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Results of Tritium Tracking and Groundwater Monitoring at the Hanford Site 200 Area State-Approved Land Disposal Site—Fiscal Year 2002

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J. T. Rieger

September 2002

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RL01830

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Summary

The Hanford Site 200 Area Effluent Treatment Facility (ETF) processes contaminated aqueous wastes derived from Hanford Site facilities. The treated wastewater occasionally contains tritium, which is not removed by the ETF, and is discharged to the 200 Area State-Approved Land Disposal Site (SALDS). During fiscal year (FY) 2002 to date (through August 31, 2002), approximately 89-million liters (23.5-million gallons) of water have been discharged to the SALDS. These discharges contained approximately 8.5 curies of tritium.

Groundwater monitoring for tritium and other constituents, and water-level measurements are required by the state-issued permit at the SALDS. The current network consists of 3 proximal monitoring wells and 19 tritium-tracking wells. Proximal wells were sampled in October 2001, and January, April, and July of 2002. Tritium-tracking wells were sampled in January and July of 2002. Water-level measurements in three wells nearest the SALDS indicate the persistence of a small hydraulic mound beneath the SALDS facility as a result of discharges. This feature is directing groundwater flow radially outward a short distance before the regional northeasterly flow predominates. This condition also places several wells south of the SALDS hydraulically downgradient of the facility. Some of the wells south of the SALDS in the tritium-tracking network have dried or are projected to soon be dry. Well 299-W7-11 has already gone dry, preventing collection of the July sample from this well.

Tritium activities decreased in all three SALDS proximal wells during FY 2002, compared with FY 2001. Activities in well 699-48-77A first decreased to less than 3,000 pCi/L in January 2002, but rose to 150,000 pCi/L in July, as a result of tritium discharges to SALDS during February 2002. Well 699-48-77C, where tritium analysis produced a maximum value of 750,000 pCi/L in January 2002, reflects the result of the delayed penetration of effluent deeper into the aquifer from tritium discharges. SALDS proximal well 699-48-77D produced a maximum result of 240,000 pCi/L in July 2002. Timing between detections of tritium and other constituents in well 699-48-77C suggest a delay of approximately 3 years from detection in wells 699-48-77A and 699-48-77D. Historical maxima for tritium (790 and 860 pCi/L in successive sample periods) in well 299-W7-5 suggest that tritium from SALDS may be reaching the northern edge of the 200 West Area, south of the facility.

Comparison of head distribution in March 2002 and reported FY 2002 tritium activities, with numerical predictions of these quantities for 2000 and 2005, suggests that modeling performed in 1997 only slightly overestimated the areal spread of tritium around the SALDS to date.

Acknowledgments

The authors thank Lila Andor and Kathy Neiderhiser for document processing support. Thanks also to Mark Sweeney and Chris Newbill for graphics support. Reviewers are Mary Hartman (Pacific Northwest National Laboratory), Phil Olson (Fluor Hanford) and Kristi Lueck (Fluor Hanford).

Acronyms

ETF	Hanford Site 200 Area Effluent Treatment Facility
FY	fiscal year
LLBGs	low-level burial grounds
MDLs	method detection limits
SALDS	200 Area State-Approved Land Disposal Site
TDS	total dissolved solids

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1.0 Introduction

Treated water from the Hanford Site 200 Area Effluent Treatment Facility (ETF) is discharged to a disposal site as allowed by State Waste Discharge Permit ST-4500 (ST-4500). The permit allows disposal of tritium to the disposal site, which is named the State-Approved Land Disposal Site (SALDS), and is located immediately north of the 200 West Area of the Hanford Site (Figure 1). In accordance with ST-4500, the groundwater in the vicinity of the SALDS is routinely sampled, and water levels in wells are measured. The permit also requires the submission of an annual tritium-tracking report and a groundwater monitoring plan that covers the 5-year period of the permit. That plan (Barnett 2000) provides additional guidance for selecting and reporting groundwater analyses. The results of the groundwater sampling and analysis are also reported in quarterly Discharge Monitoring Reports, and in the annual Hanford Site Groundwater Monitoring Report (e.g., Hartman et al. 2002).

1.1 Objectives and Scope

This report presents the results of groundwater monitoring and tritium tracking in groundwater for the SALDS facility during fiscal year (FY) 2002. The period covered by the data in this document is October 1, 2001 through September 30, 2002. The report also provides the updated background information on the facility necessary to understanding the results of the groundwater analyses. Interpretive discussions and recommendations for future monitoring are also provided where possible.

1.2 Background

The background information is mostly based on a synopsis of *Groundwater Monitoring and Tritium-Tracking Plan for the 200 Area State-Approved Land Disposal Site* (Barnett 2000). New information on hydrogeology, modeling comparison, and discharges is also provided.

The primary requirements of the permit are that a groundwater monitoring plan must be regulator approved and that analytical results must be compared annually with permit-prescribed limits; these comparisons are presented in tabular form and discussed in Section 3.0 of this report. The groundwater monitoring plan requires:

- Tracking magnitude of changes in groundwater quality associated with the SALDS discharges
- Determining how these changes have occurred, e.g., from discharges versus soil chemistry
- Tracking of the migration rate of tritium in groundwater originating from the SALDS
- Comparison of model predictions with observation for purposes of refining predictive capability
- Correlation of discharge events at SALDS with analytical results from groundwater monitoring.

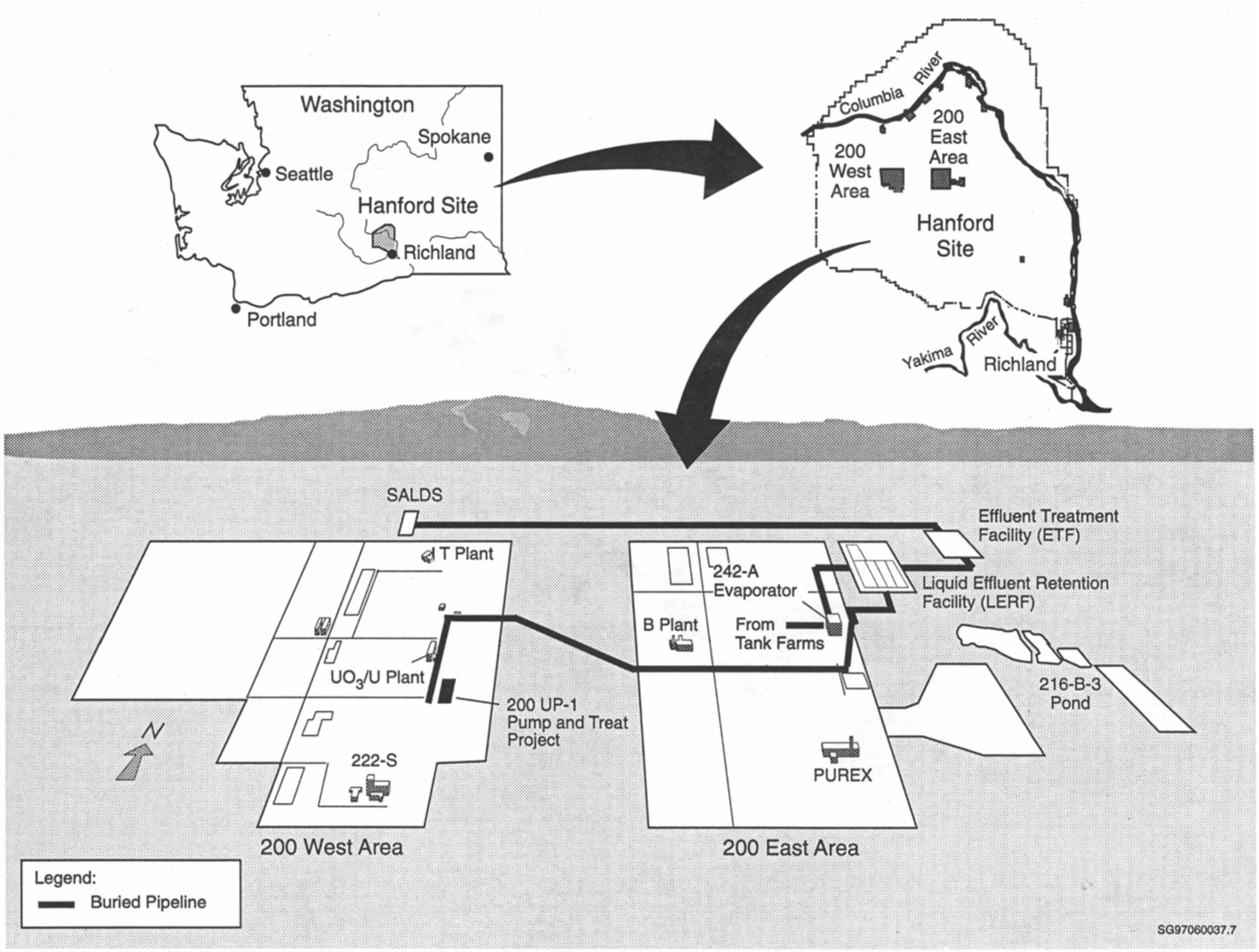


Figure 1. Location of the State-Approved Land Disposal Site and Related Infrastructure

The groundwater monitoring well network (Figure 2) was derived to address these objectives using existing wells shared with other nearby facilities, e.g., low-level burial grounds (LLBGs), and dedicated wells drilled specifically for monitoring SALDS.

1.2.1 Hydrogeological Setting

The nature of the subsurface strata beneath the SALDS facility accounts for peculiarities in the movement of the SALDS effluent downward to the groundwater. The hydrogeology of the SALDS is described in detail by Barnett (2000). Groundwater chemical analyses indicate that the proximal well farthest from the SALDS (699-48-77A) responds to SALDS discharges several months to years earlier than the remaining two wells (699-48-77C and D—see plot of Figure 8). Of particular importance are the carbonate-cemented horizons of the Plio-Pleistocene unit that lies within the vadose zone a few feet below the bottom of the SALDS drainfield. This stratum consists of a thick, but discontinuous layer of highly impermeable silt, gravel, and sand with significant interstitial calcium carbonate and sulfate as cementation. Effluent from the SALDS is diverted southward along the gentle dip of this horizon until a discontinuity or significant fracture is reached, whereupon it migrates further downward into the Ringold Formation. This circumstance allows the infiltrating effluent to reach the southernmost proximal well first.

Recent evaluations of the hydrogeology of the 200 West Area and vicinity (Williams et al. 2002) suggest the presence of an erosional channel immediately north and northwest of the SALDS location. This channel is filled with relatively permeable Hanford formation sand and gravel. However, most of this deposit is in the vadose zone north of the SALDS, with only the bottom few feet occurring within the water table. Hence, this channel may not be important as a transport feature for SALDS tritium. As water level in the aquifer continues to fall in response to discontinued Hanford Site operations, nearly all groundwater north of the SALDS area will be moving within the Ringold Formation. Generally, groundwater moves at a significantly slower rate in the Ringold Formation than in the overlying Hanford formation.

1.2.2 Groundwater Modeling

Permit ST-4500 contains provisions for update of a numerical groundwater model at least once during a permit cycle (every 5 years) to predict tritium movement and distribution in the aquifer resulting from 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 provision 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 at a concentration greater than that predicted.

The most recent model application was conducted in 1997 (Barnett et al. 1997), two years after the beginning of SALDS discharges. The model output graphically illustrates the predicted head distribution and tritium concentrations in groundwater near the SALDS for selected time frames between 1996 and 2095. Section 4.0 compares the most recent results of monitoring with the contemporaneous model predictions.

