PNNL-11665
UC-502

Tritium Monitoring in Groundwater and Evaluation of Model Predictions for the Hanford Site 200 Area Effluent Treatment Facility

D. B. Barnett
M. P. Bergeron
C. R. Cole
M. D. Freshley
S. K. Wurstner

August 1997

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

Pacific Northwest National Laboratory
Richland, Washington 99352

DISCLAIMER

DISCLAIMER

Summary

The Effluent Treatment Facility (ETF) disposal site, also known as the State-Approved Land Disposal Site (SALDS), receives treated effluent containing tritium, which is allowed to infiltrate through the soil column to the water table. Tritium was first detected in groundwater monitoring wells around the facility in July 1996. The SALDS groundwater monitoring plan requires revision of a predictive groundwater model and reevaluation of the monitoring well network one year from the first detection of tritium in groundwater. This document is written primarily to satisfy these requirements and to report on analytical results for tritium in the SALDS groundwater monitoring network through April 1997. The document also recommends an approach to continued groundwater monitoring for tritium at the SALDS.

Tritium concentrations up to 530,000 pCi/L have been reported from well 699-48-77A, formerly an upgradient well. Tritium results of up to 3000 pCi/L have been reported in the nearby downgradient well 699-48-77C, which is screened ~20 m below the water table. Hydrogeologic and hydrochemical evaluations of the SALDS suggest that effluent infiltrating beneath the SALDS may be moving southward a limited distance along the relatively impermeable Plio-Pleistocene unit before reaching the water table. Concentrations of sulfate, calcium, total dissolved solids, and levels of conductivity parallel a rise in tritium, suggesting these constituents are leached from natural soil components in the vadose zone.

Comparison of numerical groundwater models applied over the last several years indicate that earlier predictions, which show tritium from the SALDS approaching the Columbia River, were too simplified or overly robust in source assumptions. The most recent modeling indicates that concentrations of tritium above 500 pCi/L will extend, at most, no further than ~1.5 km from the facility, using the most reasonable projections of ETF operation. This extent encompasses only the wells in the current SALDS tritium-tracking network.

Acknowledgments

The authors wish to thank R. D. Hildebrand, P. C. Mohondro, R. M. Smith, and B. A. Williams for their insightful review of the report and many useful discussions.

Acronyms

AFPM	Aquifer Porous Media
BHI	Bechtel Hanford, Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability
CFEST	Coupled Fluid, Energy, and Solute Transport
DGI	Dynamic Graphics Inc.
DOE-RL	U.S. Department of Energy, Richland Operations Office
DWS	Drinking Water Standard
ETF	Effluent Treatment Facility
LERF	Liquid Effluent Retention Facility
LLBG	Low-Level Burial Grounds
PNNL	Pacific Northwest National Laboratory
PQL	Practical Quantitation Level
RCRA	Resource Conservation and Recovery Act
SALDS	State-Approved Land Disposal Site
SOLTR	Solute Transport
SWDP	State Waste Dischargee Permit
VAM3D-CG	Variably Saturated Analysis Model in Three Dimensions with Preconditioned Conjugate Gradient Matrix Solvers
WAC	Washington State Administrative Code
WHC	Westinghouse Hanford Company

Contents

Figures

Tables

1.0 Introduction

The 200 Area Effluent Treatment Facility (ETF) is a combined treatment plant and disposal drainfield system that treats and disposes of wastewater from various cleanup activities on the Hanford Site. The treated effluent disposed to the drainfield contains varying amounts of tritium in concentrations of up to 2.4E+07 pCi/L. The facility operating permit, promulgated by Washington State Administrative Code (WAC) 173-216 (Ecology 1986), requires groundwater monitoring for tritium, reporting of monitoring results, and periodic review of the monitoring network.

This report describes the results of groundwater monitoring for tritium in the tritium-tracking network surrounding the ETF disposal site for the first ~1.5 years of operation. Additionally, the report presents a summary and comparison of the most recent numerical modeling results that predict tritium movement in the aquifer, and provides recommendations for continued groundwater monitoring at the ETF disposal site.

1.1 Background

The ETF treatment plant is located near the northeast corner of the 200 East Area of the Hanford Site (Figure 1.1). Numerous generating facilities produce liquid wastes that are conveyed directly to the ETF or to the Liquid Effluent Retention Facility (LERF), which stores the feed for later treatment at the ETF. The treated effluent, which may contain tritium, is then transferred by pipeline to a disposal drainfield ~ 500 m north of the 200 West Area for infiltration into the soil column. The disposal site drainfield is also known as the "State-Approved Land Disposal Site" (SALDS) and was formerly known as "Project C-018H." Sources of wastewater for the ETF include: The 242-A Evaporator, double-shell tank wastes, UP-1 pump-and-treat project, 222 S Lab wastes, and leachates from the Environmental Remediation Disposal Facility (ERDF), and other disposal trenches. Not all of these streams contain tritium. Stream feeds from the UP-1 pump-and-treat project and the 242-A Evaporator are conveyed to the ETF by pipeline (Figure 1.1). Other streams are trucked to the facility. ETF operation is described in greater detail by DOE-RL (1993).

A Washington State Waste Discharge Permit (No. ST-4500) was granted for the ETF in June 1995, and the facility began receiving effluent in December 1995. In January 1996, the *Ground Water Screening Evaluation/Monitoring Plan -- 200 Area Effluent Treatment Facility (Project C-018H)* (Davis et al. 1996) was issued to: 1) summarize the hydrogeologic setting, 2) describe pre-operational groundwater monitoring at the SALDS, 3) provide plans for continued groundwater monitoring for nonradiological constituents, and 4) establish a plan for monitoring and tracking of tritium entering groundwater from the facility. Also included in the 1996 document are plans for updating a numerical model for prediction of groundwater flow and tritium transport. Specific elements of guidance in this plan are discussed in Section 2.0. Plans for sampling and analysis of the ETF effluent stream and the LERF, as required by Permit ST-4500, are presented in another document (WHC 1995).

