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Results of Tritium Tracking and Groundwater Monitoring at the Hanford Site 200 Area State-Approved Land Disposal Site–FY 1999

D. B. Barnett

October 1999

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

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Summary

The Hanford Site 200 Area Effluent Treatment Facility (ETF) processes contaminated liquids derived from Hanford Site facilities. The clean water generated by these processes is occasionally enriched in tritium, and is discharged to the 200 Area State Approved Land Disposal Site (SALDS). Groundwater monitoring for tritium and other constituents is required by the state-issued permit at 21 wells surrounding the facility.

During FY 1999, average tritium activities in most wells declined from average activities in 1998. The exception was deep well 699-48-77C, where tritium results were at an all-time high (77,000 pCi/L) as a result of the delayed penetration of effluent deeper into the aquifer. Of the 12 constituents with permit enforcement limits, which are monitored in SALDS proximal wells, all were within limits during FY 1999.

Water level measurements in nearby wells indicate that a small hydraulic mound exists around 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. Evaluation of this condition indicates that the network is currently adequate for tracking potential effects of the SALDS on the groundwater.

Recommendations include the discontinuation of ammonia, benzene, tetrahydrofuran, and acetone from the regular groundwater constituent list; designating background well 299-W8-1 as a tritium-tracking well only, and; the use of quadruplicate averages of field pH, instead of a single laboratory measurement, as a permit compliance parameter.

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Introduction

Treated water from the 200 Area Effluent Treatment Facility (ETF) is discharged to a disposal site as allowed by State Waste Discharge Permit ST-4500 (ST-4500). This disposal site is referred to as 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 at the SALDS is routinely sampled and water levels in wells are measured. The results of the groundwater sampling are reported in quarterly discharge monitoring reports. In 1997, the USDOE also recommended the issuance of an annual summary report of groundwater monitoring results and evaluation, with updates to the groundwater monitoring plan, as appropriate. This report summarizes the results of groundwater information for the SALDS during FY 1999.

Wells in the groundwater monitoring network (Figure 2) are sampled quarterly to annually for constituents regulated by the State Waste Discharge Permit. Wells 299-W8-1, 699-48-77A, 699-48-77C, and 699-48-77D are part of the upgradient/downgradient monitoring network designed to detect proximal effects on groundwater of the SALDS operation. These four wells are sampled quarterly for tritium and a list of constituents governed by ST-4500. An additional 17 wells are sampled semiannually to annually for tritium only. Wells 299-W6-8, 299-7-1, 299-7-6, and 299-7-11 are sampled semiannually; the remaining 13 wells are sampled annually.

Water Level Measurement Results

Water levels are measured in wells prior to each sampling event. Additionally, water levels have been measured monthly, since January 1997 in the proximal SALDS facility wells (299-W8-1, 699-48-77A, 699-48-77C, and 699-48-77D) and upgradient well 299-W8-1. Well 299-W8-1 is currently serving as a background water quality ("upgradient") well for the SALDS. Hydrographs for these wells since 1992 (through April 1999) and the remaining wells in the tritium-tracking network are shown in Figures 3 through 5.

Hydraulic head in well 699-48-77A has consistently surpassed the head in "upgradient" well 299-W8-1 and most other wells in the tritium-tracking network since late 1997 (Figures 3-5). This is a result of the continuing general decline in water levels in the 200 West Area combined with the increased head near the SALDS, resulting from SALDS operation. This condition will become more pronounced as the water table continues to decline in the vicinity of 200 West Area.

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 (Figure 5). This explains the lack of tritium in the deep well, while the shallow well

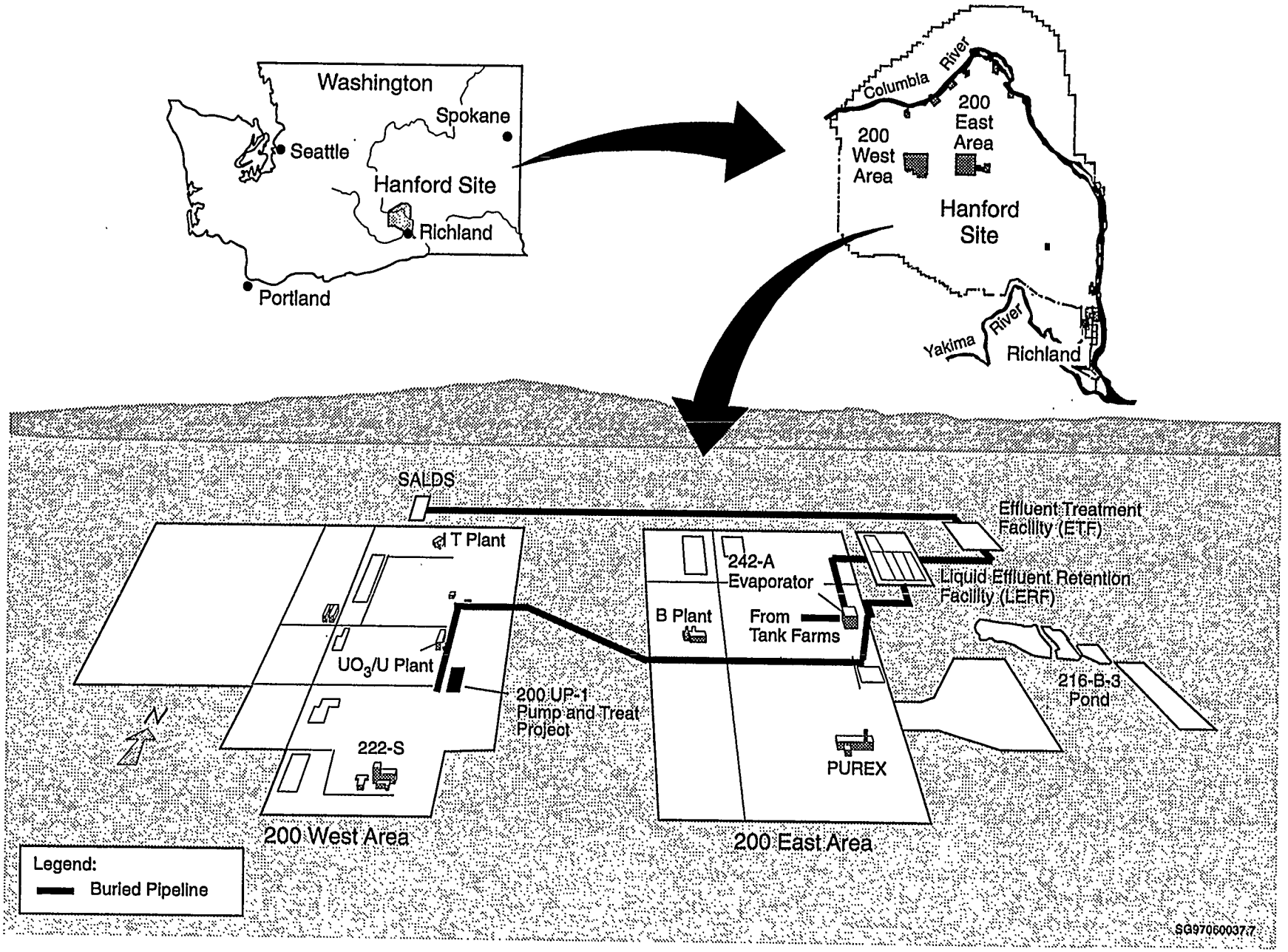

Figure 1. Location of the State-Approved Land Disposal Site (SALDS), and Related Infrastructure