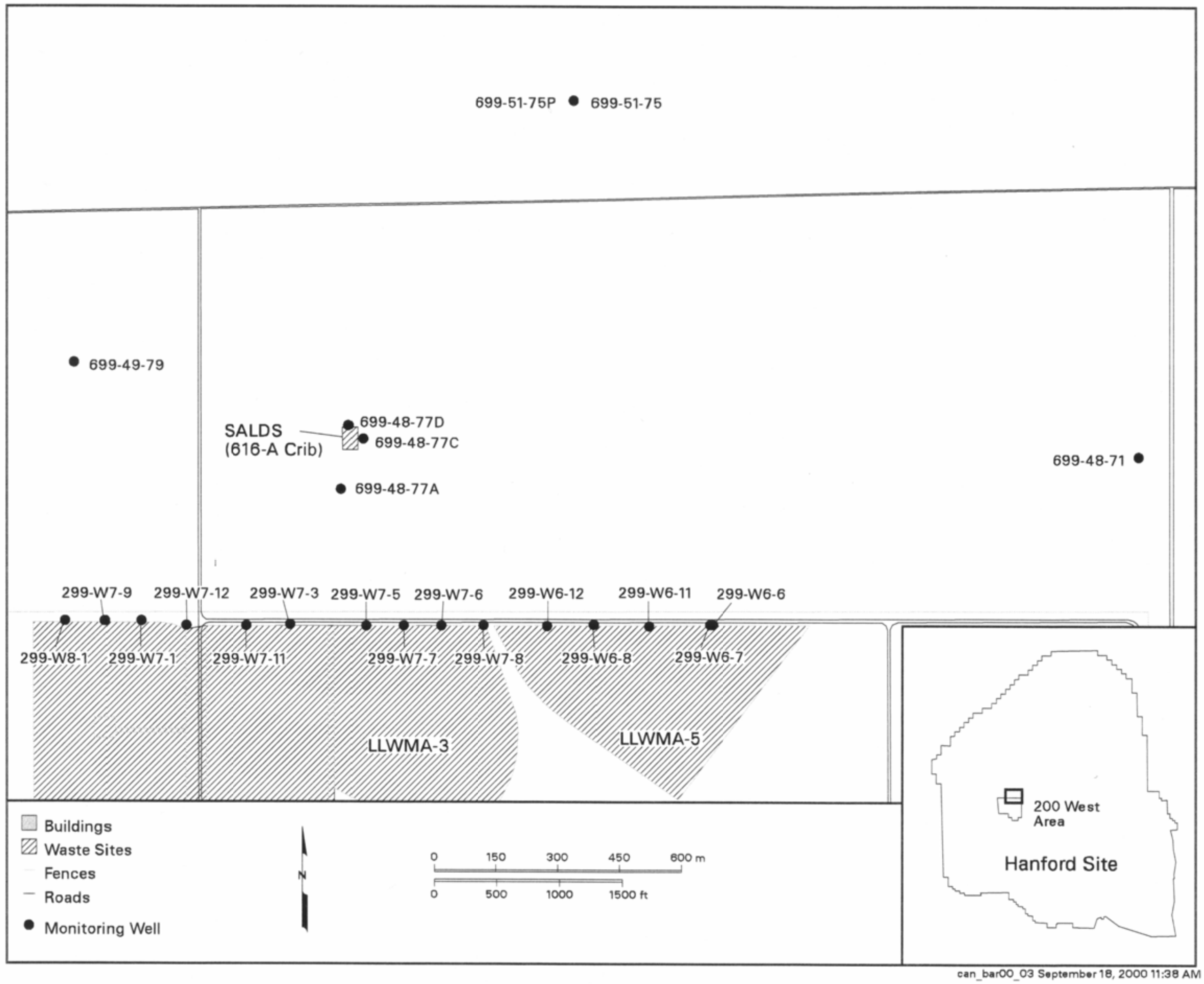


Figure 2. Locations of SALDS Tritium-Tracking Network Wells

1.2.3 SALDS Discharge History

Initial discharges to the SALDS from the ETF operations began in December 1995. Some preliminary discharges to test the drainfield and piping system were conducted in late 1994 and early 1995, but these were small-volume water releases.

During FY 2002 (through August 2002), approximately 89-million liters (23.5-million gallons) were discharged to the SALDS, compared with approximately 94.6-million liters (25-million gallons) discharged during the same period of FY 2001. May 2002 was the month with the highest discharge total – approximately 12.5-million liters (3.3-million gallons). This brings total discharge volume to the SALDS to over 530-million liters (140-million gallons) since December 1995 (Figure 3).

The quantity of tritium discharged to the SALDS during FY 2002 totals ~8.5 curies through August 2002. This amount compares with ~4.7 curies discharged during all of FY 2001. The February 2002 discharges of 3.04 curies represent a renewal of significant tritium inventories to the facility. Before the February 2002 discharges, only 0.15 curies had been discharged over the previous 14 months. Tritium quantities discharged to the SALDS since December 1995 total 333.4 curies, most of which were discharged during the first 8 months of operation (see Figure 3). The reason for the variability in tritium content of the SALDS effluent is that wastewaters containing high tritium activities (e.g., the 242-A Evaporator process condensate) are processed by the ETF only periodically. As Figure 3 reflects, most of the waste streams sent to the SALDS are relatively low in tritium.

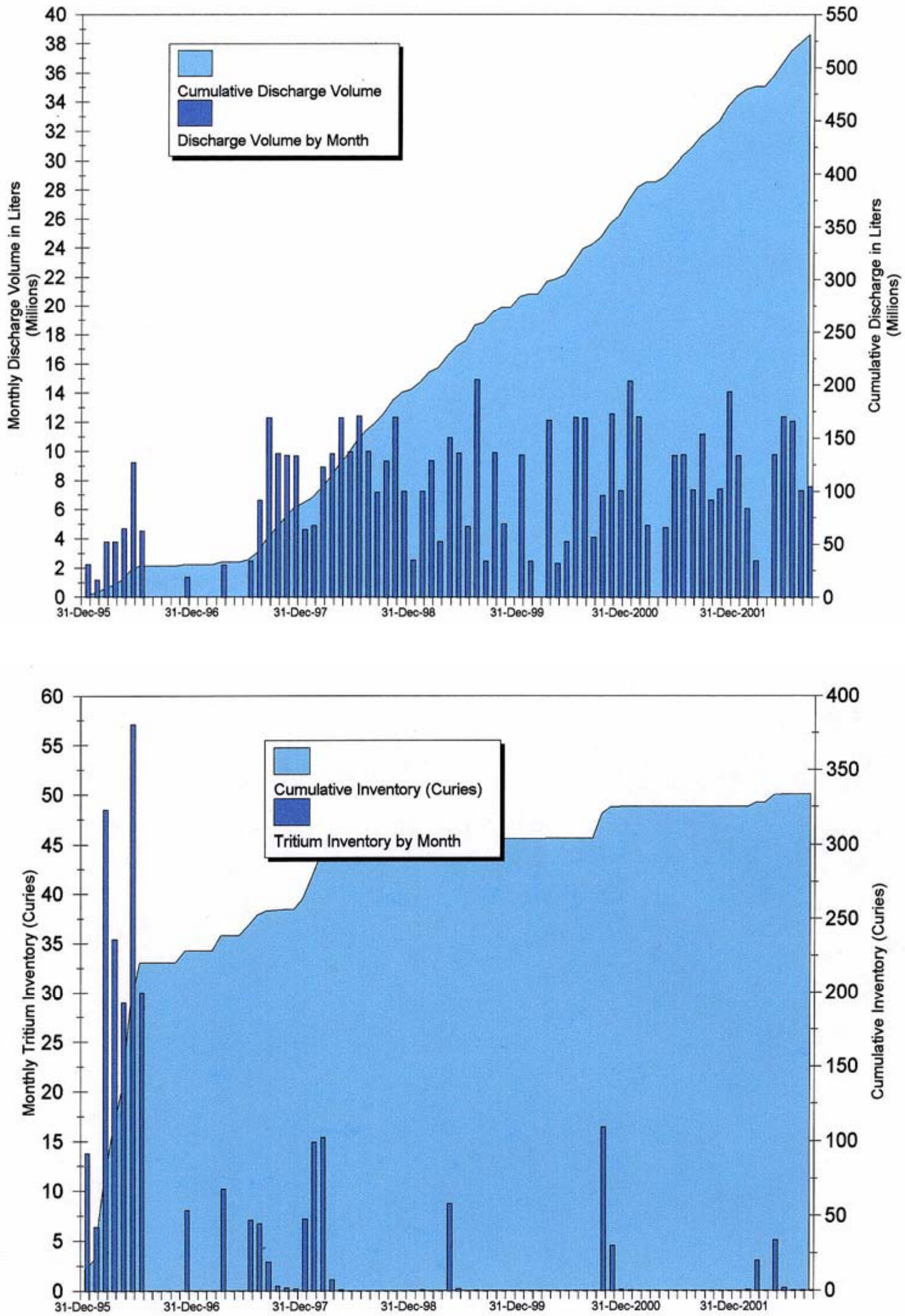


Figure 3. Monthly and Cumulative Discharge Volumes for SALDS (top) and Monthly and Cumulative Tritium Quantities Sent to SALDS (bottom) through August 2002

2.0 Results of FY 2002 Water-Level Measurements

Measurements of water levels in wells surrounding the SALDS are necessary for local and regional interpretation of head and potential groundwater flow directions. These measurements are used in combination with groundwater chemistry analyses to feed conceptual and predictive models to forecast the possible movement of tritium from the SALDS facility.

2.1 Schedule of Water-Level Measurements

Water levels are measured in all wells prior to each sampling event, and have been measured monthly since January 1997 in the proximal SALDS facility wells (699-48-77A, 699-48-77C, and 699-48-77D). Because SALDS proximal and tritium tracking wells are also sampled for other programs (LLBG and surveillance), water levels in each well may be measured several times per year.

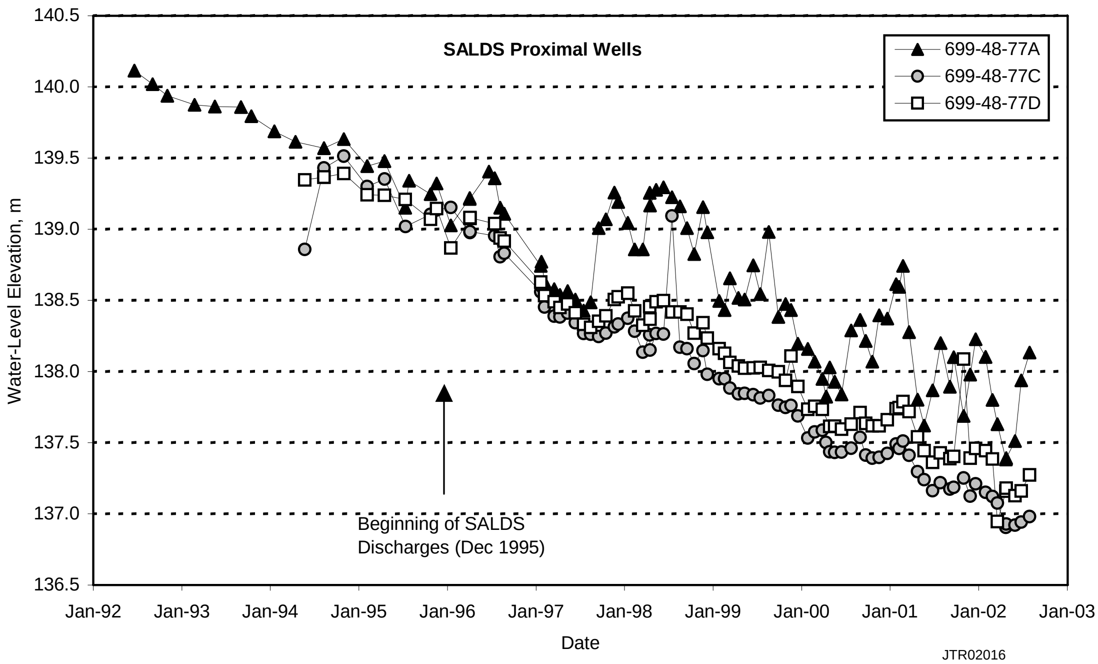
Water levels in some tritium-tracking wells have fallen in recent years to the point where some wells may become unusable for sampling (see Section 3.1). As this occurs, water-level measurement in these wells will also be discontinued.

2.2 Measurement Results and Hydraulic-Head Distribution

Current hydrographs (through August 2002) for the SALDS proximal wells and tritium-tracking network, grouped by relative position to the SALDS, are shown in Figures 4 through 6. Hydraulic head in well 699-48-77A continues to surpass the head in most wells in the tritium-tracking network (see Figures 4 through 6). This is a trend that began in late 1997 as a result of the continuing general decline in water levels in the 200 West Area and the increased head near the SALDS, which is a result of SALDS operation. The occasional exceptions are the wells southwest of the SALDS. In these wells, water-level elevations are only intermittently lower than those in well 699-48-77A, depending on the magnitude of discharges to the SALDS.

Hydrographs of deep and shallow tritium-tracking network wells 299-W6-6 and 299-W6-7, respectively, indicate that almost no vertical gradient exists in this portion of the aquifer away from the SALDS vicinity (see Figure 6). Well 299-W6-7 is completed at the water table; well 299-W6-6 is completed 49 meters deeper in the aquifer. This condition explains the lack of tritium from the 200 West Area plume in the deep well, while the shallow well shows high levels of tritium. During operational discharges in the 200 West Area, tritium was apparently not forced down to lower portions of the aquifer in this region. Likewise, coincident head values in wells 699-51-75 and 699-51-75P indicate a lack of vertical flow potential in this area, northeast of the SALDS.

Near the SALDS, however, there is a consistently downward potential, as indicated by the head differences between the shallow proximal wells 699-48-77A, 699-43-77D, and deep proximal well 699-48-77C (see Figure 4).



