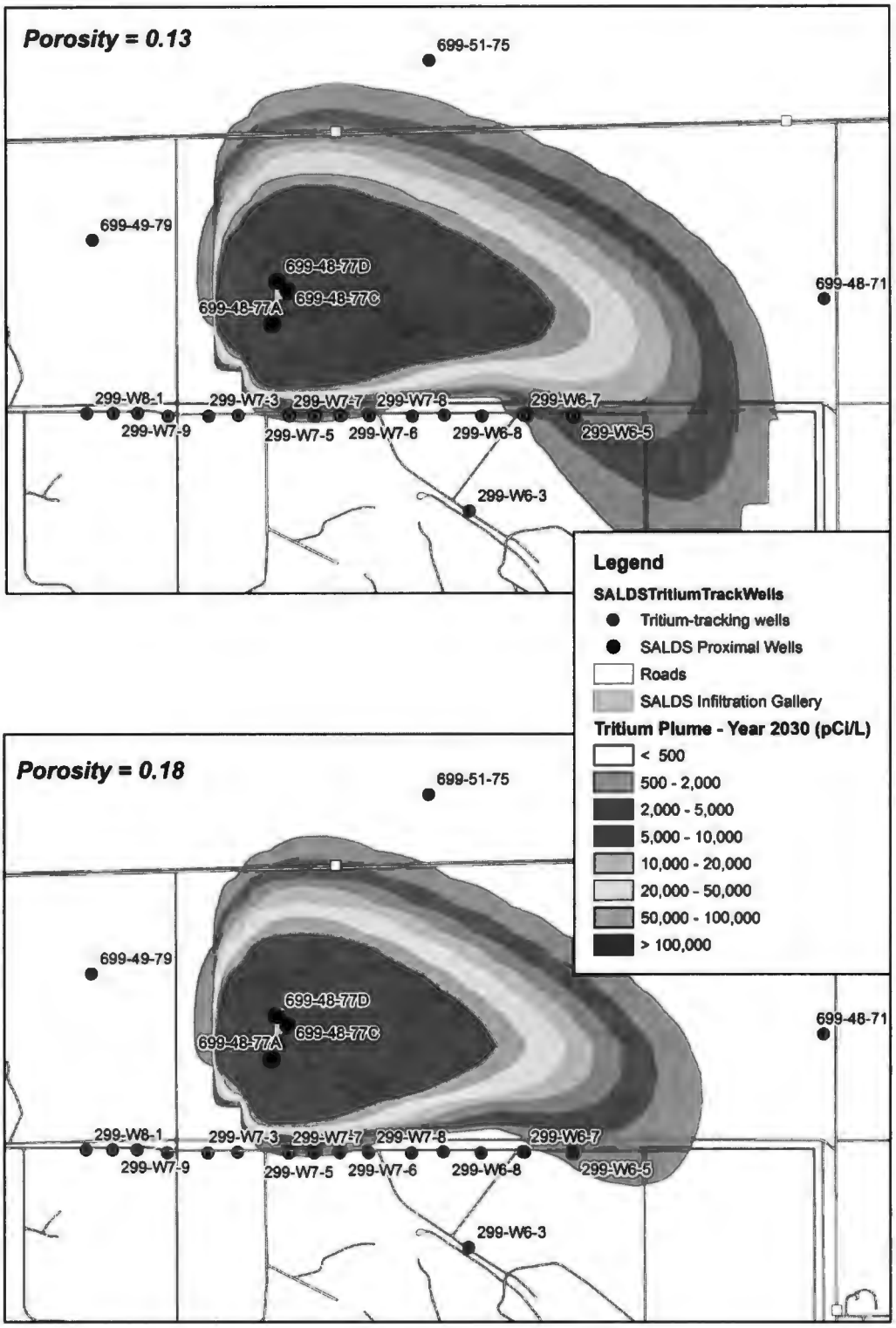

Figure 4-3. Simulated Tritium Distribution as a Result of SALDS Operation in Year 2030