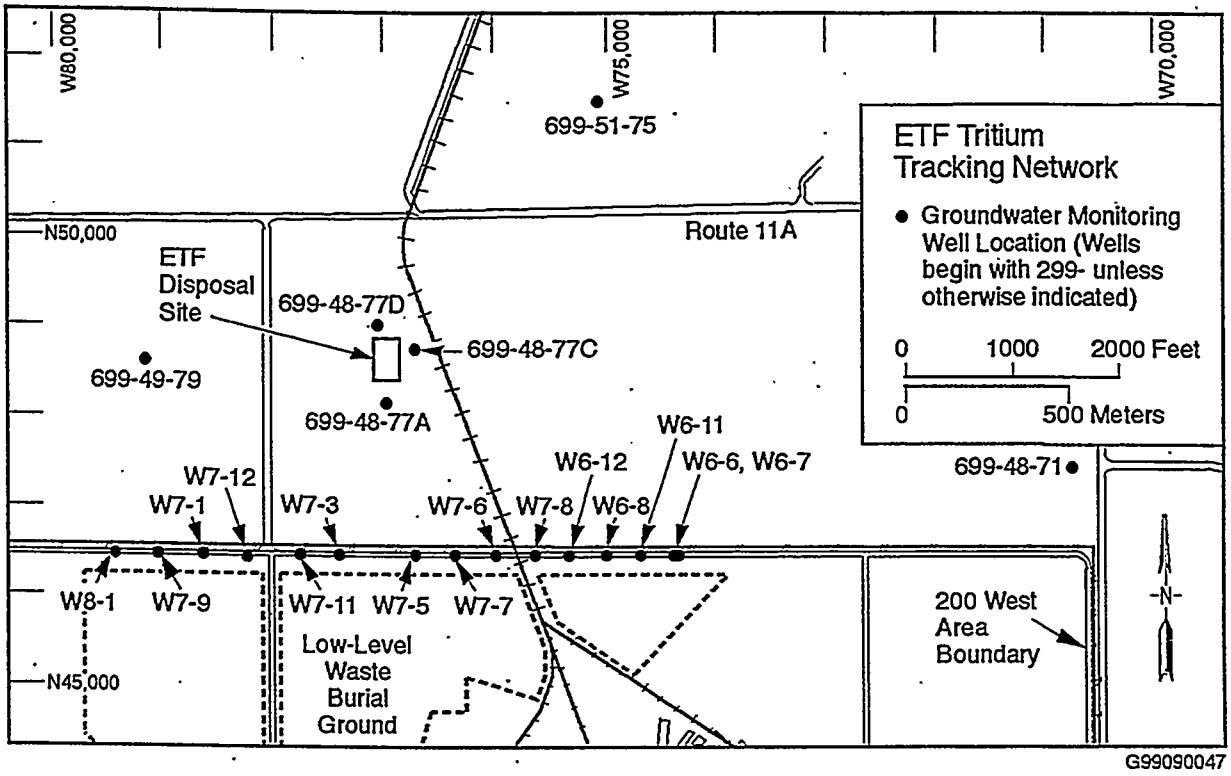

Figure 2. Locations of SALDS Tritium Tracking Network Wells

shows high levels of tritium from the plume originating in the 200 West Area. Near the SALDS, a consistently downward potential exists in the aquifer, as indicated by the water levels in the proximal wells (Figure 3).

An interpretation of the water table in the vicinity of the SALDS for March 1999 is shown in Figure 6. The groundwater mound associated with 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. 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. Exactly how far south the effluent from SALDS could actually flow before turning east is not known. If tritium is eventually detected in these wells, the flow rates and directions will be more quantifiable, and these could contribute useful data to future modeling efforts. Importantly, downgradient well 699-51-75 is apparently in an optimum location for the interception and efficient tracking of tritium in a regionally downgradient direction from the SALDS.

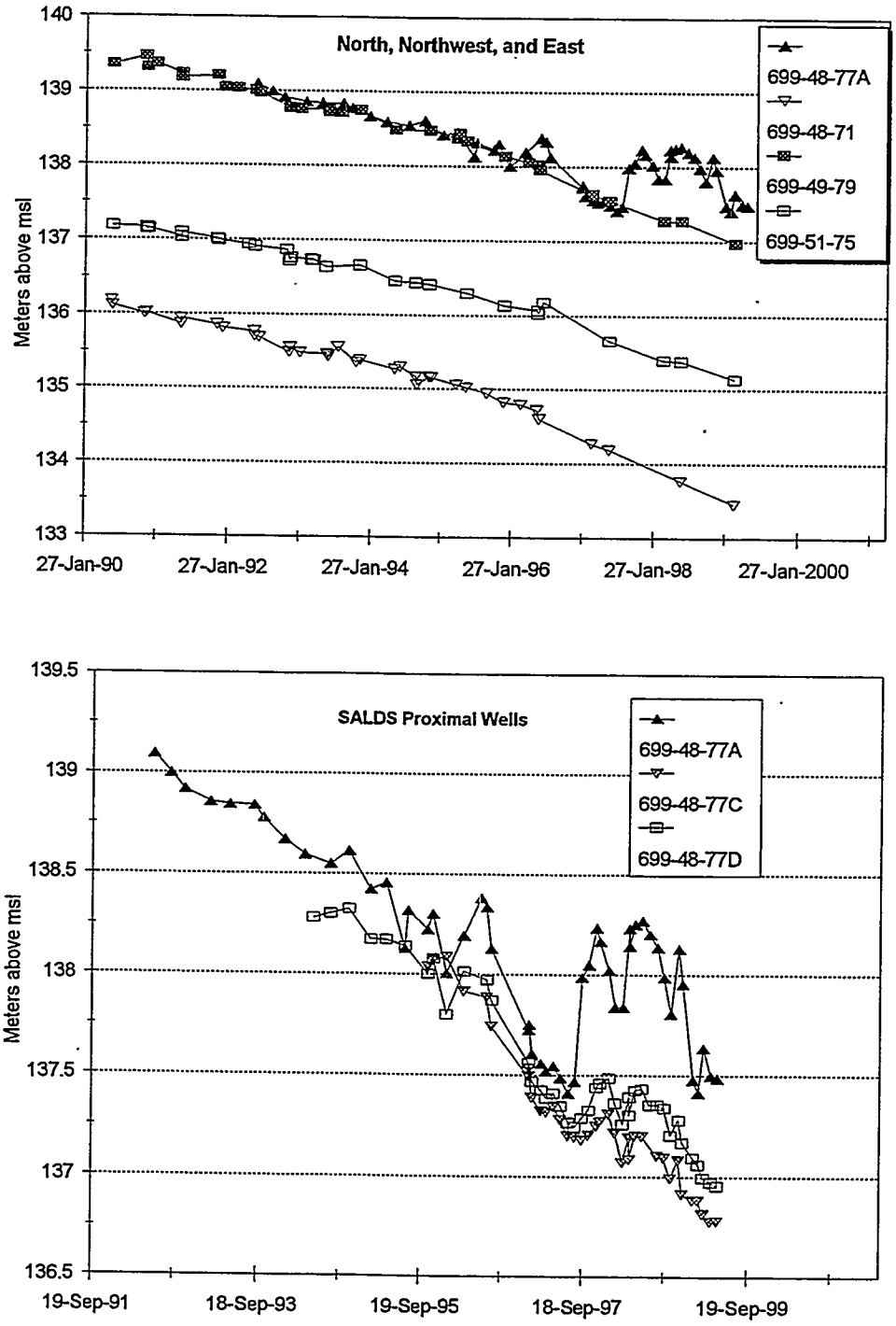

Figure 3. Hydrographs of Tritium Tracking Wells North, Northwest, and East of the SALDS, Compared with Well 699-48-77A (top), and SALDS Proximal Wells (bottom)