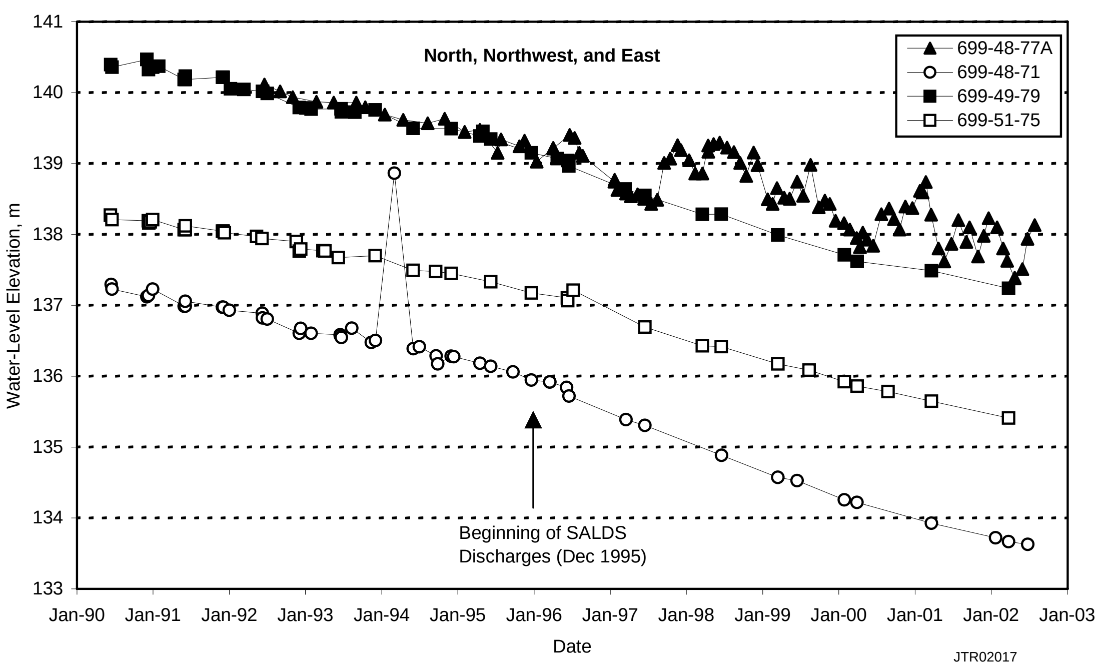
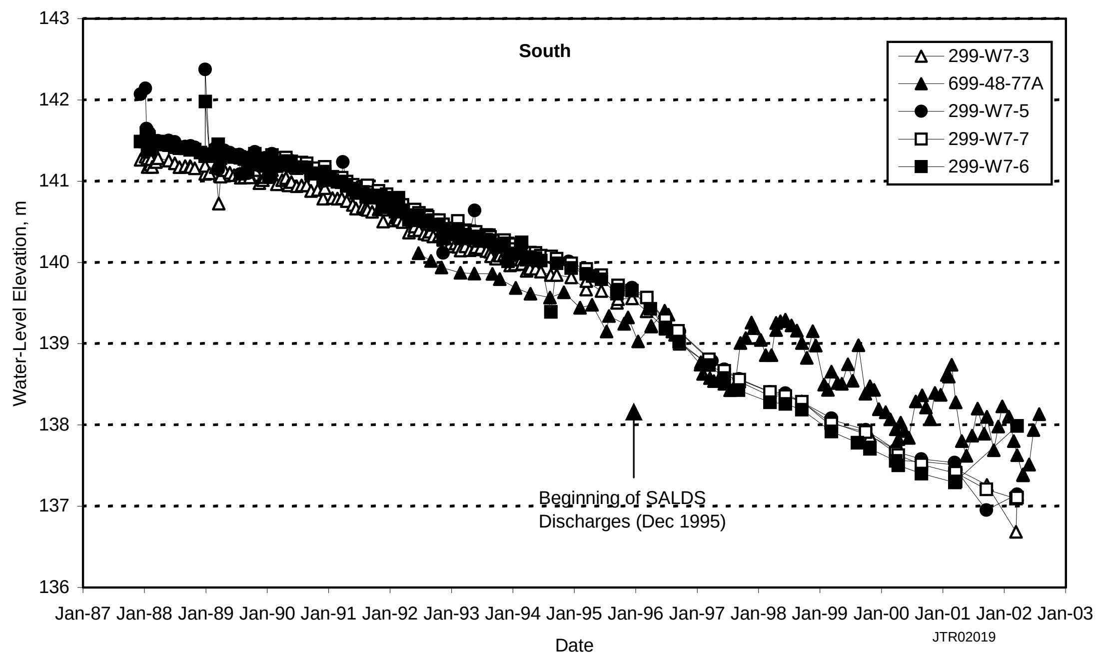


Figure 4. Hydrographs of Tritium-Tracking Wells North, Northwest, and East of the SALDS, Compared with Well 699-48-77A (top) and SALDS Proximal Wells (bottom). Well 699-48-77C is completed (screen) ~20 meters deeper within the aquifer than the other two proximal wells.



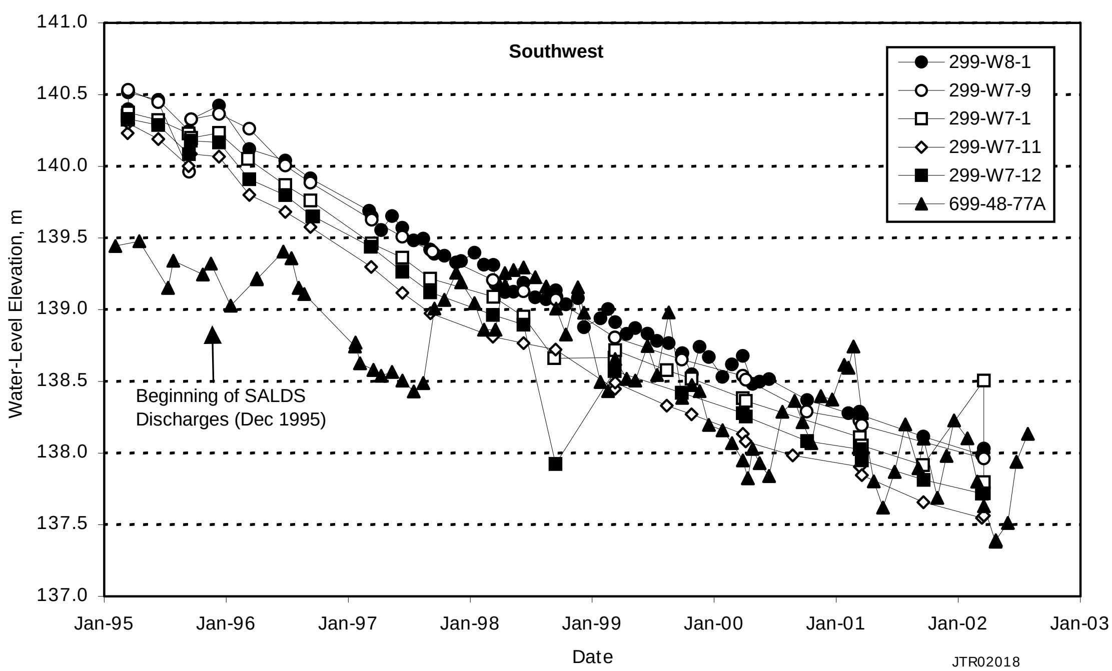


Figure 5. Hydrographs of Tritium-Tracking Wells South (top) and Southwest (bottom) of the SALDS Compared with Well 699-48-77A

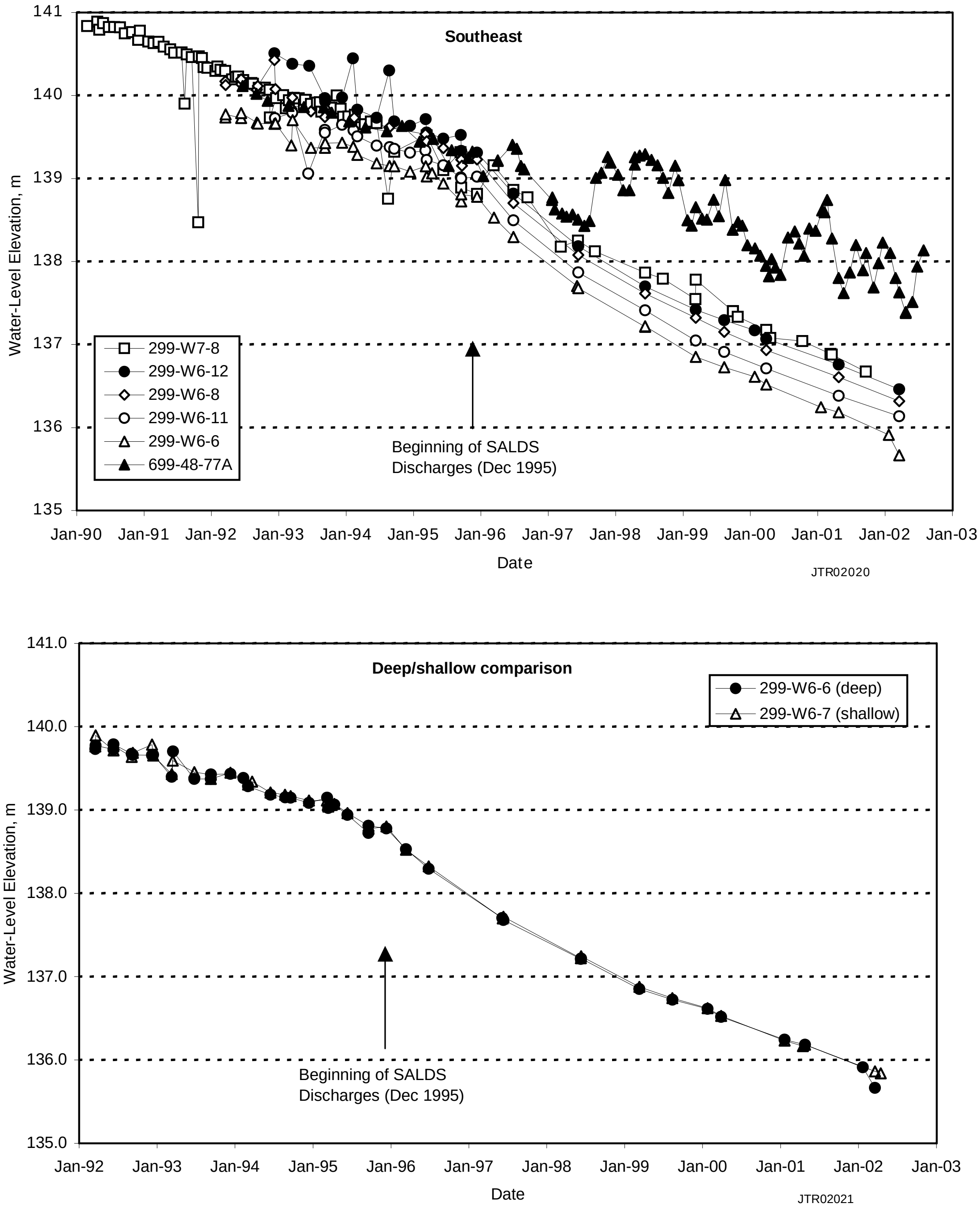


Figure 6. Hydrographs of Tritium-Tracking Wells Southeast of SALDS Compared with Well 699-48-77A (top) and Deep/Shallow Companion Wells (bottom). Well 299-W6-6 is completed approximately 49 meters deeper in the aquifer than Well 299-W6-7.

The water table in the vicinity of the SALDS for March 2002 is shown in Figure 7. The groundwater mound associated with the SALDS operation is evident near the facility. The center of the mound is not necessarily located at well 699-48-77A; its shown location is partially an artifact of well coverage at the SALDS and is an approximate location, with the actual center probably located somewhere between well 699-48-77A and the facility. Arrows denoting the interpreted flow paths (or the potential for flow) of groundwater in the vicinity of the SALDS indicate that effluent from the SALDS could eventually affect wells to the south of the facility and may have already (see Section 3.2). Exactly how far south the effluent from SALDS could actually flow before turning east is not known. The interpretation of the flow potential in Figure 7, and hydrographs of Figures 4, 5, and 6, indicate that wells immediately south and southeast of the SALDS are potentially *downgradient* of the facility. Downgradient wells 699-51-75 and 699-51-75P are in optimum, regionally downgradient locations for the interception of SALDS tritium at shallow and intermediate levels in the aquifer. The water-table map and the interpretation of flow in the vicinity of the SALDS are virtually unchanged since FY 2001.

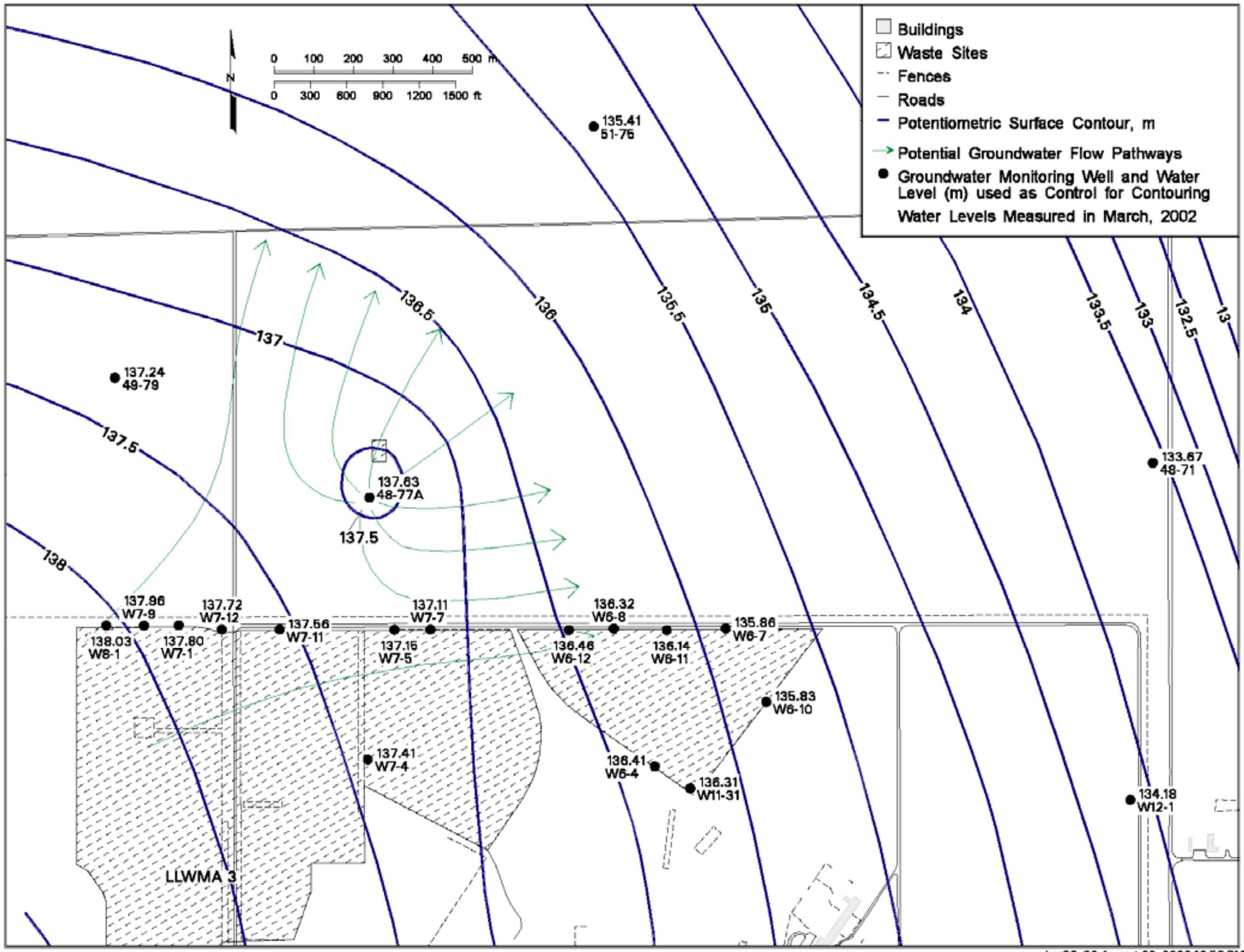


Figure 7. Water-Table Map and Interpreted Groundwater Flow Directions in the SALDS Area for March 2002