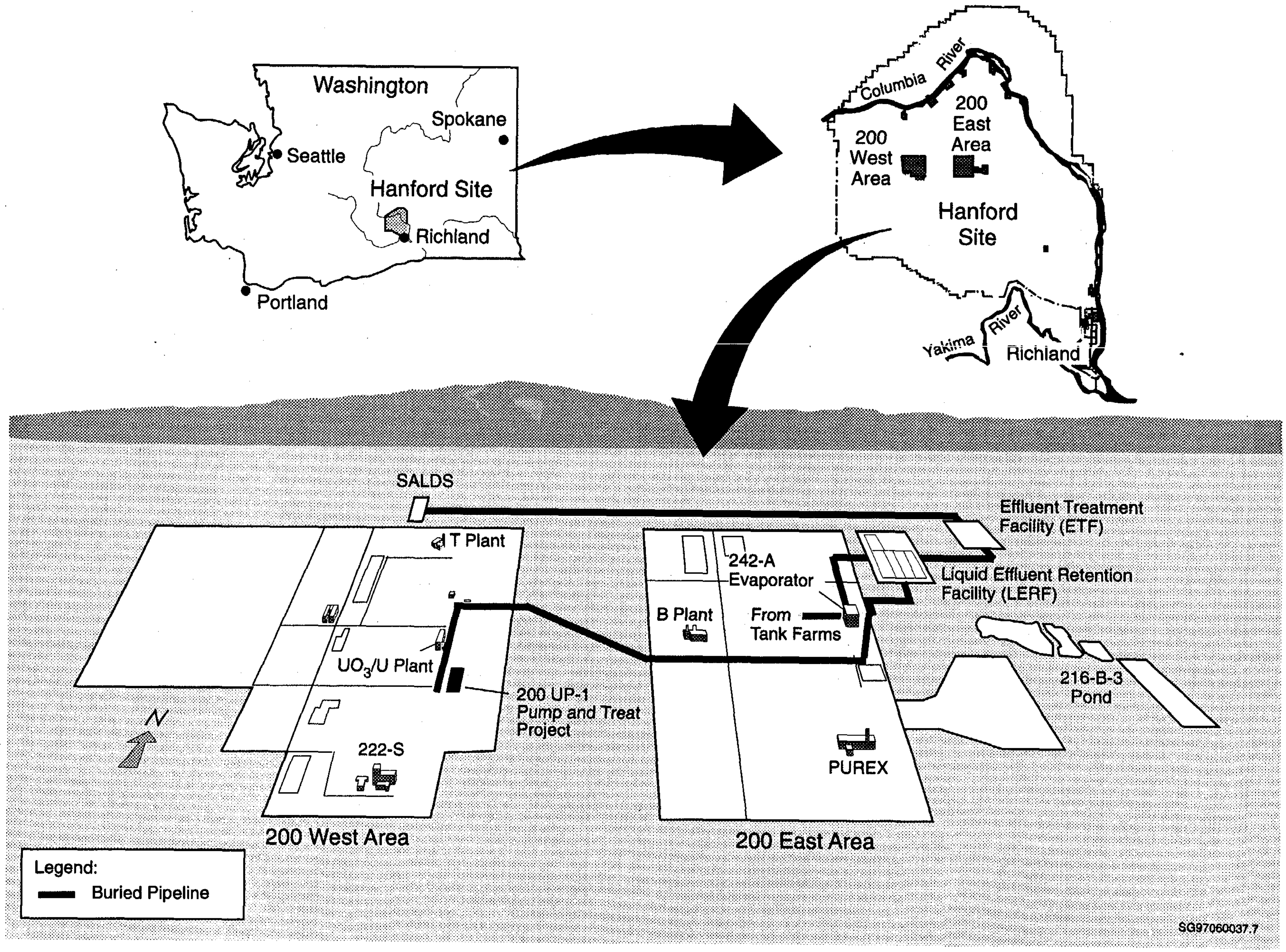


Figure 1.1. Schematic Perspective of the Effluent Treatment Facility (ETF), State-Approved Land Disposal Site (SALDS), and Related Infrastructure

The hydrogeological and geochemical framework of the SALDS is described in detail by Reidel (1993), Reidel and Thornton (1993), and Swanson (1994), and is summarized more recently by Davis et al. (1996). The most prominent hydrogeologic feature at the SALDS site is the Plio-Pleistocene Unit. This unit contains abundant carbonate cement and local calcrete, thus forming a potential discontinuous barrier to infiltration. The observed effects of this layer on SALDS operation are discussed in Section 6.0. Hydrogeology of the SALDS site is briefly summarized in Section 3.0.

Groundwater monitoring results at the SALDS prior to operation and the current groundwater monitoring network are described by Davis et al. (1996). Three wells (one upgradient and two downgradient) are the original wells drilled for groundwater monitoring purposes (Figure 1.2). Groundwater monitoring began in 1992 in well 699-48-77A, and in 1994 in wells 699-48-77C and 699-48-77D. Discharges to the facility during 1995 and early 1996 produced a slight hydraulic mound in the vicinity of the SALDS, thus compromising the status of the upgradient well. To reestablish an upgradient monitoring site, an existing Resource Conservation and Recovery Act (RCRA) monitoring well, 299-W8-1, was selected as a replacement upgradient well in late 1996 (see Section 3.2). The ETF groundwater monitoring plan (Davis et al. 1996) also identifies numerous other wells between the SALDS and the Columbia River for the purpose of tritium monitoring only (Figure 1.3). The more distant wells are considered potential future tritium monitoring sites, but a subset of 20 of these wells in the immediate vicinity of the SALDS are part of the current, "near-field" tritium-tracking network (Figure 1.4).

Tritium originating from the SALDS was first detected in groundwater in July 1996 in well 699-48-77A, the former upgradient well, and the well most distant from the facility in the original SALDS network. The probable reasons for this occurrence are discussed in Section 6.0.