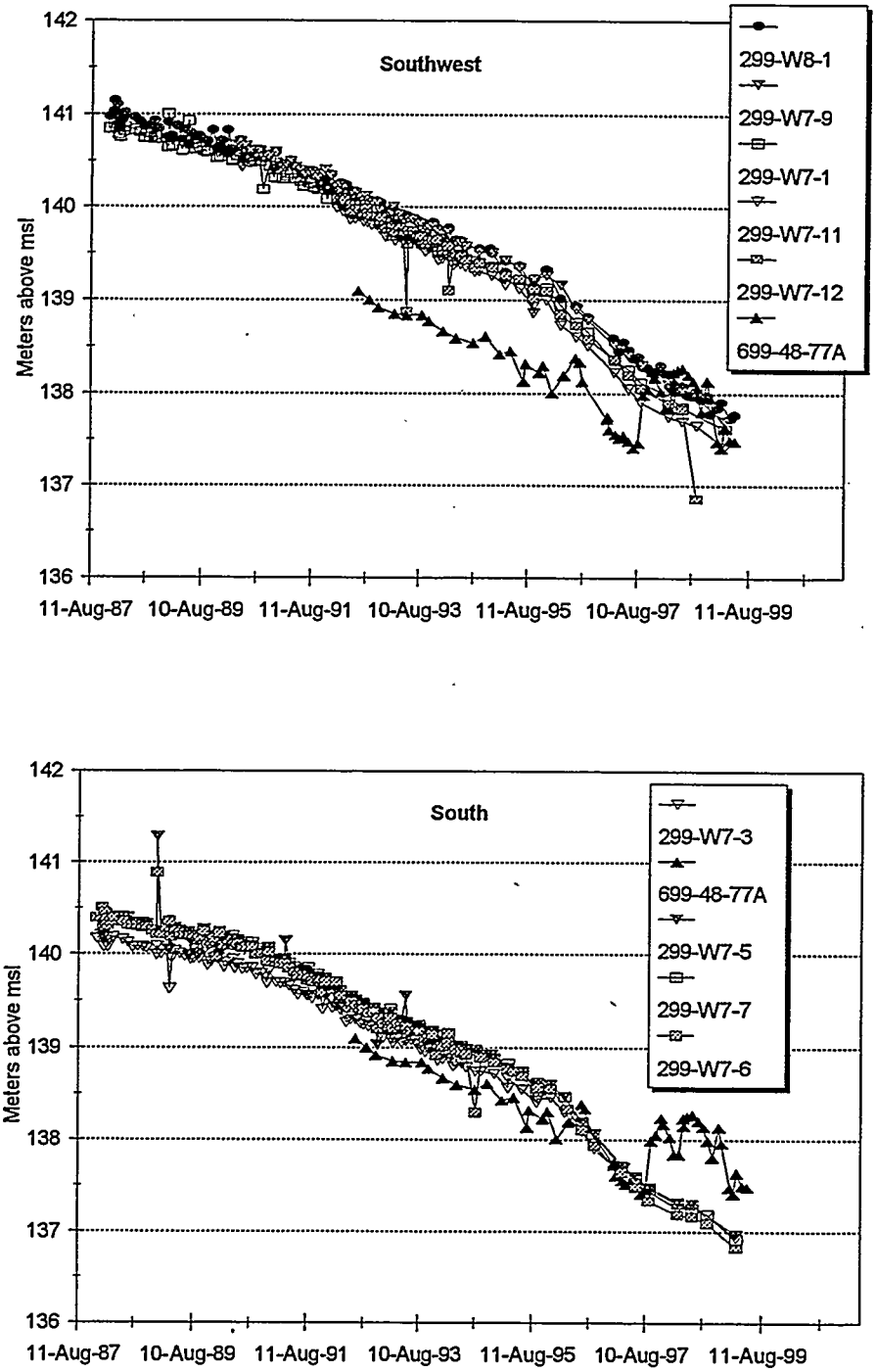

Figure 4. Hydrographs of Tritium Tracking Wells Southwest (top) and South (bottom) of the SALDS, Compared with Well 699-48-77A