3.0 Results of FY 2002 Groundwater Analyses for SALDS

Tritium in groundwater is analyzed quarterly in the SALDS proximal wells (699-48-77A, 699-48-77C, and 699-48-77D) and annually to semiannually in 19 additional "tritium-tracking" wells in the vicinity of the facility. Tritium results from FY 2002 are discussed in Section 3.2 and listed in the Appendix.

In addition to tritium, groundwater from the SALDS proximal wells (699-48-77A, 699-48-77C, and 699-48-77D) is analyzed for a list of 15 constituents required by the State Waste Discharge Permit ST-4500 Special Condition S1 (A). Enforcement limits were set for most of these constituents: acetone, benzene, cadmium (total), chloroform, copper (total), lead (total), mercury (total), pH, sulfate, tetrahydrofuran, total dissolved solids (TDS). Gross alpha, gross beta, strontium-90, and tritium are not assigned enforcement limits, but are monitored and reported. Analytical results for all parameters required by ST-4500 are also reported quarterly in Discharge Monitoring Reports. Additional parameters, such as alkalinity, dissolved oxygen, temperature, and turbidity, are sought for determination of general groundwater characteristics and verifying the quality of analytical results. Maximum concentrations for these constituents and the corresponding sample months for FY 2002 are discussed below and listed in Table 1.

3.1 Groundwater Sampling and Analysis for FY 2002

Samples for the three SALDS proximal wells were collected in October 2001, and January, April, and July of 2002. Tritium-tracking wells are sampled on an annual or semiannual basis for tritium only and were sampled in January and July of 2002. Some of the tritium-tracking wells are also sampled for a broader range of constituents for the LLBGs facility and sitewide groundwater surveillance. Tritium results from this sampling, in addition to those collected specifically for the SALDS, are also included in the reported data in the Appendix.

Some wells in the tritium-tracking network are becoming dry. The water level in well 299-W7-11 was too low to yield a sample for the July 2002 sampling event. Thus, the final sample from this well will likely be that taken in January 2002. Well 299-W6-8 produced a water-level measurement in March 2002, but there was insufficient water to collect a sample. The last tritium result from this well was January 2001. Wells 299-W7-6 and 299-W7-9 were sampled by bailer. Well 299-W6-7 was sampled using a *KABIS* sampler in coordination with the LLBG monitoring. Wells 699-51-75, 699-48-71, and 699-49-79 are older wells that were sampled with dedicated submersible electric pumps. Well 699-51-75P is a piezometer completed within well 699-51-75, and was sampled with an airlift hose. These methods are acceptable where sampling for tritium only, as long as well recovery can be confirmed after purging. All other wells were sampled using dedicated *Hydrostar* pumps.

3.2 Results of Tritium Analyses (Tritium Tracking)

Results of tritium analyses in the SALDS tritium-tracking well network for FY 2002 are shown on Figure 8 and listed in the Appendix. Wells in the SALDS proximal network (699-48-77A, 699-48-77C,

Table 1. Maximum Concentrations of Constituents in Groundwater and Corresponding Sample Month for SALDS Wells, FY 2002

Constituent (permit limit)	Well 699-48-77A	Well 699-48-77C	Well 699-48-77D
Acetone (160)	<4.4 (u)	<4.4 (u)	<4.4 (u)
Benzene (5)	<0.5 (u)	<0.5 (u)	<0.5 (u)
Cadmium, total (10)	<0.13 (u)	<0.13 (u)	<0.13 (u)
Chloroform (6.2)	<0.40 (u)	<0.40 (u)	<0.40 (u)
Copper, total (70)	2.71—Jan 2002	3.7—Jan 2002	1.54—Jan 2002
Lead, total (50)	<1.5 (u)	<1.5 (u)	<1.5 (u)
Mercury, total (2)	<0.13 (u)	<0.13 (u)	<0.13 (u)
Laboratory pH, pH units[b] (6.5 – 8.5)	8.14—8.23	7.91—8.01	8.01—8.11
Field pH, pH units[b] (6.5 – 8.5)	8.02—8.46	7.90—8.01	7.98—8.11
Sulfate (250,000)	2,032—Oct 2001	19,050—Oct 2001	9,834—Jan 2002
Tetrahydrofuran (100)	<4.6 (u)	<4.6 (u)	<4.6 (u)
Total Dissolved Solids (500,000)	124,000—Jan 2002	191,000—Jan 2002	174,000—Jan 2002
Gross Alpha, pCi/L[c]	1.2 (J)—Jan 2002	3.2 (J)—Jan 2002	2.1 (J)—Apr 2002
Gross Beta, pCi/L[c]	1.9—Jul 2002	4.0—Jul 2002	3 (J)—Apr 2002
Strontium-90, pCi/L[c]	1.3—Jul 2002[a]	2.7—Jul 2002[a]	3.9 (J)—Oct 2001[a]
Tritium, pCi/L[c]	150,000—Jul 2002	740,000—Oct 2001	240,000—Jul 2002
Alkalinity, mg/L[d]	67—Oct 2001	120—Oct 2001	120—Oct 2001+
Field Conductivity, µS/cm[b,d]	127—140	245—269	244—253
Dissolved Oxygen, mg/L[d]	7.86—Oct 2001	10.20—Oct 2001	9.01—Oct 2001
Field Temperature, °C[b,d]	21.2—23.7	16.8—18.5	16.2—18.3
Turbidity, NTU[d]	5.66—Oct 2001	5.40—Jul 2002	6.73—Oct 2001

Notes:
1. All concentrations in µg/L unless noted.
2. "(u)" = not detected; "(J)"= estimated quantity.

(a) Anomalous or suspect reading—see text for discussion.
(b) Entire range of readings for FY 2002 (October 1, 2001 through July 30, 2002).
(c) Constituent is not assigned an enforcement limit, but is subject to routine monitoring and reporting.
(d) Constituent is sought for evaluation of groundwater character and analytical quality, and is not subject to permit conditions.
\+ This same result was obtained from subsequent sample dates.

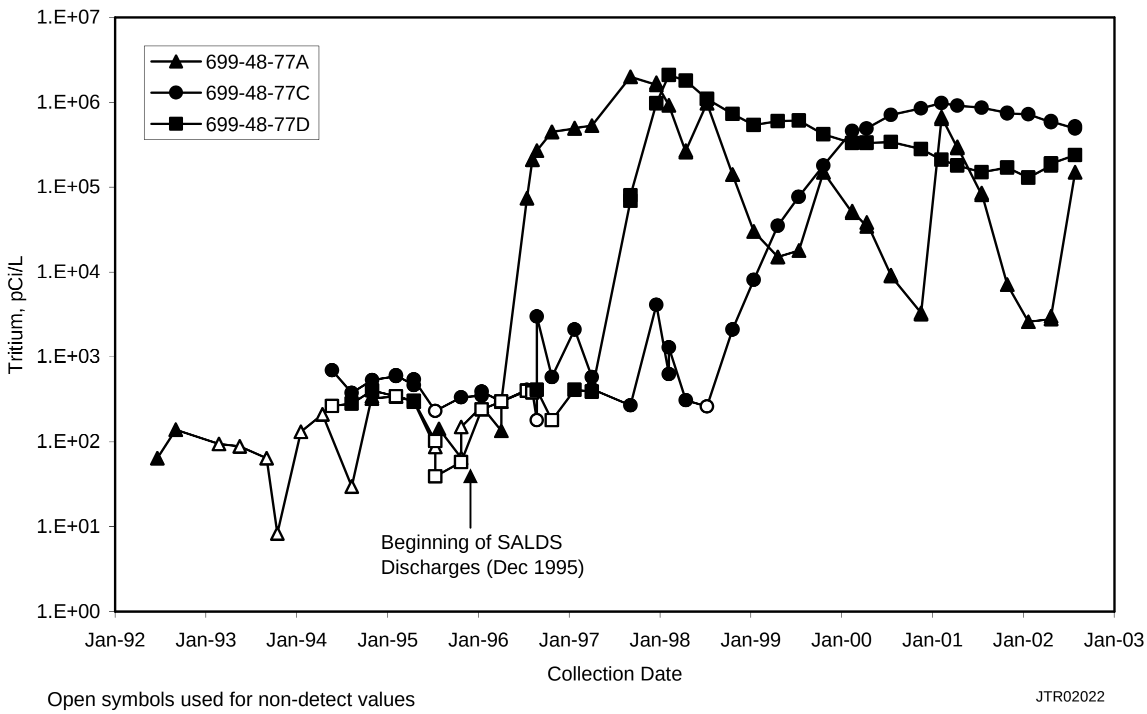


Figure 8. Tritium Activity Trends in SALDS Proximal Wells through July 2002. Well 699-48-77C is completed ~20 meters deeper in the aquifer than wells 699-48-77A and 699-48-77D.

and 699-48-77D) have been affected by SALDS tritium discharges since 1996. Wells 299-W6-7 and 299-W6-11 continue to show the effects of the decaying tritium plume originating from the northeast portion of the 200 West Area. Well 299-W6-8 had shown some of these effects in the past, but was not sampled this fiscal year because it went dry in 2001.

Figure 8 illustrates the trends in tritium activities in the three SALDS proximal wells (see Figure 9 for location). Well 699-48-77A was first affected by discharges in July 1996. Although this well is farthest away from the facility of the three "proximal" SALDS wells, subsurface geologic features allowed the effluent to reach this well before any others (Barnett et al. 1997; Barnett 2000). This well produced tritium activities two orders of magnitude lower during most of FY 2002 than in FY 2001. However, in the latest analysis (July 2002), the well showed an activity of 150,000 pCi/L, which is two orders of magnitude higher than the April 2002 result. The reason for this sudden increase is most likely due to the arrival of tritium in the groundwater from the February 2002 SALDS discharges (see Section 1.2.3).

The maximum tritium result for well 699-48-77D in FY 2002 was 240,000 pCi/L (July 2002), which is down slightly from a maximum of 280,000 pCi/L in FY 2001. Well 699-48-77D is nearest the SALDS, but showed tritium incursion only as recently as September 1997, about 18 months later than the more distant well 699-48-77A. The reason for this delay is related to the fact that the SALDS drainfield fills from the end of the facility (south end) farthest away from well 699-48-77D and the aforementioned geologic features beneath the SALDS. These two conditions shunt the subsurface flow of effluent away from well 699-48-77D before it reaches groundwater.