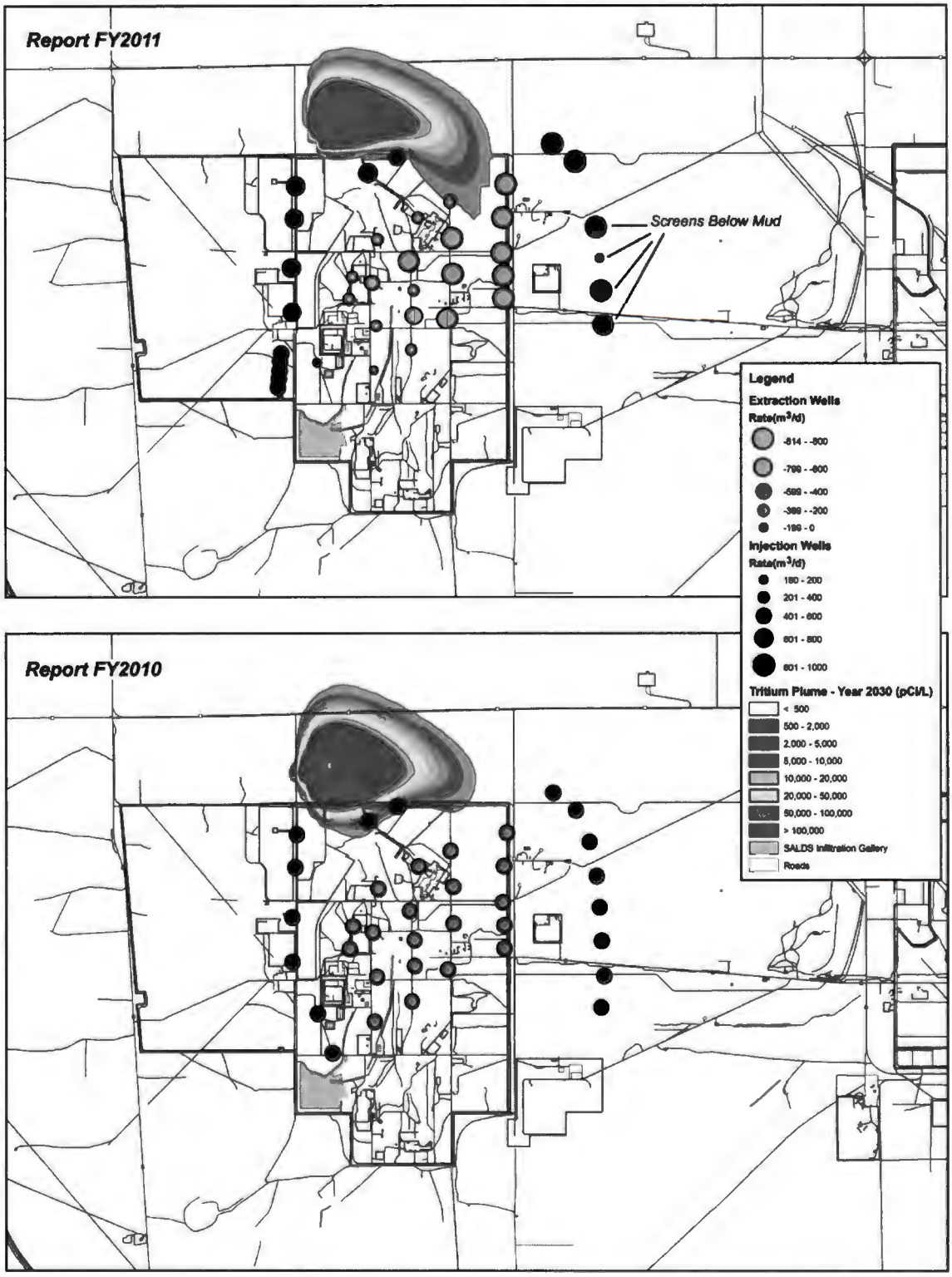

Figure 4-4. Comparison of the Model Updates Performed in FY 2010 and FY 2011 Along with the Different 200-ZP-1 P&T System Flow Rates Used in the Simulations

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5 References

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Appendix A

State-Approved Land Disposal Site Tritium Results for Fiscal Year 2012

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Table A-1. State Approved Land Disposal Site Tritium Results for Fiscal Year 2012