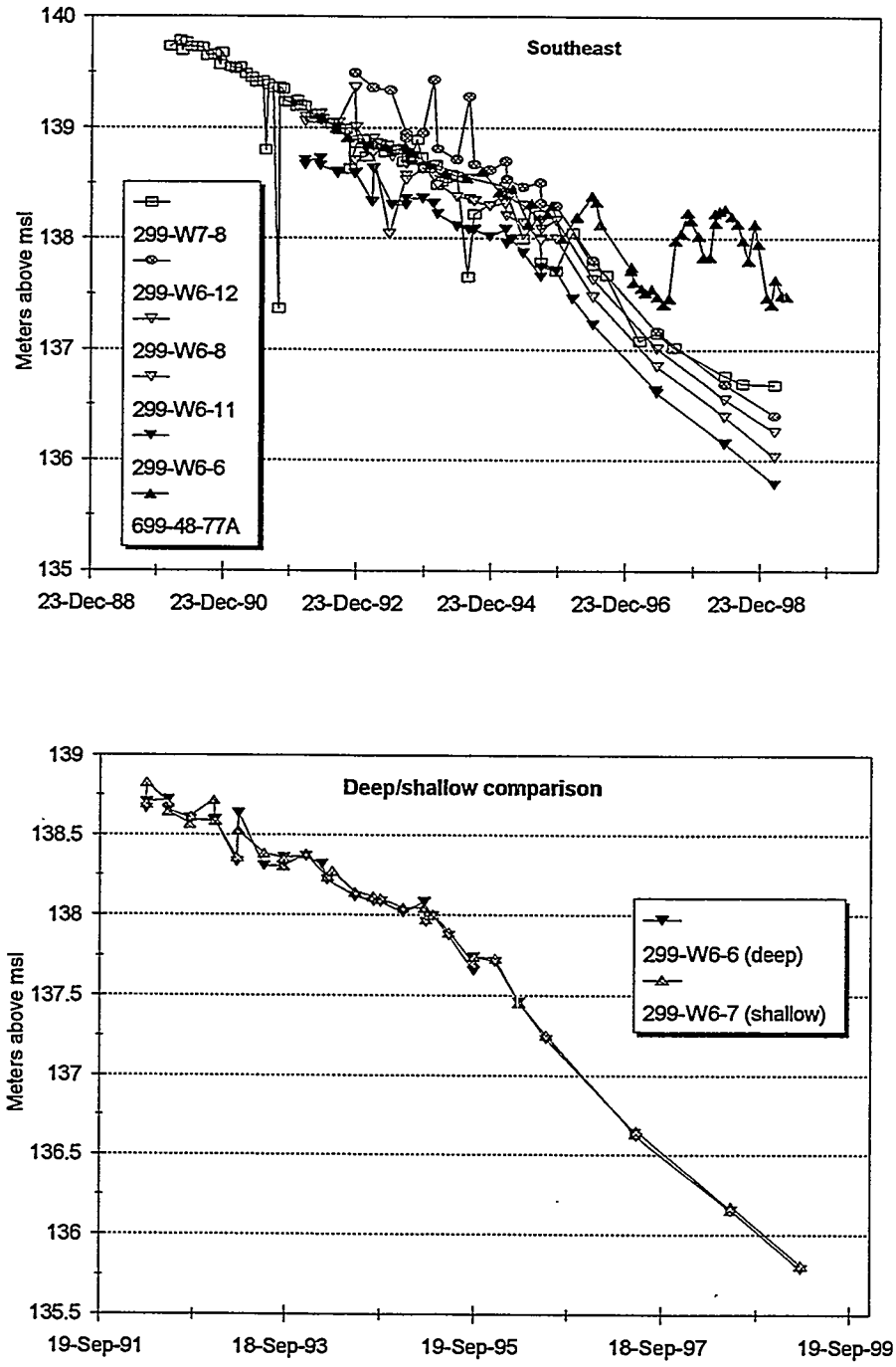

Figure 5. Hydrographs of Tritium Tracking Wells Southeast of SALDS Compared with Well 699-48-77A (top), and Deep/Shallow Companion Wells (bottom)

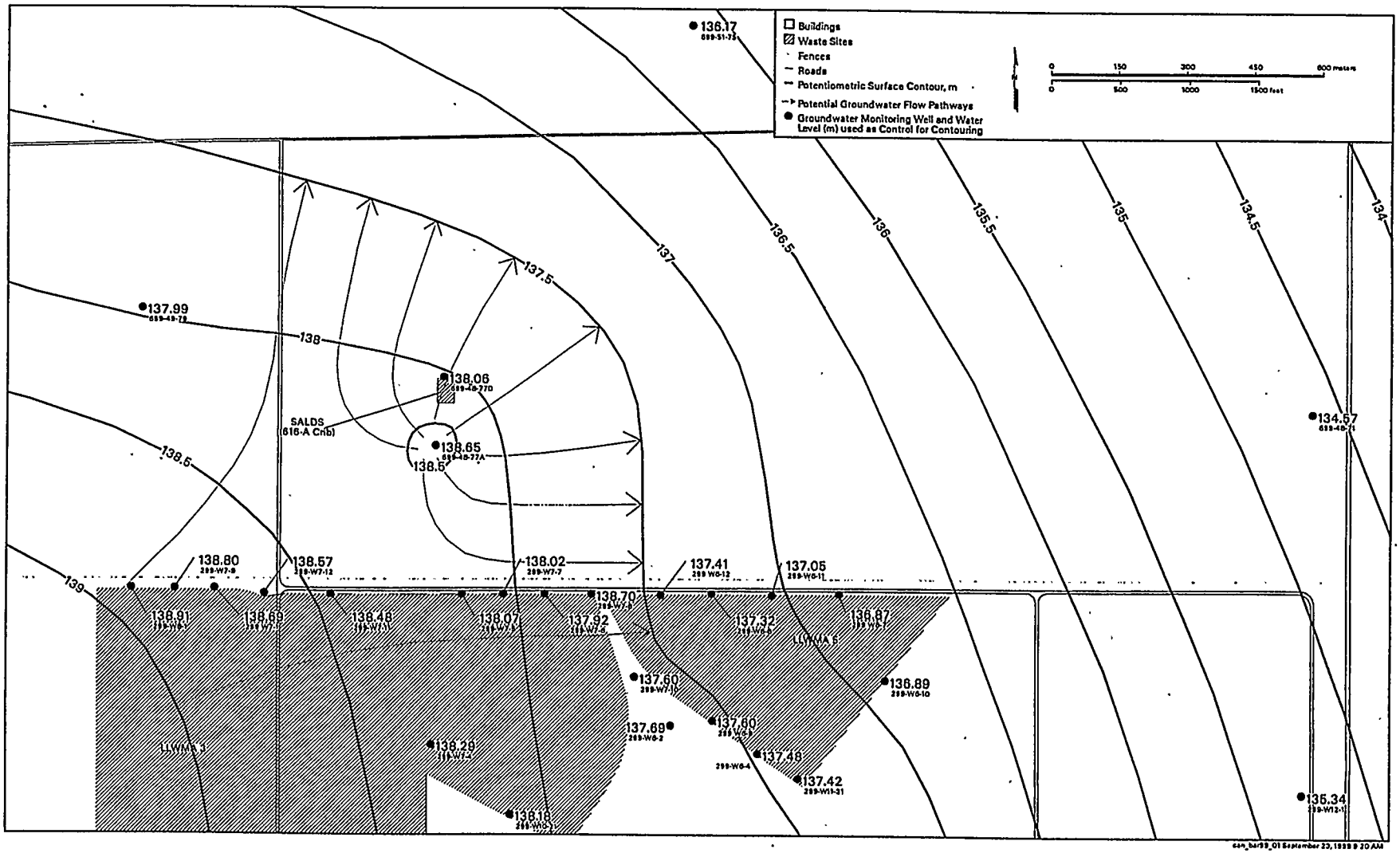

Figure 6. Water Table Map and Interpreted Groundwater Flow Directions in the SALDS Area for March 1999

Results of Tritium Analyses of Groundwater

Results of tritium analyses in the SALDS tritium-tracking well network for FY 1999 are shown on Figure 7 and listed in Appendix A. The only wells in the network that have been affected thus far by SALDS tritium discharges are wells 699-48-77A, 699-48-77C, and 699-48-77D. Average tritium activities during FY 1999 in wells 699-48-77A and 699-48-77D actually decreased from that of FY 1998 activities. Only well 699-48-77C, the deeper well in the proximal SALDS network, showed increased tritium activities from 1998 to 1999. All other wells in the tritium-tracking network indicate unchanged or declining concentrations of tritium in groundwater. Wells 299-W6-7, 299-W6-8, 299-W6-11, and 299-W6-12 continue to show the effects of the decaying tritium plume originating from the northeast portion of the 200 West Area.

Figure 8 illustrates the trends in tritium activities in the three SALDS proximal wells and upgradient well 299-W8-1. Well 699-48-77A was first affected by discharges in August of 1996. Although this well is furthest from the facility of the three "downgradient" facility wells, subsurface geologic factors allowed the effluent to reach this well before any others (see Barnett et al. 1997). This well continues to be affected before other wells, depending on the discharge schedule of the SALDS, and produced a maximum tritium activity during FY 1999 of 140,000 pCi/L (October 1998). Well 699-48-77D is nearest the SALDS, but indicated tritium incursion only as recently as September 1997. The maximum tritium result for this well in FY 1999 was 730,000 pCi/L (October 1998). Well 699-48-77C is screened ~20 m deeper in the aquifer than 77A and 77D. Because of its deeper position, tritium incursions from SALDS operation have been lower in activity and intermittent in this well. During times of high discharge the hydraulic head beneath the SALDS is increased and effluent is forced deeper into the aquifer. The screen in well 699-48-77C is likely at the dilute bottom edge of the tritium plume, and is thus affected much less than the two shallow wells. In July 1999 a historically high tritium activity of 77,000 pCi/L was measure in this well, indicating that the downward moving SALDS effluent is reaching this location with greater consistency and strength.