1.2 Objectives and Scope

The purpose of this document is to present an overall assessment of the tritium-tracking network at the SALDS and recommend an approach to continued monitoring. The document specifically addresses:

- results and interpretations from the first phase of tritium monitoring
- results and applicability of past and current vadose-zone and groundwater modeling predictions
- evaluation of the current monitoring well network
- recommendations for continued tritium monitoring, based on the hydrogeologic evaluation of the network and numerical groundwater modeling results.

The document reports on the results of tritium monitoring in groundwater in the vicinity of the SALDS, and does not discuss groundwater monitoring results for other constituents, except as they relate to tritium transport or hydrogeological interpretation. The evaluation of vadose-zone and

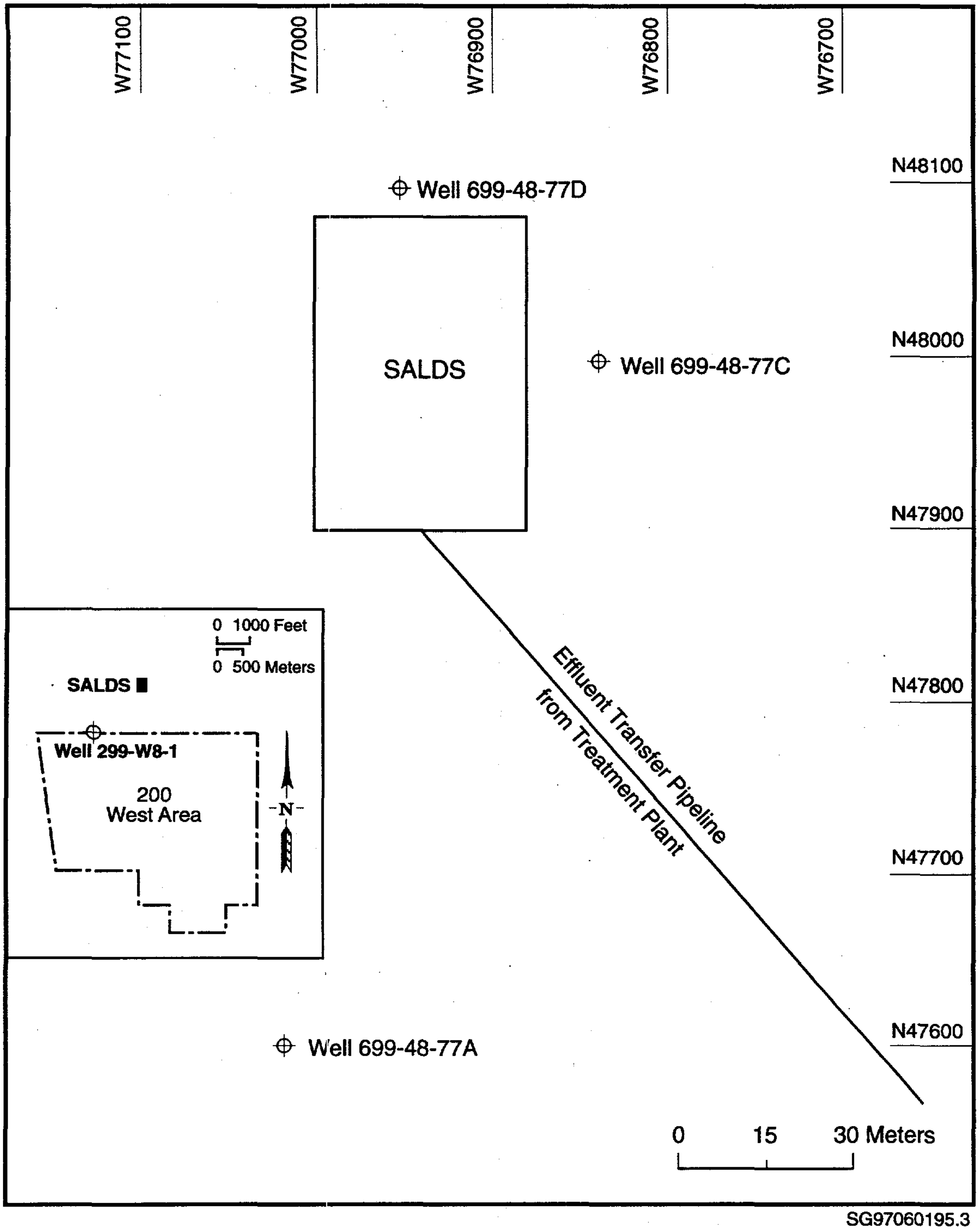


Figure 1.2. Location of the SALDS, the Original Three Monitoring Wells, and Upgradient and Upgradient Replacement Well 299-W8-1