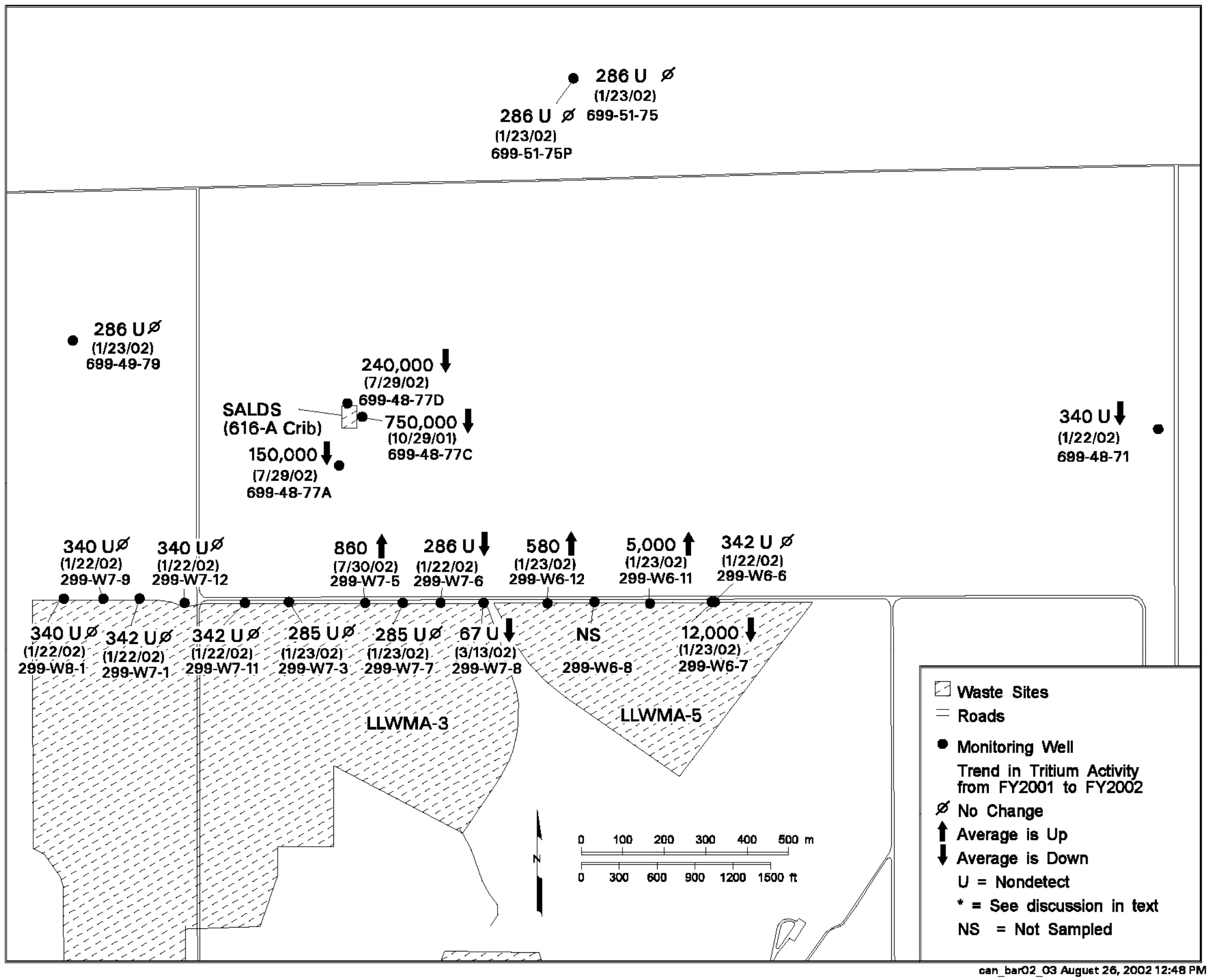


Figure 9. Maximum Tritium Activities in Groundwater for the SALDS Tritium-Tracking Network for FY 2002, Indicating (date of measurement) Change from FY 2001

Well 699-48-77C is screened ~20 meters deeper in the aquifer than wells 699-48-77A and 699-48-77D. Because of its deeper position, tritium incursions from the SALDS operation have been historically lower in activity and intermittent in this well until recently. During times of high discharge, the hydraulic head beneath the SALDS is increased, and effluent is forced deeper into the aquifer. The historical high tritium activity of 980,000 pCi/L was measured in well 699-48-77C in February 2001, indicating that the downward-moving SALDS effluent from earlier (prior to April 1999), tritium-rich discharges are still reaching this location in considerable strength. The trend shown in Figure 8, which indicates successively lower activities measured in FY 2002, suggests that the maximum strength of the tritium plume from the early discharges may have reached this well, and activities are now declining.

A few wells along the border of the 200 West Area, generally southeast of the SALDS, have produced elevated values for tritium as a result of historical disposal practices in the 200 West Area. As shown in Figure 10, tritium activities in these wells have generally decreased or remained the same over the past several years. Well 299-W6-7 has experienced a steady decline in activity since FY 1995, reflecting the diminished effect of the plume originating in the northeast part of the 200 West Area. Well 299-W7-8 has also produced detectable tritium (as high as 800 pCi/L) prior and subsequent to SALDS operation, but the overall trend in this well for tritium activity is downward.

Well 299-W7-5 has produced detectable tritium results sporadically since 1991. Some of the detections from this well may be false because of large counting errors or they may be actual detections of the decaying plume originating from the 200 West Area. The most recent tritium results from this well (July 2002) indicated activities of 790 and 860 pCi/L (see Figure 10). These latest results are historical maxima, and may indicate an incursion of tritium from the SALDS.

Well 299-W7-6 no longer has sufficient water to produce a reliable sample by conventional means (pump). A bailer was used for both FY 2002 events (January and July) to collect samples, and the tritium result indicated that activities remained below detection limits. This well is projected to be unusable within the next year, even with aggressive sampling methods, i.e., a bailer. Because the wells in a closely spaced array with other wells in this area, its loss would not be critical to the network.

Well 699-48-71, east of the SALDS, has historically (prior to SALDS operations) produced tritium-activity results comparable to the FY 2001 result of 250 pCi/L. Although this level of activity is near the method detection limit, it could be that this well is affected by the outer limbs of the tritium plume emanating from the 200 West Area (see tritium-distribution map in Hartman et al. 2002). The FY 2002 results for this well indicated activities below detection limits.

3.3 Results of Other Constituent Analyses

In addition to tritium, groundwater from the SALDS proximal wells (699-48-77A, 699-48-77C, and 699-48-77D) is analyzed for a list of 15 constituents required by the State Waste Discharge Permit ST-4500 Special Condition S1 (A). Permit limits are set for most of these constituents: acetone, benzene, cadmium (total), chloroform, copper (total), lead (total), mercury (total), pH, sulfate, tetrahydrofuran, TDS. Gross alpha, gross beta, strontium-90, and tritium are not assigned enforcement limits, but are monitored and reported. Additional parameters, such as alkalinity, dissolved oxygen, temperature, and turbidity are

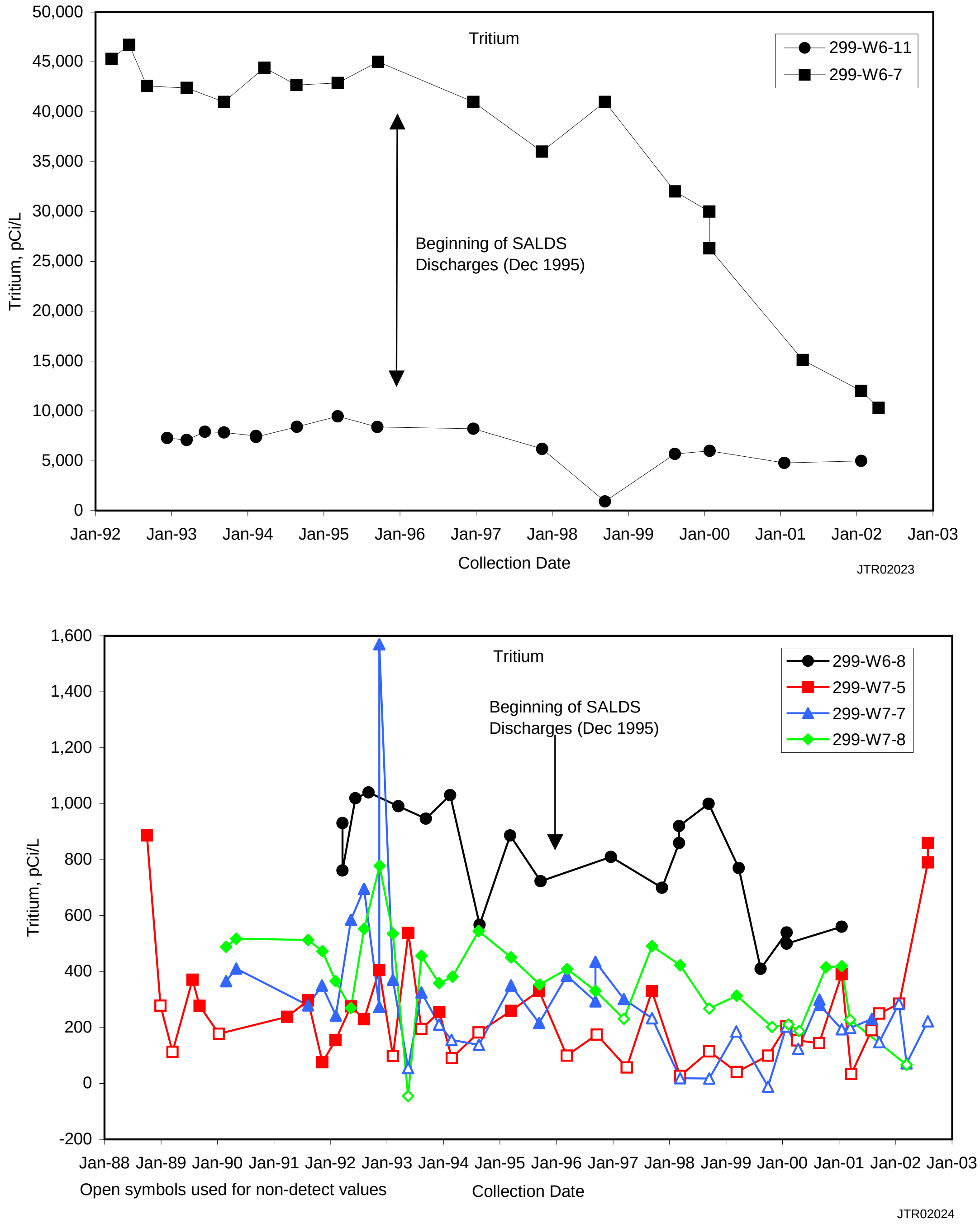


Figure 10. Tritium Activity Trends in Wells Southeast of the SALDS Showing Remnant Effects of the Tritium Plume from the 200 West Area. The high value for Well 299-W7-7 is suspected to be erroneous, with a duplicate on this date producing a result in line with the historic range.

sought for determination of general groundwater characteristics and verifying the quality of analytical results. Maximum concentrations for these constituents, and the corresponding sample months for FY 2002, are listed in Table 1.

All 11 constituents with ST-4500 permit limits were below these limits for groundwater during FY 2002[1]. As in previous years, acetone, benzene, chloroform, and tetrahydrofuran results were reported below detection limits in all three wells for all of FY 2002. Benzene, chloroform, and tetrahydrofuran were also analyzed in a separate laboratory for groundwater surveillance, and produced non-detection results with method detection limits (MDLs) of 0.23, 0.21, and 2.30 μg/L, respectively. Copper is the only metal analyzed that produced detectable concentrations (highest was 3.7 μg/L in January 2002 in well 699-48-77C) in groundwater at SALDS during FY 2002. Lead, mercury, and cadmium were all below MDLs.

The annual laboratory measurements of pH performed in January 2002 are in agreement with the ranges of field pH values measured during FY 2001. No trends are evident for this parameter since monitoring of SALDS wells began in 1992-1994.

The highest gross alpha result for FY 2002 of 3.2 pCi/L was recorded for well 699-48-77C in January 2002, but is qualified with a "J", signifying an estimated quantity below a requested detection level. This well also produced the highest gross alpha result in FY 2001. Gross beta also was highest in well 699-48-77C, with a maximum result of 4.0 pCi/L in July 2002. The results for both gross alpha and gross beta in FY 2002 are higher than maxima for both indicators in FY 2001, which were 1.7 and 3.0 pCi/L, respectively. These activities are well below groundwater quality standards. No definite trends are apparent for gross alpha or gross beta.

Results for strontium-90 for FY 2002 are probably non-detections, despite the reported values in Table 1. Independent analyses by PNNL sitewide surveillance in the three proximal SALDS wells produced no detectable results during the same period (FY 2002). The independent analyses have a ~0.5 pCi/L minimum detection limit and lower counting errors than the routine measurements, though the samples were not taken the same day as the scheduled SALDS samples. However, FY 2001 split samples from SALDS that were analyzed by the independent laboratory also produced non-detection results, while the routine laboratory reported detectable results for the same samples (Barnett and Rieger 2001). Hence, it is unlikely that any results for strontium-90 reported from SALDS are above method detection limits.