Well 299-W8-1 is nearly 1 km away from the facility, and is unaffected by discharges to the SALDS. This well produced one marginally-detectable tritium result of 220 pCi/L (MDA = 184 pCi/L) in July 1999, but has historically produced higher results prior to SALDS operation. All other tritium results from this well during FY 1999 were below detection. Overall, tritium activities in the SALDS proximal wells measured during FY 1999 are significantly lower than FY 1998.

Other Constituents in Groundwater

In addition to tritium, groundwater from the SALDS proximal wells (699-48-77A, 699-48-77C, and 699-48-77D) and well 299-W8-1 is analyzed for a list of 16 constituents required by the State Waste Discharge Permit ST 4500 Special Condition S1 (A). Enforcement limits are set for most of these

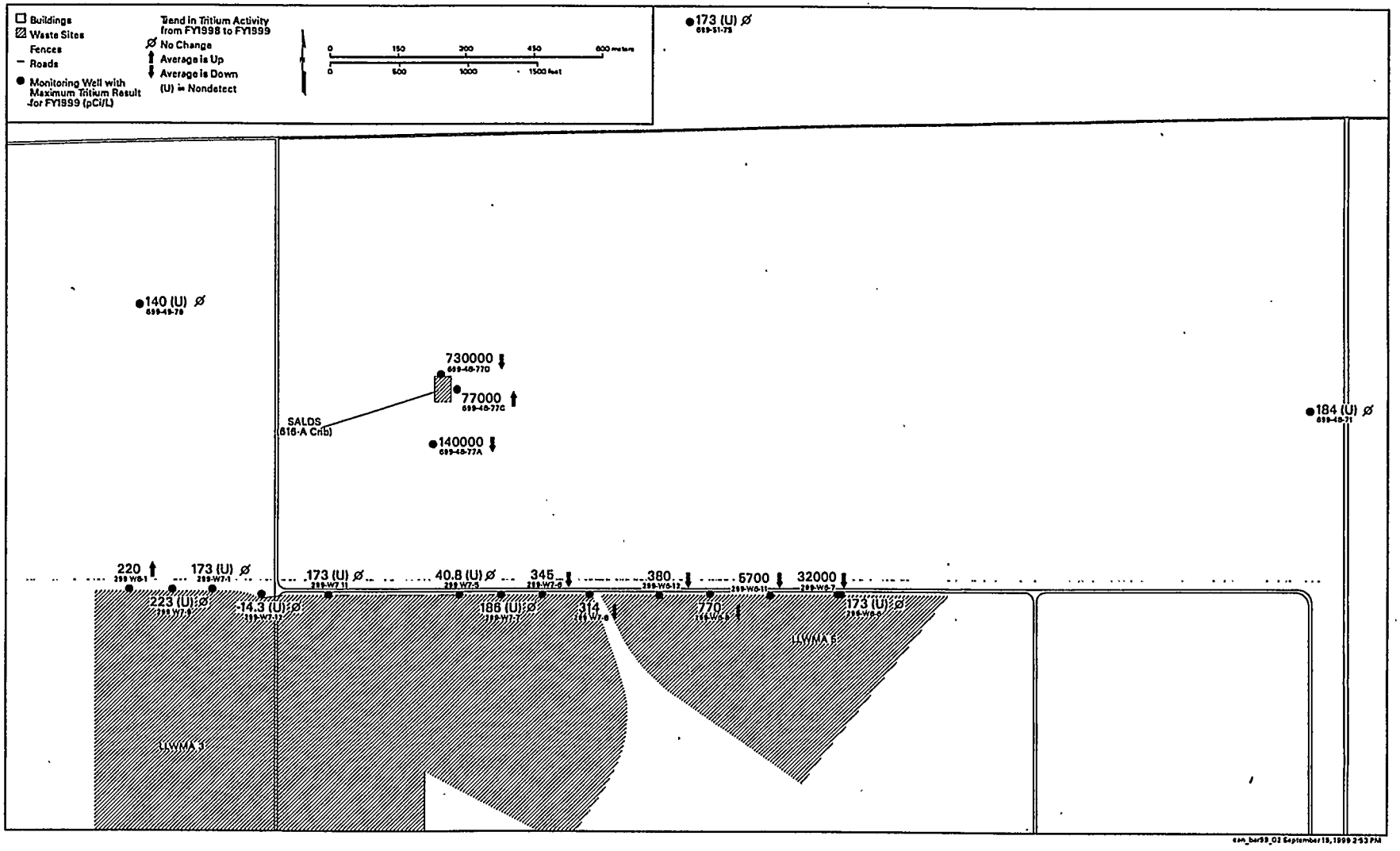

Figure 7. Maximum Tritium Activities in Groundwater for the SALDS Tritium Tracking Network for FY 1999, Indicating Change from FY 1998

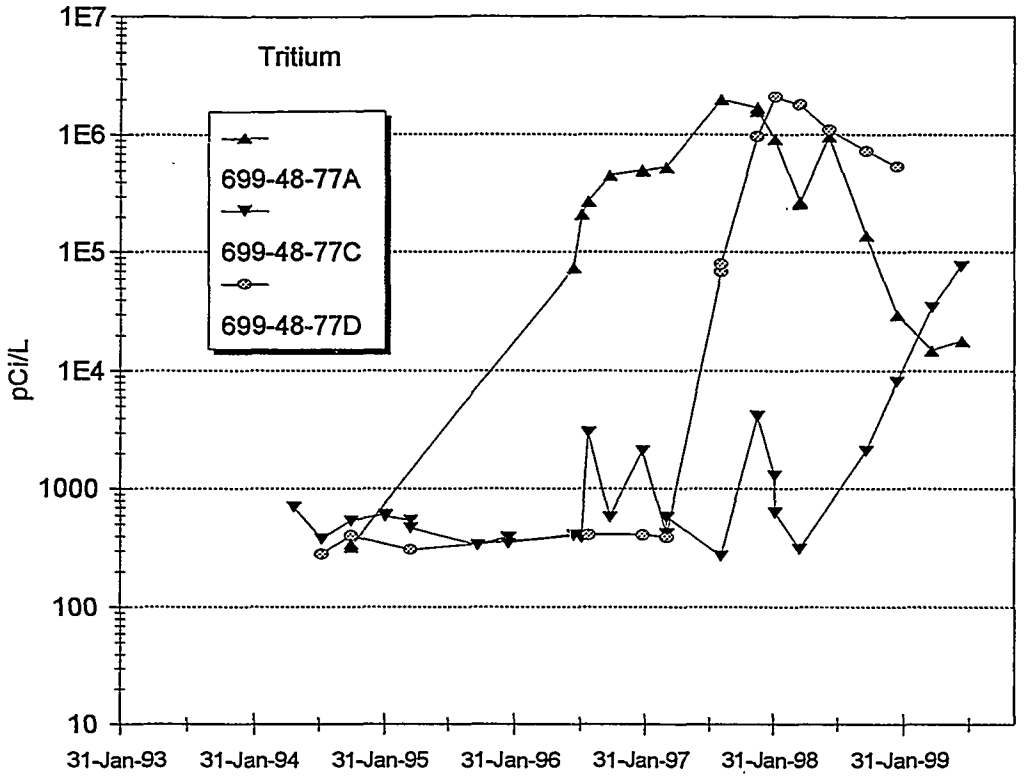

Figure 8. Tritium Trends in SALDS Proximal Wells Through July 1999

constituents [acetone, ammonia, 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. Maximum concentrations for these constituents, and the corresponding sample months for FY 1999, are listed in Table 1.