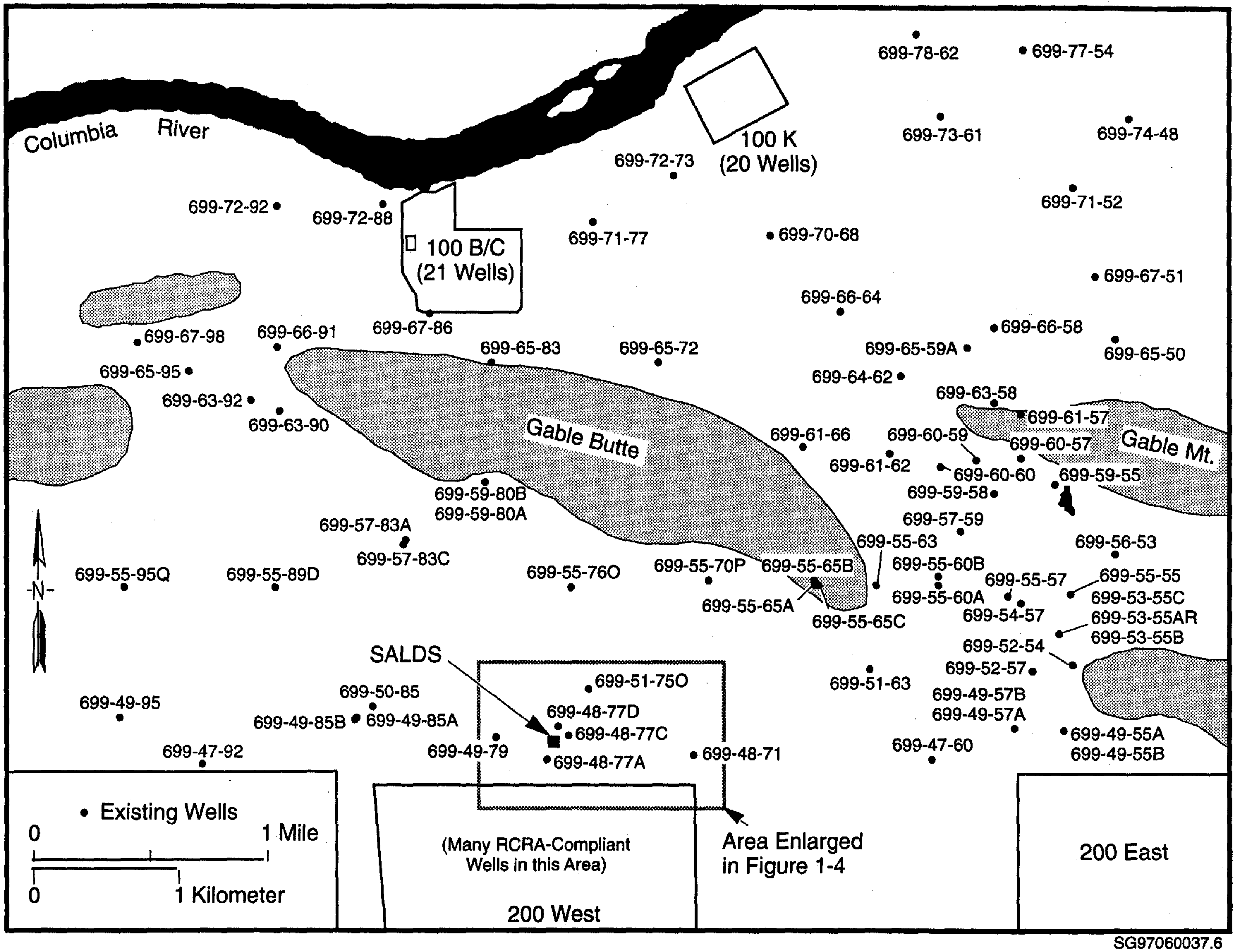


Figure 1.3. Location of the SALDS Showing Active and Potential Tritium-Tracking Wells

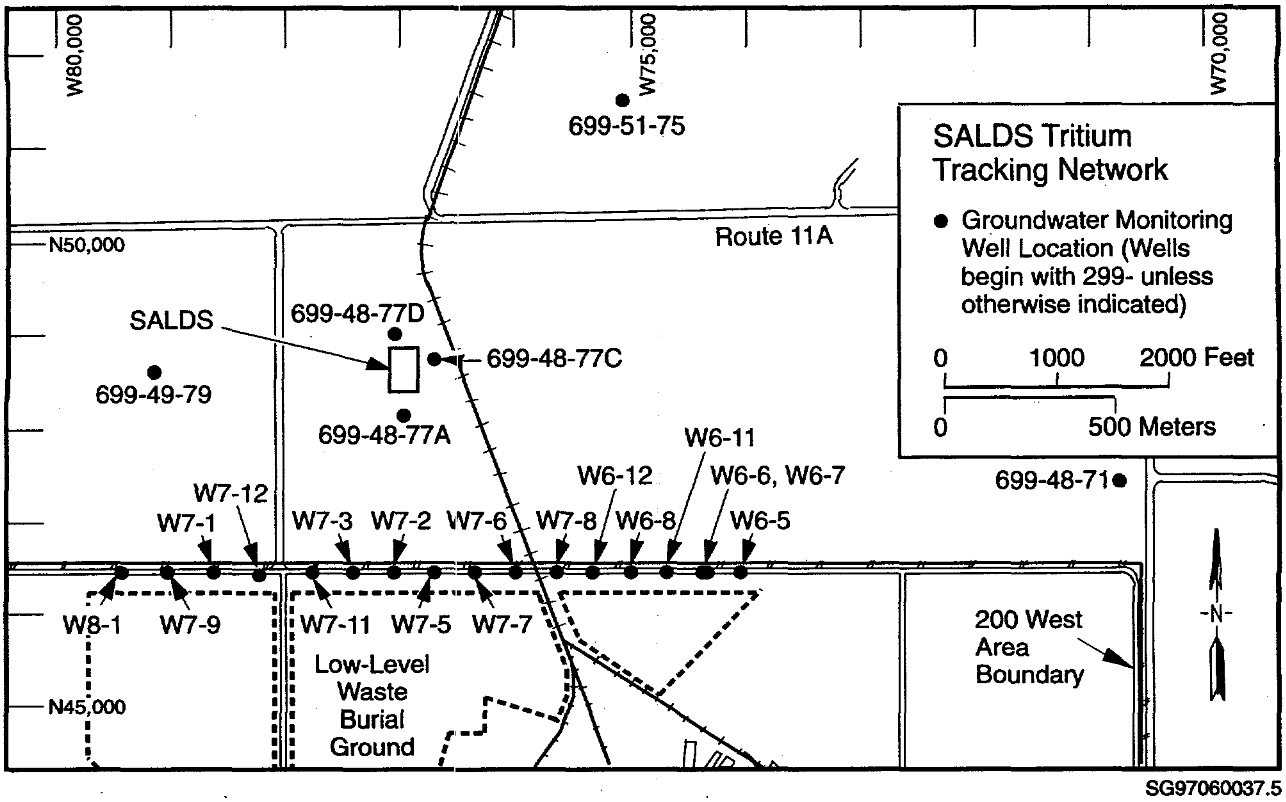


Figure 1.4. Monitoring Well Locations for the Current SALDS Tritium-Tracking Network

groundwater modeling (conceptual and numerical) is analyzed from the standpoint of the results produced and the fundamental reasons or assumptions that account for the differences in results between models, and between model predictions and actual observations. No attempt is made at an in-depth analysis of model parameters or model architecture.