Along with detection of the first elevated tritium in late 1996, concentrations of anions, metals, and other parameters were also found to have increased in groundwater from well 699-48-77A. This is interpreted to be a result of the dilute (clean water) effluent from SALDS dissolving soluble mineral species (such as gypsum in the case of sulfate) in the vadose zone during infiltration (Thornton 1997; Barnett et al. 1997). More recently, wells 699-48-77C and 699-48-77D have shown similar, but more subtle, incursions of these constituents. Figures 11 through 13 show the trends for some of the parameters in the SALDS wells that best reflect this phenomenon, e.g., sulfate, conductivity, and TDS. Other species, such as calcium and sodium, show a more subdued response during the same time period. Similarly, a slight upward trend in dissolved arsenic in well 699-48-77A (maximum = 7.25 μg/L) is also

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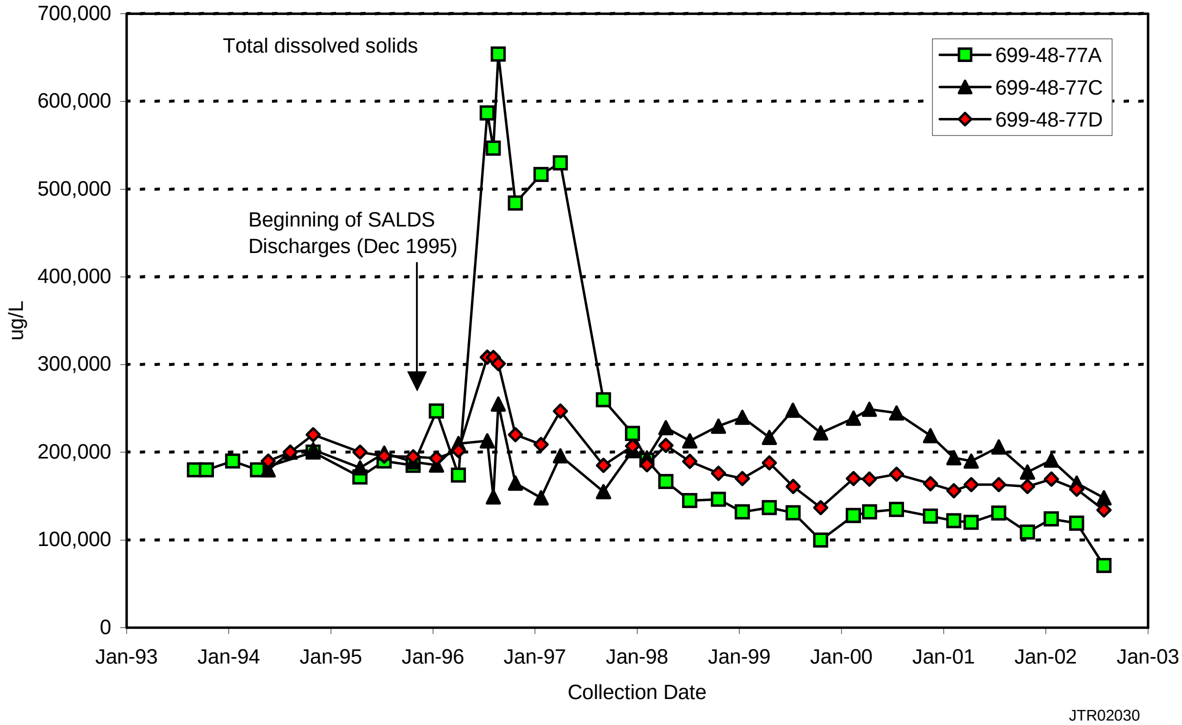
[1] Period reported is October 1, 2001, through August 31, 2002.



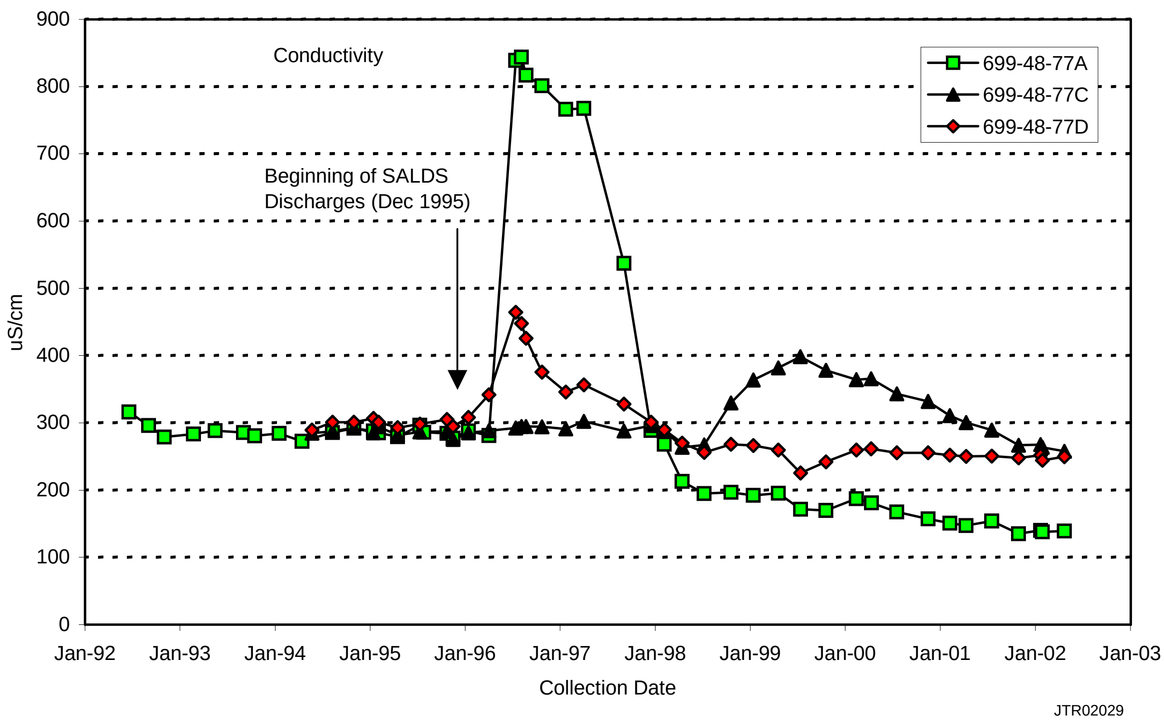
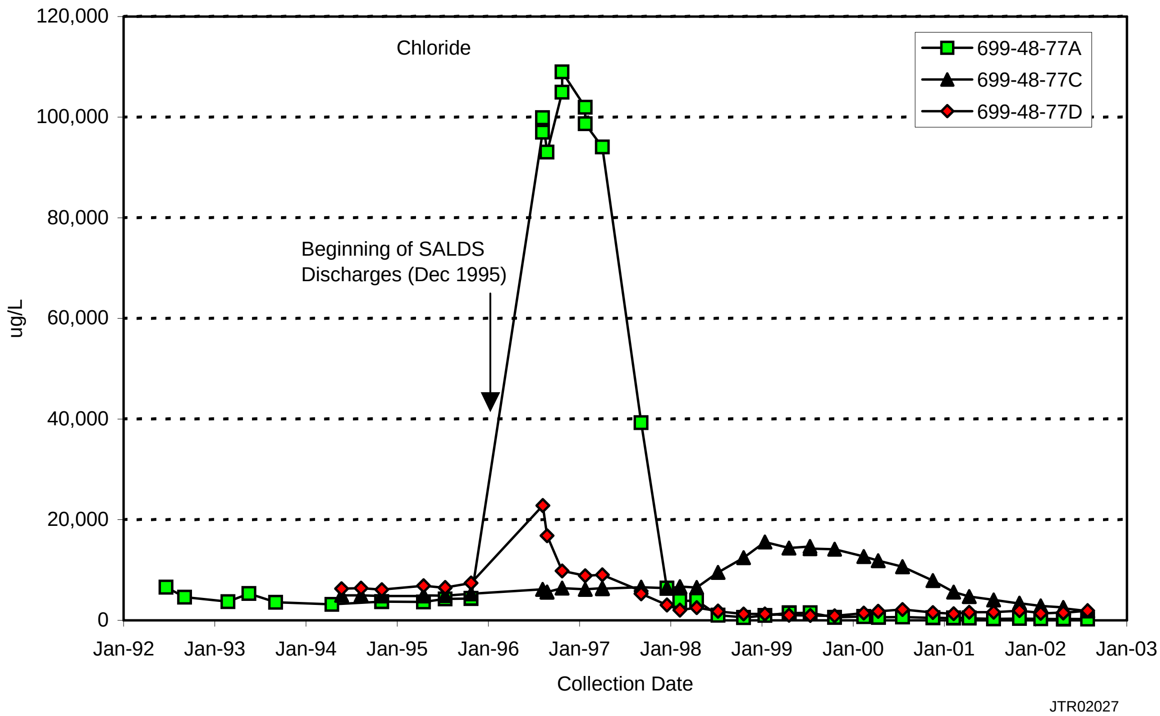


Figure 11. Trend Plots for Conductivity and Total Dissolved Solids in SALDS Proximal Wells



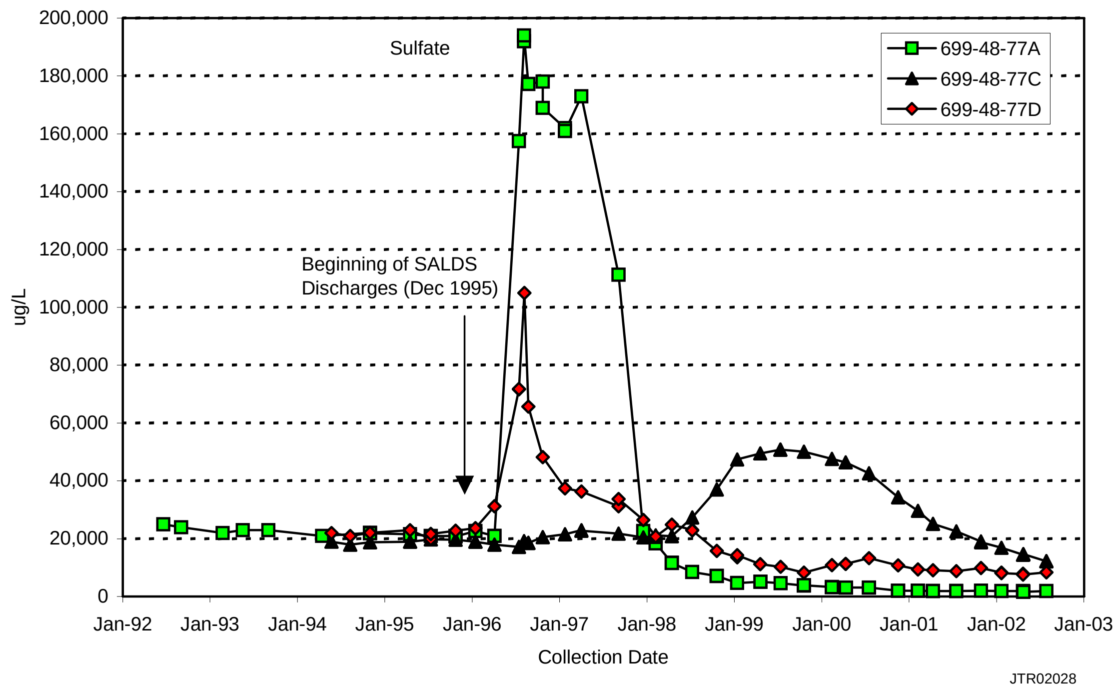
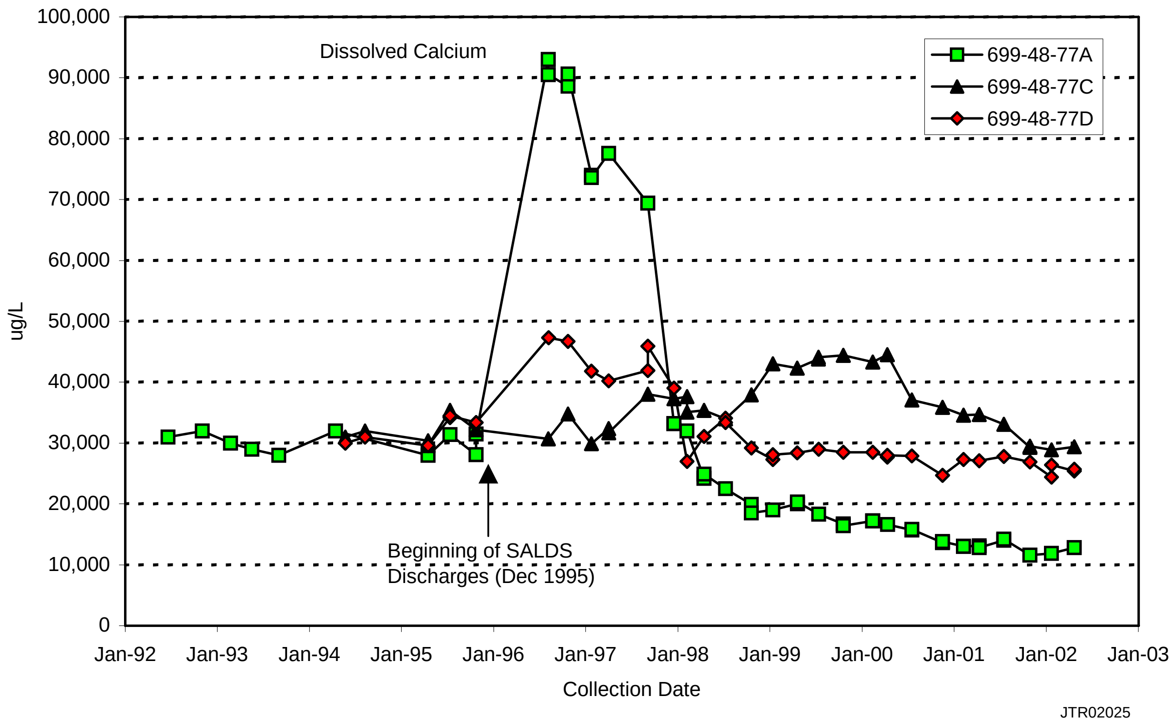