Of the 12 constituents with permit limits, all were below the ST-4500 enforcement limits for groundwater during FY 1999[1]. Acetone, ammonia, benzene, and tetrahydrofuran results were all below detection limits. Several other constituents, such as lead, mercury, and chloroform were either below detection or below the assigned confidence level for quantitation, as determined by the laboratory (indicated as "J" in Table 1). Wells 299-W8-1 and 699-48-77A produced individual (not averaged quadruplicate measurements) laboratory results for pH in October 1998 that were slightly above enforcement limits. However, corresponding averages of field pH results from the same sampling event were in line with historic averages (8.18 for well 299-W8-1 and 8.08 for well 699-48-77A), and indicate that the isolated laboratory results are of suspect quality.

FY 1999 maxima for gross alpha and gross beta results both occurred in upgradient well 299-W8-1 (3.2 pCi/L in April 1999 and 7.1 pCi/L in January 1999, respectively). The maximum strontium-90 result was 5.5 pCi/L (October 1998) in well 699-48-77D. Strontium-90 results in this well fell to 1.5 pCi/L in January 1999, then rose to 5.2 pCi/L in April 1999. The highest results (5.5 and 5.2 pCi/L) do not correlate with gross beta results, and are suspected of error.

[1] Period reported is October 1, 1998 through July 1999.

Table 1. Maximum Concentrations of Constituents with Permit Enforcement Limits in Groundwater and Corresponding Sample Month, SALDS, FY 1999

Constituent (permit limit)	Well 299-W8-1	Well 699-48-77A	Well 699-48-77C	Well 699-48-77D
Acetone (160)	(u)	(u)	(u)	(u)
Ammonia (1,100)	(u)	(u)	(u)	(u)
Benzene (5)	(u)	(u)	(u)	(u)
Cadmium ,total (10)	0.5 --jan 99	1.09--jan 99	2.09(J)--jan 99	2.8(J)--jan 99
Chloroform (6.2)	0.8 (J)--apr 99	0.7(J)--oct 98	0.8(J)--jan 99	(u)
Copper, total (70)	1.43--apr 99	1.68--oct 98	2.21--apr 99	5.23--oct 98
Lead, total (50)	4.84--jul 99	0.05(J)--jul 99	0.23(J)--jul 99	0.14(J)--jul 99
Mercury, total (2)	0.3 (J)--jan 99	(u)	(u)	(u)
Laboratory pH, pH units (6.5 - 8.5)	9.08[a]--oct 98	8.58[a]--oct 98	8.32--oct 98	8.36--oct 99
Field pH, pH units[c] (6.5 - 8.5)	8.18--apr 99	8.15--apr 99	7.87--jan 99	8.36--oct 99
Sulfate (250,000)	50,600--mar 99	7,108--oct 98	50,820--jul 99	15,770--oct 98
Tetrahydrofuran (100)	(u)	(u)	(u)	(u)
Total Dissolved Solids (500,000)	291,000--oct 98	156,000--oct 98	248,000--jul 99	188,000--apr 99
Gross Alpha (pCi/L)[b]	3.2--apr 99	0.76--jan 99	2.2--apr 99	1.7--jan 99
Gross Beta (pCi/L)[b]	7.1--jan 99	2.3--jan 99	4.2--jul 99	2.8--jan 99
Strontium-90 (pCi/L)[b]	(u)	(u).	1.6--jan 99	5.5--oct 98
Tritium (pCi/L)[b]	220--jul 99	140,000--oct 98	77,000--jul 99	730,000--oct 98

Notes:

1. All concentrations in ug/L unless noted.
2. "(u)" = not detected
3. "(J)" = estimated quantity (concentration is below laboratory internal standards for accurate quantitation)

(a) Anomalous reading–see text for discussion.
(b) Constituent is not assigned an enforcement limits, but is subject to routing monitoring and reporting.
(c) The average of four sequential measurements after readings have stabilized.

Coincident with the first detection of elevated tritium in late 1996, concentrations of sulfate and a few other parameters were also found to have increased in groundwater from well 699-48-77A. These occurrences were interpreted to be a result of the dilute (clean water) effluent from SALDS dissolving soluble mineral species (mostly gypsum) in the vadose zone during infiltration (Thornton 1997, Barnett et al. 1997). Figures 8 through 11 show the trends for some of the parameters that best reflect this phenomenon; e.g., sulfate, conductivity, and TDS. Other species, such as calcium, show a more subdued response during the same time period, probably as a result of cation adsorption. The trends are most pronounced in wells 699-48-77A and 699-48-77D because these wells are screened at the water table. Since the period of late 1996 to late 1997, these parameters have trended downward, except for recent incursions in well 699-48-77C, which is screened ~20 m below the water table. The effects of this event have only recently penetrated deeply enough into the aquifer to affect this well. Levels of some parameters, such as conductivity, may still be rising at this depth. Occasional "spikes" of these 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.

Recommendations for Continued Monitoring

Water levels in upgradient well 299-W8-1 and nearby RCRA wells continue to decline from the cessation of operations in the 200 West Area. Because this well is consistently lower in hydraulic head than SALDS "downgradient" (proximal) wells (699-48-77A, C, D), it does not accurately represent upgradient groundwater quality. Thus, it is recommended that this well be discontinued as an upgradient well for SALDS and henceforth sampled for tritium only, as part of the tritium-tracking network. Groundwater geochemical results in proximal wells at the SALDS (699-48-77A, C, D) will continue to be evaluated against the enforcement limits as provided in ST-4500.

Experience from other Hanford Site groundwater programs indicate that field measurements of pH are typically more reliable and consistent than single laboratory measurements from the same sampling event. The effects of transport and storage may occasionally have deleterious effects on the samples, such as loss of CO_2, which may cause elevated pH results. It is recommended that averaged quadruplicate measurements of pH, taken in the field after readings have stabilized, be used as the determinant of this property for future comparisons, instead of single laboratory measurements.

With rare exceptions, ammonia, benzene, and tetrahydrofuran have been largely undetectable in groundwater at the SALDS. Likewise, acetone has been detected infrequently at low levels, and is a known laboratory contaminant. Analyses for these constituents in groundwater should be reduced to annual frequency or discontinued. The continued monitoring of end-of-pipe discharge for these constituents will provide the necessary early warning.