The results and interpretations of groundwater monitoring for tritium presented in this document cover the period from the beginning of monitoring at the SALDS wells (June 1992) through December 1996. More recent data are available from the three original wells near SALDS and are included for interpretive purposes. Older data from wells predating SALDS construction are also provided for reference.

2.0 State Waste Discharge Permit Compliance

Specific requirements for monitoring tritium concentrations in groundwater beneath the SALDS are defined in State Waste Discharge Permit ST-4500 (SWDP) (Ecology 1995), as promulgated by WAC 173-216 (Ecology 1986). The SWDP also draws upon provisions in WAC 173-200 *Water Quality Standards for Ground Waters of the State of Washington* (Ecology 1990) for actions to address the exceedance of early-warning values for monitored constituents. The SWDP requires that groundwater sampling and analysis be conducted on a quarterly basis in the three original SALDS wells (Figure 1.2). Enforcement limits or specific conditions for monitoring are listed for several constituents, including tritium.

Because the U.S. Department of Energy is self-regulating with regard to radionuclides, the SWDP does not assign a permit limit or early-warning value for tritium concentration. However, the SWDP establishes a Practical Quantification Level (PQL) and a mandatory sampling/analysis schedule for tritium and other constituents. The plans for implementation of the SWDP groundwater monitoring requirements are presented by Davis et al. (1996) in the ETF groundwater monitoring plan. The SWDP also requires submission of specific groundwater reports and plans over the life of the permit. These reports include a pre-operational groundwater report describing background conditions, an annual report of groundwater analytical results, and a groundwater monitoring plan.

The SWDP empowers the ETF groundwater monitoring plan (Davis et al. 1996) as the planning vehicle for:

- continued groundwater monitoring and analytical reporting for all chemical constituents
- development of a tritium-tracking well network and reporting schedule for tritium analyses
- computer modeling updates for tritium-transport predictions
- contingency measures in the event that tritium originating from the SALDS is predicted to reach the Columbia River in concentrations that exceed the Drinking Water Standard (DWS) for tritium (20,000 pCi/L).

These requirements are integrated with the hydrogeologic and geochemical setting of the SALDS and knowledge of existing groundwater-monitoring infrastructures to arrive at specific actions for groundwater monitoring, modeling, and reporting. For tritium tracking in groundwater at the SALDS, the actions specified by Davis et al. (1996) are as follows.

1. Quarterly sampling and analysis in the three facility wells (699-48-77A, C, D) to determine if changes have occurred from pre-operational conditions and evaluate the effects, if any, of the facility

on groundwater quality (the number of wells is now four, with the addition of 299-W8-1 as the new upgradient well)

2. Annual (at minimum) tritium monitoring in an additional 20 nearby, existing wells surrounding the facility (Figure 1.3), many of which are monitored for tritium by other programs (e.g., RCRA). These wells will be used for model calibration and to maintain definition between tritium originating from the SALDS and tritium from the 200 West Area

3. Provisional evaluation of the integrity of the monitoring network in the event that tritium sampling for a well is dropped by another program or tritium is detected in downgradient monitoring wells significantly sooner than predicted by modeling

4. Scheduled evaluation of the effectiveness of the monitoring network and updating of the numerical model either 1) within 4 years of the current permit issuance date or 2) within 1 year of the initial appearance of tritium in a tritium-tracking well, whichever occurs first

5. Revision of the numerical model every 5 years (every permit cycle)

6. Presentation to the Washington State Department of Ecology (Ecology) a list of proposed actions, within 90 days, should a model revision predict that tritium will exceed regulatory standards at the Columbia River

7. Identification of an additional, "far field" array of serviceable wells for potential future tritium monitoring (see Figure 1.4).

Two general phases of groundwater monitoring for tritium are defined. The first phase affects monitoring, model recalibration, and network evaluation involving the nearby 23 wells (1-5 above). The second phase incorporates "far-field" wells into the active network, and is predicted to occur after several years or decades of SALDS operation (see Section 5.0).

Because tritium was detected in the July 1996 samples of well 699-48-77A, the actions required by elements 3, 4, and 5 are thus addressed in this document.

3.0 Summary of Hydrogeologic Setting

This section briefly describes salient elements of the hydrogeologic framework specific to the SALDS. Details of this hydrogeologic setting are presented by Lindsey and Reidel (1992), Reidel (1993), and Reidel and Thornton (1993), with more recent information compiled by Davis et al. (1996). Lindsey et al. (1994) described the stratigraphy and provided detailed geologic cross-sections of the Low-Level Burial Grounds (LLBG) in the 200 West Area, immediately south of the SALDS. The 200 West LLBG is a RCRA facility, and hosts several wells used in the SALDS tritium-tracking network. Details of the carbonate-rich Plio-Pleistocene unit, an important vadose-zone stratum beneath the SALDS, are provided by Slate (1996).[a] Hanford Site geology and stratigraphy have been characterized by Myers et al. (1979), DOE (1988), Delaney et al. (1991), and Reidel et al. (1992). Groundwater hydrology of the Hanford Site and the surrounding region is discussed by Gephart et al. (1979), Wurstner et al. (1995), and is most recently summarized by Hartman and Dresel (1997).

3.1 Stratigraphy of the SALDS

Figure 3.1 illustrates suprabasalt stratigraphy in portions of the 200 West Area, extending northward through the SALDS site. Figure 3.2 shows stratigraphic relationships beneath the SALDS, as determined by site-specific investigations.