Figure 12. Trend Plots for Chloride and Sulfate in SALDS Proximal Wells



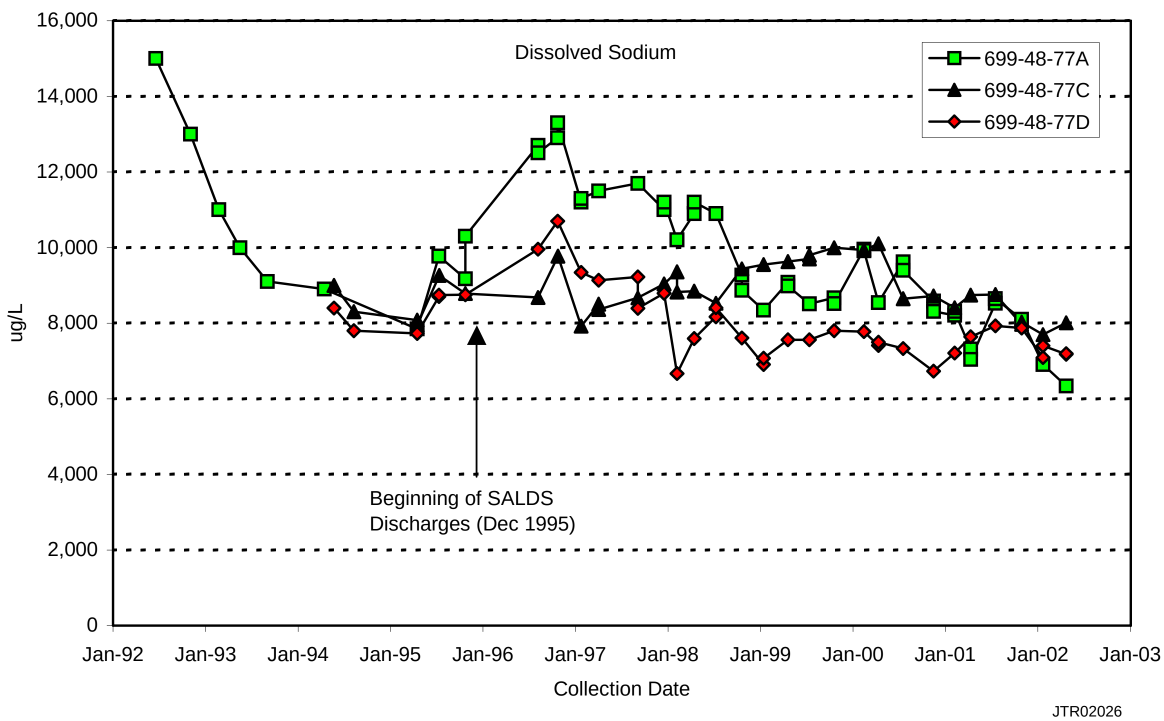


Figure 13. Trend Plots for Dissolved Calcium and Dissolved Sodium for SALDS Proximal Wells

probably related to the leaching of minerals in the vadose zone. Several other metals show similar trends of increase with subsequent decreases. The trends are most pronounced in wells 699-48-77A and 699-48-77D because these wells are screened at the water table. The six parameters in Figures 11 to 13 have trended downward for the past few years in wells 699-48-77A and 699-48-77D, and appear now to be stabilizing below initial background (before 1995) concentrations in these two wells.

The groundwater temperature has been rising gradually in well 699-48-77A since 1998 (Figure 14). This well is known to respond more quickly than the other two proximal wells to SALDS discharges. The rising groundwater temperature most likely reflects the combined temperature effects of the effluent leaving the ETF and thermal modifications that take place en route to the SALDS. Because infiltrating water in repeated discharges usually follows established flow paths in the vadose zone, the thermal character of the effluent may be more readily preserved as it moves downward to the groundwater. In general, rock material and sediments are poor thermal conductors. Thus, the sediments surrounding the flow paths may not efficiently dissipate the thermal signature of the effluent. Temperatures of ETF effluent in the verification tank range between 21°C and 29°C prior to entering the transfer line to the SALDS.

Well 699-48-77C is screened ~20 meters below the water table, so the effects of SALDS discharges in this well are significantly delayed and diluted with respect to the two shallow wells. The peak concentrations of the parameters represented in Figures 11 to 13 occurred in this well in late 1999 to early 2000, approximately 3 years later than in wells 699-48-77A and 699-48-77D. Concentrations in all three wells now reflect the dilute effluent from the SALDS that have now replaced the natural concentrations to a minor degree in well 699-48-77C and more so in wells 699-48-77A and 699-48-77D.

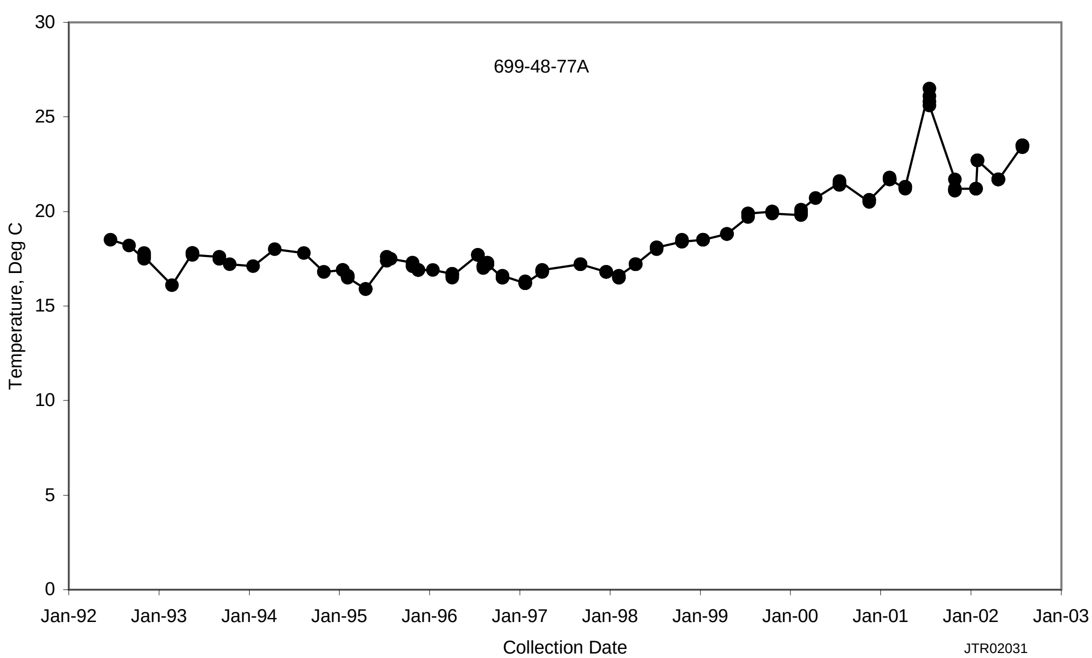


Figure 14. Temperature Plot of Groundwater from Well 699-48-77A. The outliers of July 2001 are suspected to be the result of erroneous measurements.

4.0 Conclusions and Recommendations

Because of a consistently downward potential, as indicated by the head differences between the shallow proximal wells 699-48-77A, 699-43-77D, and deep proximal well 699-48-77C (see Figure 4), tritium from SALDS is gradually being forced to lower levels in the aquifer in the immediate vicinity of the facility.

Occasional "spikes" of dissolved, soil-derived salts and related parameters may be expected to occur sporadically at any of the SALDS proximal wells, but at lower levels of concentration than in the original occurrences. Concentrations of other constituents, such as arsenic (see Section 3.0), may also respond to this effect, and should be evaluated for trends. These trends may correspond to those of the parameters discussed in Section 3.3, or may exhibit delayed responses due to different solubility and transport properties.

Water levels are falling critically low in several of the tritium-tracking wells to the south of the SALDS, such that sampling will become infeasible. Table 2 lists wells in the SALDS network with serviceability information for each. Wells highlighted in bold in Table 2 are estimated to go dry or require some modification to sampling approach due to low water levels within the next 6 to 12 months. As noted in Section 3.2, well 299-W7-11 and 299-W6-8 have already gone dry. As wells continue to become unserviceable, the network should be periodically evaluated for adequacy. At the present time, the network is sufficient to track movement of tritium from the SALDS. Wells 699-51-75 and 699-51-75P are apparently directly downgradient of the SALDS, and will provide information on tritium transport should the plume reach that far north. Negative values in Table 2 are a result of slight inaccuracies in available well-completion information. Any efforts to extend the serviceability life of a well should include measurements of well bottom depth to refine actual completion details.

Numerical model predictions of SALDS tritium distribution in groundwater for years 2000 and 2005 (Figure 15) (Barnett et al. 1997) show an incursion of tritium into wells along the southern portion of the tritium-tracking network (>500 pCi/L by year 2000 and nearly 2,000 pCi/L by year 2005). Well 299-W7-5 is projected to be one of the first wells affected in this area. Based on the most recent tritium results for this well (790 and 860 pCi/L), it appears that tritium from SALDS may have reached this location as predicted. Three other wells south of SALDS predicted to detect tritium from the facility by 2000 are as yet unaffected. Models of vertical distribution of tritium beneath SALDS predict activities of tritium of >200,000 pCi/L reaching to depths monitored by well 699-48-77C. Thus far, the maximum is 980,000 pCi/L in this well. It should be noted that although discharge volumes to date are in line with model assumptions, the model assumed that a total of ~745 Ci would be discharged to the SALDS by the end of CY 2002. This is more than double the actual amount (~333 Ci) discharged thus far, and may eventually result in a disparity between the activities observed in the tritium-tracking wells versus the predicted activities.

Hydraulic potential distribution in the area of SALDS for the same two time frames (Figure 16) is similar to current interpretations of potential (see Figure 7). The actual March 2002 potential at SALDS well 699-48-77A is approximately 1.5 meters lower than that predicted for 2000 and 2005. Also, the March 2002 water table indicates a more easterly component of flow potential than model predictions for 2002 and 2005.

Table 2. Well Serviceability Information for SALDS Tritium-Tracking Network

Well	Earliest Date	Latest Date	Earliest DTW	Latest DTW	WT Elevation (ft)	Ref Elevation (ft)	Depth of Well Screen Bottom	Depth of Pump Intake	Water Left Above Intake (ft)	Amount Pump can be Lowered (ft)	Water Left in Well	Annual Rate of Decline (ft)	Years of Service Left
299-W6-6	11-Mar-99	19-Mar-02	264.49	268.41	441.58	709.99	429.30	422.2	153.79	7.10	160.89	1.30	123.8
299-W6-7	11-Mar-99	16-Apr-02	264.7	268.11	445.58	710.28	267.20	267	2.30	0.20	2.50	1.10	**1.8**
299-W6-8	11-Mar-99	19-Mar-02	247.69	251.02	443.71	694.73	250.60	NA	NA	NA	-0.42	1.10	**-0.8**
299-W6-11	11-Mar-99	19-Mar-02	256.56	259.58	443.28	702.86	271.20	272.00	12.42	-0.80	11.62	1.00	11.1
299-W6-12	11-Mar-99	19-Mar-02	244.99	248.16	444.35	692.51	257.30	257.00	8.84	0.30	9.14	1.05	8.2
299-W7-1	11-Mar-99	19-Mar-02	239.21	242.26	451.50	690.71	245.00	244.65	5.44	0.35	5.79	1.01	5.2
299-W7-11	11-Mar-99	19-Mar-02	230.57	233.63	450.88	681.45	232.00	232	1.43	0.00	1.43	1.01	**0.9**
299-W7-12	10-Mar-99	19-Mar-02	236.81	239.6	451.12	687.93	240.00	NA	NA	NA	3.19	0.92	**2.9**
299-W7-3	11-Mar-99	19-Mar-02	226.88	229.86	449.26	676.14	470.00	461.79	234.91	8.21	243.12	0.99	246.3
299-W7-5	11-Mar-99	19-Mar-02	223.65	226.71	449.40	673.05	227.70	227.25	3.60	0.45	4.05	1.01	3.5
299-W7-6	11-Mar-99	19-Mar-02	229.79	231.79	448.85	678.64	229.00	234.2	4.41	-5.20	-0.79	0.66	**-2.0**
299-W7-7	11-Mar-99	19-Mar-02	225.72	228.74	449.22	674.94	227.80	227.8	2.08	0.00	2.08	1.00	**1.6**
299-W7-8	11-Mar-99	19-Sep-01	238.92	242.55	448.43	687.35	240.60	240.03	1.11	0.57	1.68	1.44	**0.8**
299-W7-9	11-Mar-99	19-Mar-02	240.3	243.04	451.79	692.09	241.10	NA	NA	NA	0.80	0.91	**0.3**
299-W8-1	11-May-99	19-Mar-02	249.31	252.13	452.02	701.33	256.50	NA	NA	NA	7.19	0.99	6.8
699-48-71	16-Mar-99	26-Jun-02	250.3	253.41	437.85	688.15	283.60	NA	NA	NA	33.30	0.95	32.0
699-48-77A	11-May-99	30-May-02	223.65	226.93	451.07	674.72	235.17	233.52	9.87	1.65	11.52	1.07	10.3
699-48-77C	11-May-99	30-May-02	225.52	228.58	448.76	674.28	312.37	303.9	78.38	8.47	86.85	1.00	86.2
699-48-77D	11-May-99	19-Mar-02	224.53	228.08	449.34	673.87	237.20	233.35	8.82	3.85	12.67	1.24	9.8
699-49-79	16-Mar-99	26-Mar-02	239.78	242.22	449.42	689.2	279.40	NA	NA	NA	39.62	0.81	45.5
699-51-75	16-Mar-99	25-Mar-02	198.12	200.62	443.39	641.51	235.00	204.1	5.98	30.90	36.88	0.83	41.0
699-51-75P	2-Mar-95	27-Aug-02	194.31	201.2	447.18	641.49	375.00	NA	NA	NA	180.69	0.92	196.0

All measurements are in feet, as they appear in the database.
DTW and well screen bottom is measured from top of casing.
NA = Information not available or entry not applicable.
"Earliest" refers to the date selected for the starting point of trend calculations; "latest" refers to the most recent, representative water level measurement available.
Years of service left is based on bailer sampling and a minimum water level of 0.5 ft in the well for 4-inch diameter wells and 3.0 ft for 6-inch diameter or larger.
Wells in **bold** are those currently dry or unserviceable using historical sampling methods.
Negative values are a result of slight inaccuracies in well/pump depth data.