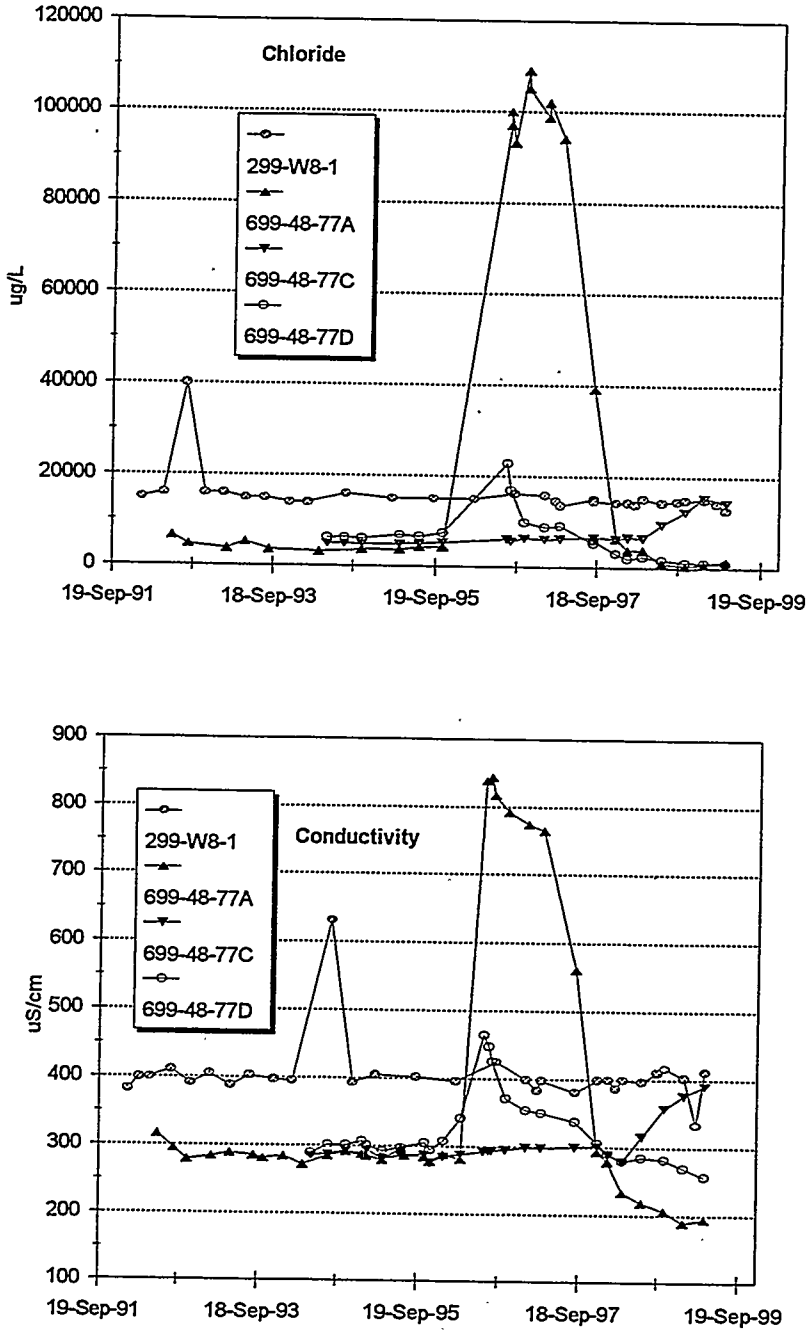

Figure 9. Trend Plots for Chloride (top) and Conductivity (bottom) in SALDS Proximal Wells and Upgradient Well 299-W8-1

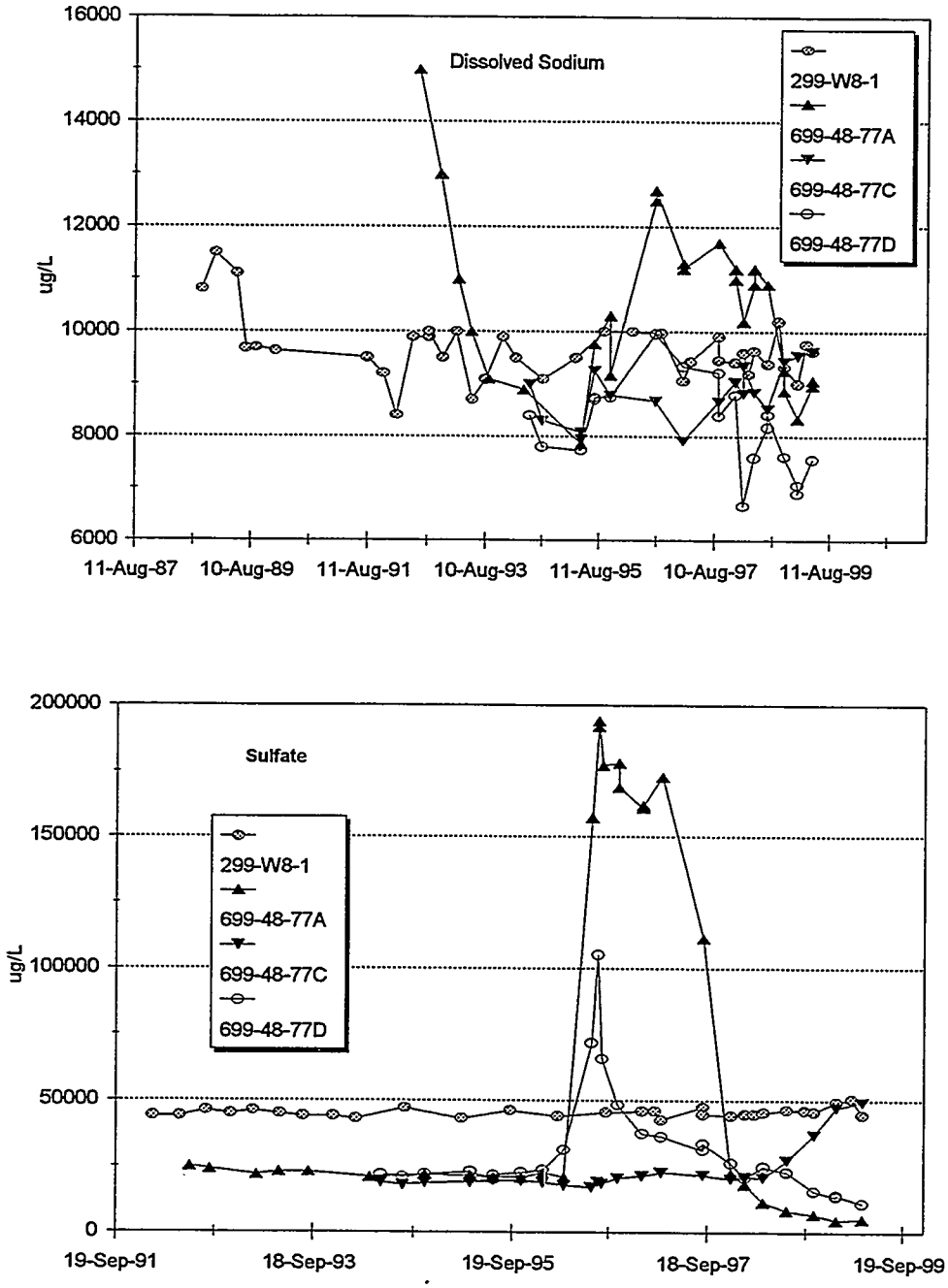

Figure 10. Trend Plots for Dissolved Sodium (top) and Sulfate (bottom) in SALDS Proximal Wells and Upgradient Well 299-W8-1