The Miocene Elephant Mountain Member of the Saddle Mountains Formation basalt underlies the sequence of sediments of late Miocene to Holocene age that comprise the vadose zone and uppermost, unconfined aquifer beneath the Hanford Site. The basalt surface occurs at a depth of ~ 132 m beneath the SALDS. The surface of the basalt beneath the facility dips to the south at ~3°.

The late Miocene-to-Pliocene Ringold Formation fluviolacustrine sediments immediately overlie the basalt, and account for ~84% (~119 m) of thickness of the suprabasalt strata beneath the SALDS. The top of the Ringold occurs approximately 19 m below land surface at this location. The dominant facies of the Ringold Formation beneath the SALDS are fluvial sand and gravel of the upper Ringold and units A and E (Figure 3.2). The Ringold Formation sediments are variably cemented at this location with calcium carbonate and probably other evaporite minerals (see Section 4.2). The structural trend of these strata appears to be concordant with that of the underlying basalt.

The Plio-Pleistocene unit overlies the Ringold Formation, and is ~16 m thick beneath the SALDS. The top of the unit is encountered at only 2 m (6 ft) below the surface in well 699-48-77D, and, like the basalt surface, dips gently to the south. The Plio-Pleistocene unit is typically silt, sand, and local basaltic gravel, with abundant carbonate cement and local caliche layers. Lindsey and Reidel (1992) describe

[a] Slate, J.L. 1996. *Report for Virginia Rohay on Boreholes in the 200 West Area Regarding the Nature and Variability of the "Caliche."* Unpublished Report for IT Hanford Company, Richland, Washington.

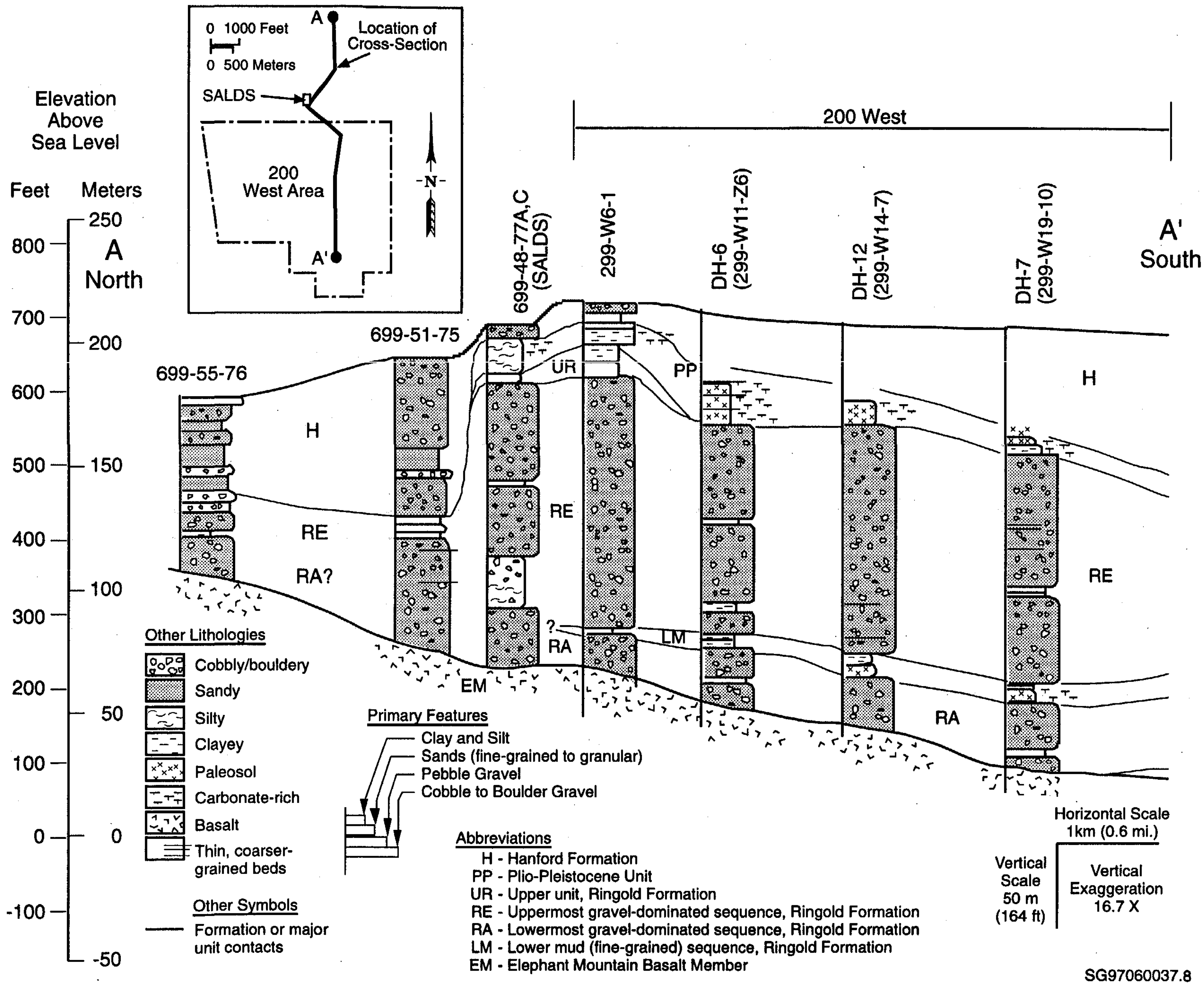


Figure 3.1. Cross Section of Suprabasalt Sedimentary Units in the Vicinity of the 200 West Area and the SALDS