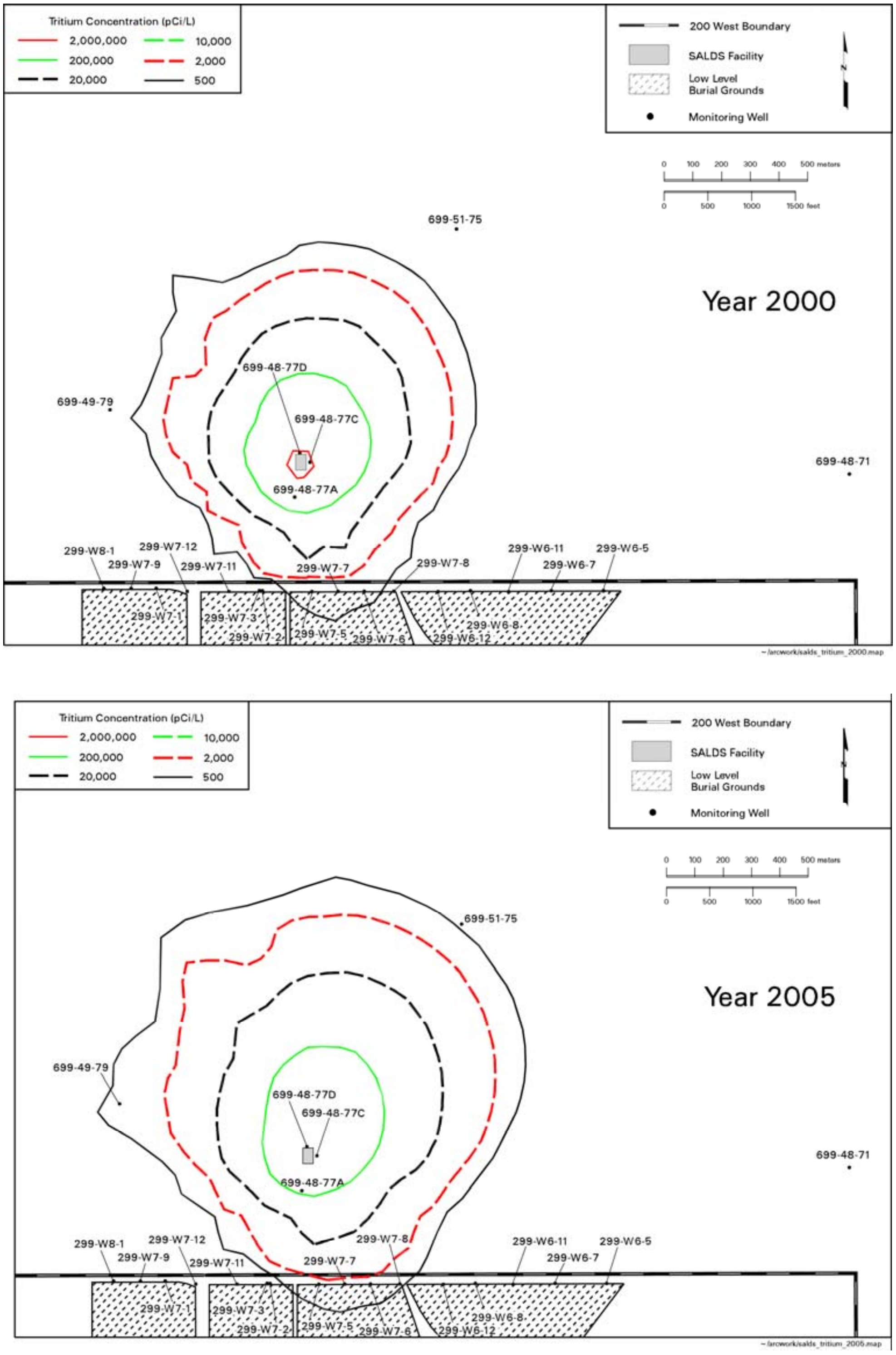
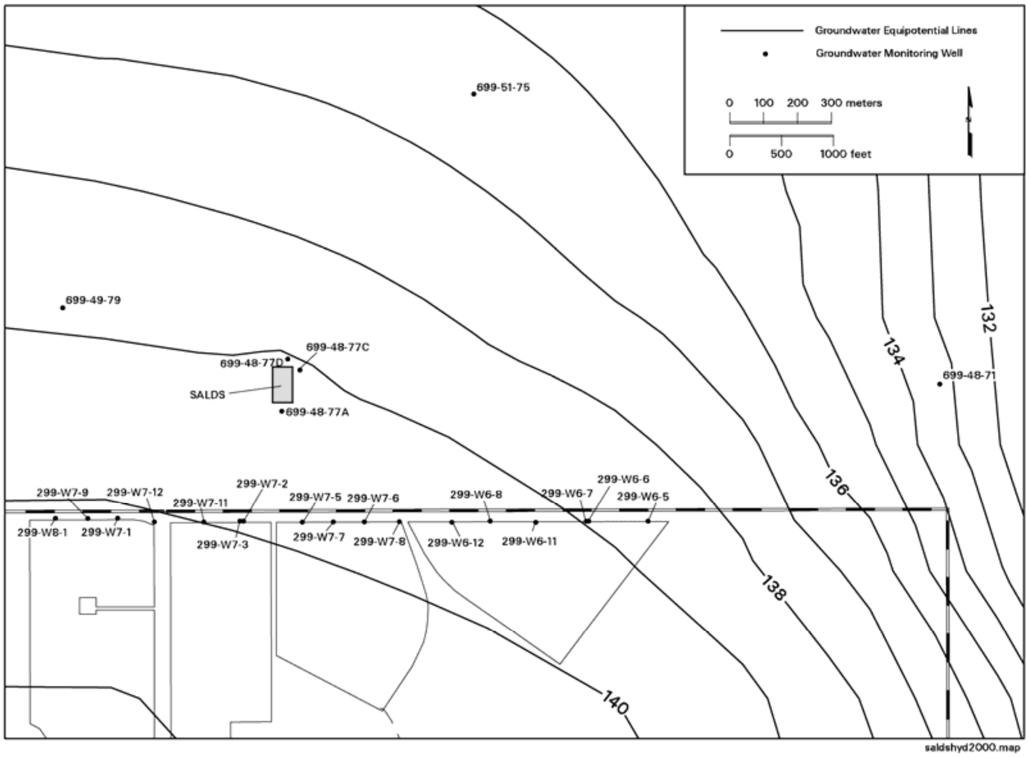


Figure 15. Predicted Tritium Distribution as a Result of SALDS Operation in Years 2000 (top) and 2005 (bottom) (after Barnett et al. 1997)



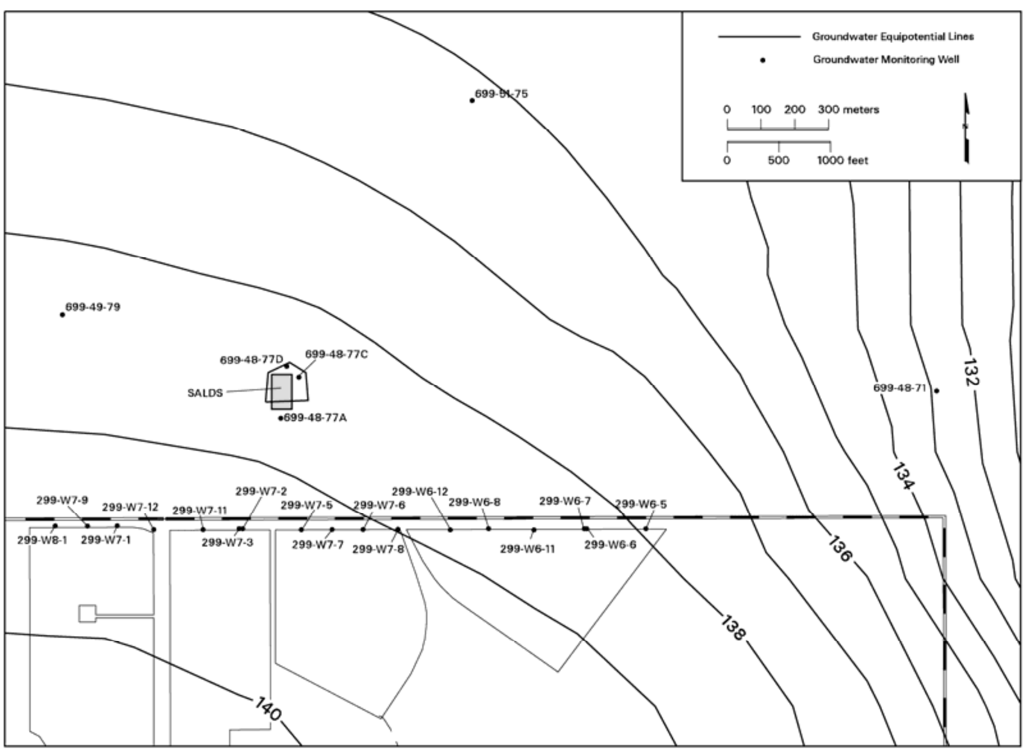


Figure 16. Hydraulic Head Distribution Predicted for SALDS in Years 2000 (top) and 2005 (bottom) (after Barnett et al. 1997)

Despite some discrepancy between the predicted hydraulic potential distribution in 2000 and 2005, and the observed water levels through FY 2002, the 1997 model provides an excellent estimate of hydraulic head and tritium dispersal in the SALDS area. However, new hydrostratigraphic information (Williams et al. 2002) and recent numerical and conceptual modeling efforts (e.g., Cole et al. 2001, Vermeul et al. 2001) will need to be applied to future estimates of tritium migration from the SALDS. A revised flow/transport model of the SALDS is due by 2005, and should incorporate parameters from this new information, and actual operational parameters (e.g., actual tritium inventories) for the SALDS.

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Appendix

SALDS Tritium Results for FY 2002

Table A.1. SALDS Tritium Results During FY 2002

Well Number	Date Sampled	Result, pCi/L	Qualifier	Comments (change in maximum result from FY 2001)
299-W6-11	01/22/02	5,000.00		(up slightly)
299-W6-12	01/23/02	580		(no change)
299-W6-6	01/22/02	193	U	I
299-W6-6	01/22/02	342	U	(no change)
299-W6-7	01/22/02	12,000		(down)
299-W6-7	04/16/02	10,300		I
299-W7-1	01/22/02	342	U	(no change)
299-W7-1	03/19/02	8.46	U	I
299-W7-11	01/22/02	342	U	(no change)
299-W7-11	01/22/02	340	U	Duplicate, no July sample due to drying of well
299-W7-12	01/22/02	340	U	(no change)
299-W7-12	03/13/02	-35.7	U	I
299-W7-3	01/23/02	285	U	(no change)
299-W7-3	03/13/02	-17.5	U	I
299-W7-3	07/30/02	222	U	(no change)
299-W7-5	01/24/02	285	U	
299-W7-5	07/30/02	790		
299-W7-5	07/30/02	860		(up) Duplicate
299-W7-6	01/22/02	286	U	(down)
299-W7-6	07/30/02	222	U	
299-W7-7	01/23/02	285	U	(no change)
299-W7-7	03/13/02	72.40	U	I
299-W7-7	07/30/02	222	U	(no change)
299-W7-8	03/13/02	67	U	(down) I
299-W7-9	01/22/02	340	U	(no change)
299-W8-1	01/22/02	340	U	(no change)
299-W8-1	03/14/02	-126	U	(no change) I
699-48-71	01/22/02	284	U	
699-48-71	01/22/02	340	U	(no change)
699-48-77A	10/29/01	7,100		
699-48-77A	01/22/02	2,600		
699-48-77A	04/23/02	2,800		
699-48-77A	04/23/02	2,840		I
699-48-77A	04/23/02	3,030		Duplicate, I

I = Independent sample collected for groundwater surveillance or Low-Level Burial Grounds.

Table A.1. (contd)

Well Number	Date Sampled	Result, pCi/L	Qualifier	Comments (change in maximum result from FY 2001)
699-48-77A	07/29/02	150,000		(down)
699-48-77C	10/29/01	740,000		
699-48-77C	10/29/01	750,000		
699-48-77C	01/22/02	720,000		
699-48-77C	04/23/02	580,000		
699-48-77C	04/23/02	596,000		I
699-48-77C	04/23/02	602,000		(down), I, duplicate
699-48-77C	07/29/02	490,000		Duplicate
699-48-77C	07/29/02	520,000		
699-48-77D	10/29/01	170,000		
699-48-77D	01/22/02	130,000		
699-48-77D	01/22/02	130,000		Duplicate
699-48-77D	04/23/02	190,000		
699-48-77D	04/23/02	189,000		I
699-48-77D	04/23/02	180,000		Duplicate
699-48-77D	07/29/02	240,000		(down)
699-49-79	01/23/02	286	U	(no change)
699-51-75	01/23/02	286	U	(no change)
699-51-75	07/30/02	222	U	
699-51-75P	01/23/02	286	U	(no change)
I = Independent sample collected for groundwater surveillance or Low-Level Burial Grounds.				

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