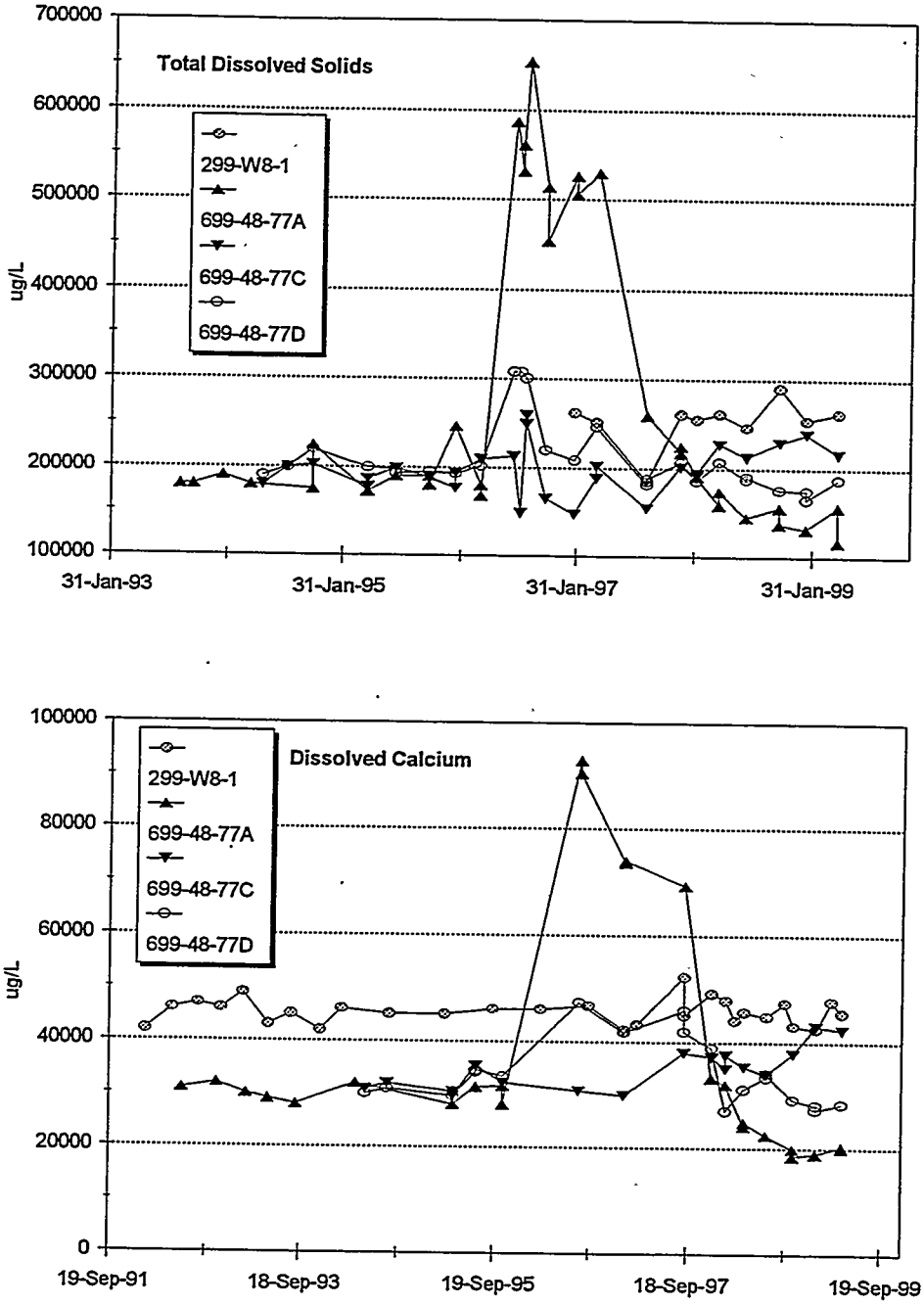

Figure 11. Trend Plots for Total Dissolved Solids (top) and Dissolved Calcium (bottom) in SALDS Proximal Wells and Upgradient Well 299-W8-1

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Barnett, D. B., M. P. Bergeron, C. R. Cole, M. D. Freshley, and S. K. Wurstner. 1997. *Tritium Monitoring in Groundwater and Evaluation of Model Predictions for the Hanford Site 200 Area Effluent Treatment Facility*. PNNL-11665, Pacific Northwest National Laboratory, Richland, Washington.

Thornton, E. C. 1997. *Origin of Increased Sulfate in Groundwater at the ETF Disposal Site*. PNNL-11633, Pacific Northwest National Laboratory, Richland, Washington.

Appendix A

SALDS Tritium Results During FY 1999

Appendix A. SALDS Tritium Results During FY 1999 (through August 1999)

Well	Result	Total Error	Qualifier	Sample Collection Date	Comments (change from FY 1998)
299-W6-6	173		U	13-Aug-99	(Unchanged)
299-W6-6	173		U	13-Aug-99	Duplicate
299-W6-7	32000			13-Aug-99	(Down from previous year)
299-W6-8	770			25-Mar-99	
299-W6-8	410			13-Aug-99	(Average is down from previous year)
299-W6-11	5700			13-Aug-99	(Down from previous year)
299-W6-12	380			13-Aug-99	(Down from previous year)
299-W7-1	-6.65	185	U	10-Mar-99	
299-W7-1	173		U	13-Aug-99	(Unchanged)
299-W7-11	-57	181	U	11-Mar-99	
299-W7-11	173		U	13-Aug-99	(Unchanged)
299-W7-12	-14.3	184	U	10-Mar-99	(Unchanged)
299-W7-3	-26.1	183	U	10-Mar-99	(Unchanged)
299-W7-5	40.8	188	U	11-Mar-99	(Unchanged)
299-W7-6	345	208	J	10-Mar-99	
299-W7-6	173		U	13-Aug-99	(Average is down from previous year)
299-W7-7	186	207	U	09-Mar-99	(Unchanged)
299-W7-8	314	207	J	11-Mar-99	(Down from previous year)
299-W7-9	223	200	U	11-Mar-99	Duplicate
299-W7-9	172	196	U	11-Mar-99	(Unchanged)
299-W8-1	274		U	20-Oct-98	
299-W8-1	141		U	13-Jan-99	
299-W8-1	193	198	U	11-Mar-99	
299-W8-1	193		U	20-Apr-99	
299-W8-1	220			13-Jul-99	(Up from all nondetect in previous year)
699-48-71	184		U	27-Jul-99	(Unchanged)
699-48-71	184		U	27-Jul-99	Duplicate
699-48-77A	140000			20-Oct-98	
699-48-77A	140000			20-Oct-98	
699-48-77A	30000			13-Jan-99	
699-48-77A	15000			20-Apr-99	
699-48-77A	15000			20-Apr-99	
699-48-77A	18000			14-Jul-99	(Average is down from previous year)
699-48-77C	2100			20-Oct-98	
699-48-77C	8100			13-Jan-99	
699-48-77C	35000			20-Apr-99	
699-48-77C	77000			13-Jul-99	

699-48-77C	77000		13-Jul-99	(Average is up significantly --deep well)
699-48-77D	730000		20-Oct-98	
699-48-77D	540000		13-Jan-99	
699-48-77D	540000		13-Jan-99	
699-48-77D	600000		20-Apr-99	
699-48-77D	610000		14-Jul-99	(Average is down from previous year)
699-49-79	140	U	25-Mar-99	(Unchanged)
699-51-75	140	U	25-Mar-99	
699-51-75	140	U	25-Mar-99	Duplicate
699-51-75	173	U	13-Aug-99	(Unchanged)

All results in pCi/L

Qualifiers: 'U = nondetect, J = estimated quantity

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