Well	Date Sampled	2012 Tritium Analyses (pCi/L)	Lab Qualifier	2011 Tritium Maximum (pCi/L)	2012 Tritium Maximum (pCi/L)	Trend
299-W6-11	1/30/2012	1,600	--	2,180	1,600	Decreasing
	1/30/2012	1,600	--			
299-W6-12	1/26/2012	185	--	242	185	Decreasing
299-W6-6	1/30/2012	<31.0	U	U	U	Unchanged
	1/30/2012	<290	U			
299-W7-3	1/25/2012	<27.9	U	U	U	Unchanged
	5/8/2012	<26.0	U			
	5/8/2012	<290	U			
699-48-71	1/30/2012	1,360	--	1,300	1,500	Increasing
	1/30/2012	1,500	--			
699-48-77A	Dry	N/A	--	110,000	N/A	N/A
699-48-77C	11/30/2011	154,000	--	130,000	170,000	Increasing
	11/30/2011	155,000	--			
	1/26/2012	140,000	--			
	4/17/2012	160,000	--			
	7/13/2012	170,000	--			
699-48-77D	12/14/2011	133,000	--	160,000	133,000	Decreasing
	1/26/2012	97,000	--			
	4/17/2012	120,000	--			
	7/13/2012	89,000	--			
699-49-79	4/5/2012	<26.2	U	U	U	Unchanged
699-51-75	1/30/2012	<31.2	U	U	U	Unchanged
	6/19/2012	<20.9	U			
699-51-75P	1/26/2012	<30.0	U	U	U	Unchanged

Table A-1. State Approved Land Disposal Site Tritium Results for Fiscal Year 2012

Well	Date Sampled	2012 Tritium Analyses (pCi/L)	Lab Qualifier	2011 Tritium Maximum (pCi/L)	2012 Tritium Maximum (pCi/L)	Trend

Notes:

Increasing = 20% higher average concentration in FY 2012 than in FY 2011.

Decreasing = 20% lower average concentration in FY 2012 than in FY 2011.

Unchanged = FY 2012 average concentration within 20% of FY 2011 value.

FY = fiscal year

N/A = not applicable

U = less than detection

Distribution

	MS	Quantity
U.S. Department of Energy, Office of Environmental Compliance		
T.M. Crandall	EM-41	1
U.S. Department of Energy, Office of River Protection		
B.L. Charboneau	A6-33	1
J.C. Connerly	A7-80	1
O.A. Farabee	A5-11	1
R.D. Hildebrand	A6-38	1
R.L. Long	A5-15	1
E.D. MacAlister	A5-19	1
O.C. Robertson	A3-04	1
A.E. Teimouri	A3-04	1
S.R. Weil	A5-15	1
DOE Public Reading Room	H2-53	1
U.S. Environmental Protection Agency		
D.A. Faulk	B1-46	1
CH2M HILL Plateau Remediation Company – Electronic Distribution		
J.A. Archuleta	H8-43	
F.H. Biebesheimer	R3-50	
L.T. Blackford	T4-09	
M.W. Bowman	S5-31	
A.E. Cawrse	H8-45	
D.E. Dooley	R3-50	
D.L. Flyckt	T4-10	
M.N. Jaraysi	H8-43	
J.P. McDonald	R3-50	

	MS	Quantity
J.L. Pennock	S5-31	
L.C. Petersen	S5-31	
R.S. Popielarczyk	R3-60	
P.T. Saueressig	S5-31	
J.R. Seaver	H8-45	
F.M. Simmons	H8-45	
L.C. Tuott	T4-06	
J.E. Bates	R3-50	5
Administrative Record	H6-08	1
Document Clearance	H6-08	1

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Document Number: SGW-53569 **Revision/Change Number:** 0

DOCUMENT TYPE *(Check Applicable)* [ ] Plan [X] Report [ ] Study [ ] Description Document [ ] Other

DOCUMENT ACTION *(Check One)* [X] New [ ] Revision [ ] Cancellation

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Name	Phone Number
Author: J. P. McDonald	373-3727
Manager: F. H. Biebesheimer	373-1928

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Name: (Print)	J. P. McDonald	Date	
Responsible Manager:		11-14-12	**DATE:** Nov 20, 2012 HANFORD RELEASE
Name: (print)	F. H. Biebesheimer	Date	
Other:			
Name: (print)	S. L. Huggins / QA Per email	Date 11/15/2012	
Name: (print)	R. W. Oldham / ECO Per email	Date 11/14/2012	
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