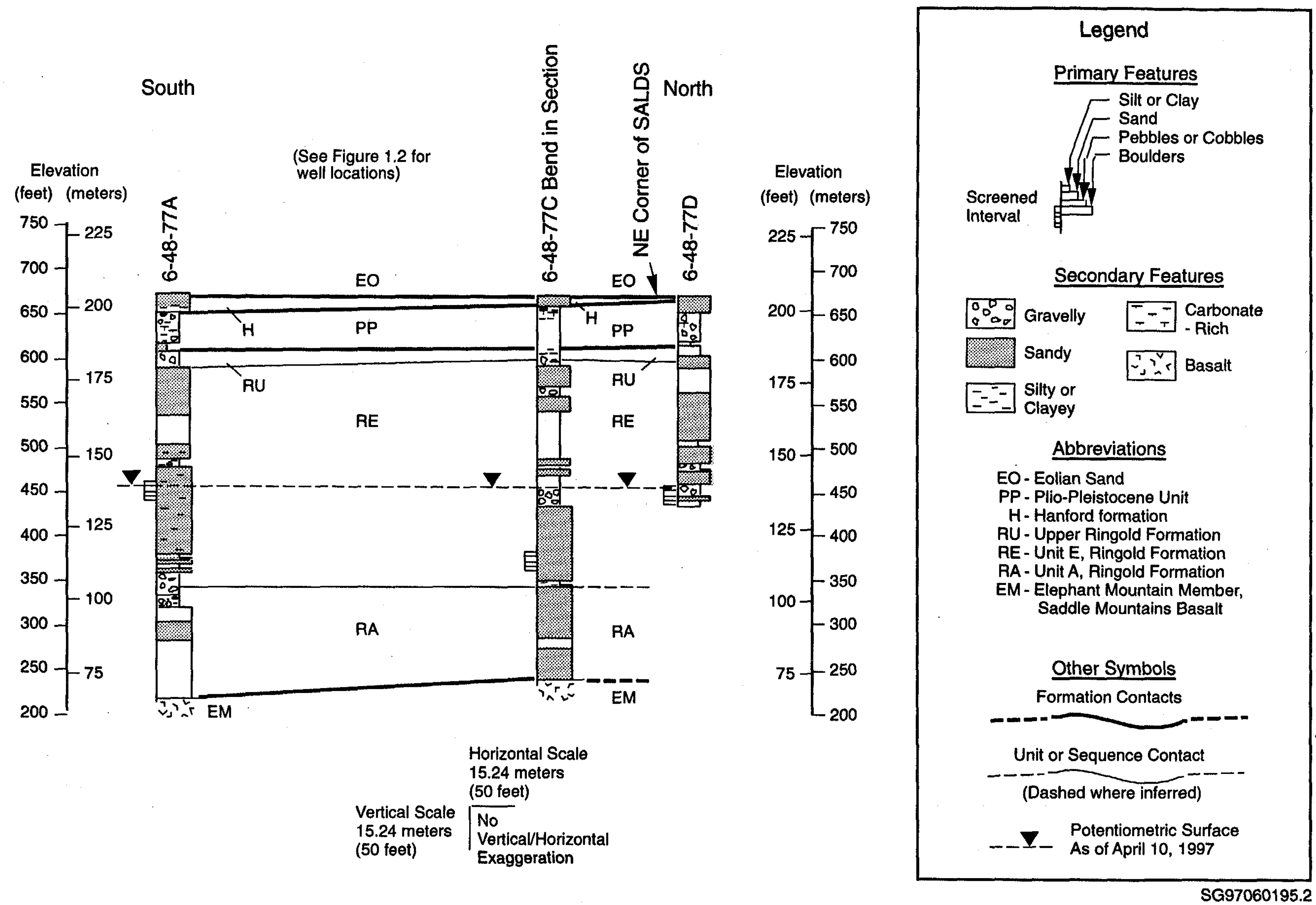


Figure 3.2. Cross Section of Suprabasalt Stratigraphy Beneath the SALDS

this unit as occurring discontinuously throughout much of the 200 West Area. Lindsey et al. (1994) state that it is continuous beneath the entirety of the LLBG immediately south of the SALDS, but add that considerable variability exists in carbonate cementation and degree of caliche development at this location. Slate (1996)[a] describes the caliche of the Plio-Pleistocene unit as a persistent feature in the 200 West Area, but varying considerably in thickness and degrees of development. From cored intervals of boreholes at the SALDS, Reidel and Thornton (1993) note a lack of "significant" caliche layers or calcrete zones in the Plio-Pleistocene unit, with mostly thin (<0.5 cm) stringers of caliche present. Observations made by Swanson (1994) during the excavation of infiltration test holes near the SALDS also attest to the lateral variability in cementation and permeability of the Plio-Pleistocene unit at this site.

The Hanford formation sediments consists of non-cemented gravel, sand, and silt, which unconformably overlie the Plio-Pleistocene unit in the 200 West Area. In the vicinity of the SALDS, the Hanford formation is encountered at approximately 0.5 m below land surface, and is only 1.4-m thick near the northern edge of the facility; to 6.4-m thick near well 699-48-77A. The Hanford formation is overlain by a thin veneer of eolian sand.

3.2 Groundwater Hydrology of the SALDS

The uppermost, unconfined aquifer beneath the SALDS occurs primarily within units E and A of the Ringold Formation. The water table (or potentiometric surface) occurs approximately 68 m below land surface at the SALDS (Figure 3.2). Although the uppermost aquifer is unconfined on a Hanford sitewide scale (Thorne 1997, in Hartman and Dresel 1997), local confining conditions exist. Based on constant-rate pumping tests, two "semi-confining" horizons within the Ringold Formation, beneath the SALDS, are postulated by Swanson (1994). These horizons are interpreted as irregular patterns of cementation in the Ringold Formation and may have a highly localized effect on groundwater movement.

Hydraulic head decreases in a northeasterly direction (Figure 3.3) in the vicinity of the SALDS. Based on estimates of hydraulic conductivity and effective porosity from the three wells nearest the facility, and the April 1995 hydraulic gradient, the average linear flow velocity of groundwater beneath the SALDS was calculated at 0.5 to 1.1 m/d in a northeasterly direction (Davis et al. 1996). This range of velocities should be viewed with caution because the effective porosity estimates typically have a large range of uncertainty. Groundwater velocities indicated by the current numerical model (see Section 5.3) may be considered more representative, especially over a longer time frame. This is because the hydraulic properties used are derived from, and integrated over a much larger area. The local groundwater velocity magnitude and direction may be expected to change as mounding occurs and subsides beneath the SALDS in response to ETF discharges.

[a] Slate, J.L. 1996. *Report for Virginia Rohay on Boreholes in the 200 West Area Regarding the Nature and Variability of the "Caliche."* Unpublished Report for IT Hanford Company, Richland, Washington.

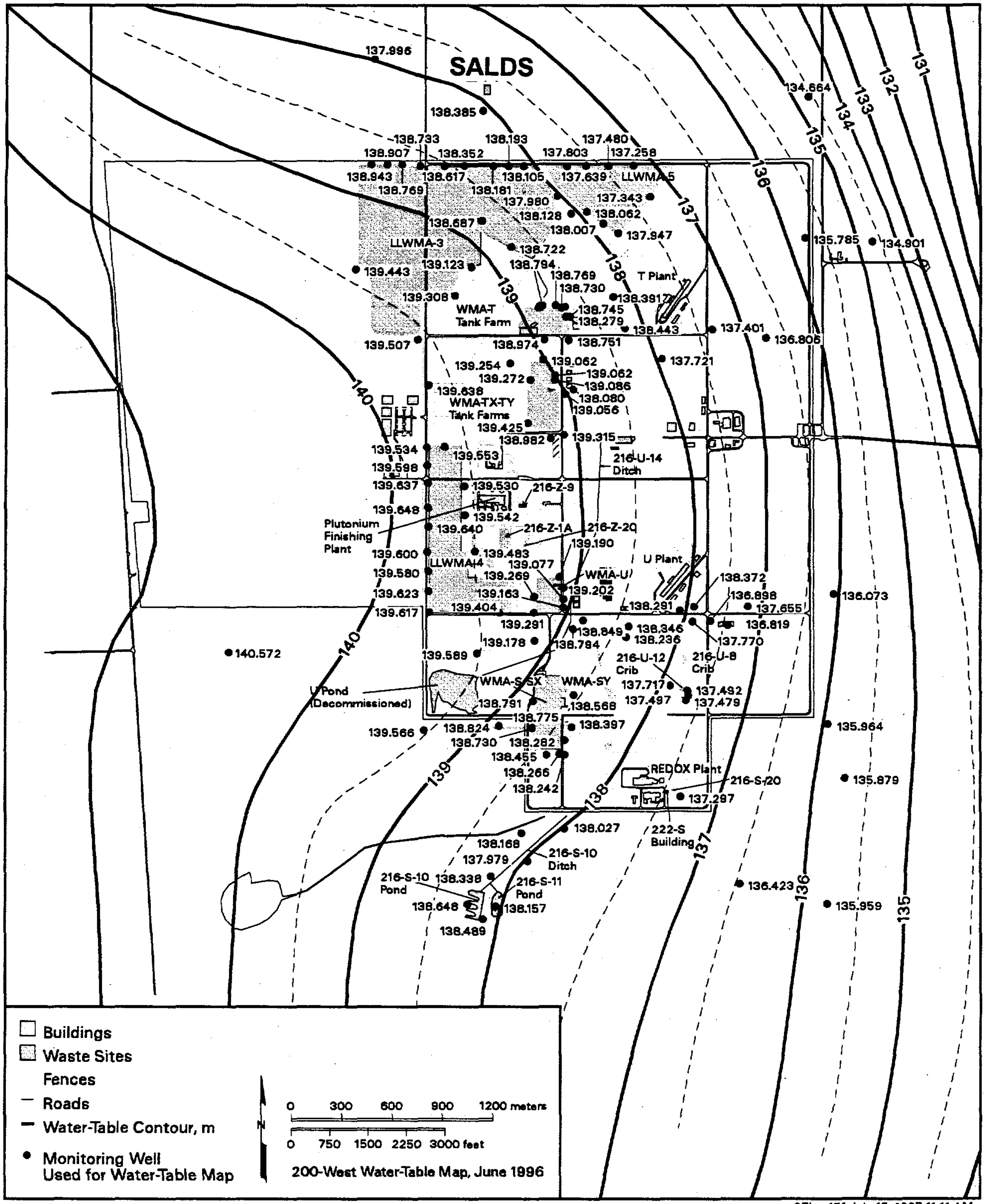


Figure 3.3. Water table contours for the 200 West Area and SALDS, June 1996 (After Hartman and Dresel 1997)

Water level measurements are made monthly in the four facility wells (Figure 1.2) , and quarterly, semiannually, or annually in other wells. Water level measurements have been taken from well 299-W8-1 since 1987 as part of RCRA monitoring for the 200 West Area LLBGs. Monitoring of water levels began in well 699-48-77A in 1992 and in wells 699-48-77C and D in 1994. Figure 3.4 is a hydrograph of all four wells through May 1997. Clearly evident is the continuing decline in head in these wells mostly as a result of the cessation of 200 West Area disposal practices. Superimposed on this downward trend, for the three wells nearest the SALDS (699-48-77A, C, D), are smaller perturbations interpreted as SALDS disposal events.

Of chief concern was the transposition of upgradient and downgradient hydraulic status between these three wells as a groundwater mound developed beneath the facility. Well 699-48-77A was initially intended as the upgradient monitoring location for the SALDS (see Section 1.1), but because of the well's proximity to the facility, has occasionally had water levels lower than in downgradient wells 699-48-77C and 699-48-77D. As ETF operation continues, this condition will persist or become more pronounced, thus requiring the selection of a more suitable upgradient well. From the potential selection of wells immediately upgradient (~south) of the SALDS, well 299-W8-1 was chosen as the new upgradient monitoring location. This well was selected primarily because it is expected to be less affected by groundwater mounding from the SALDS than other potential monitoring wells to the east.

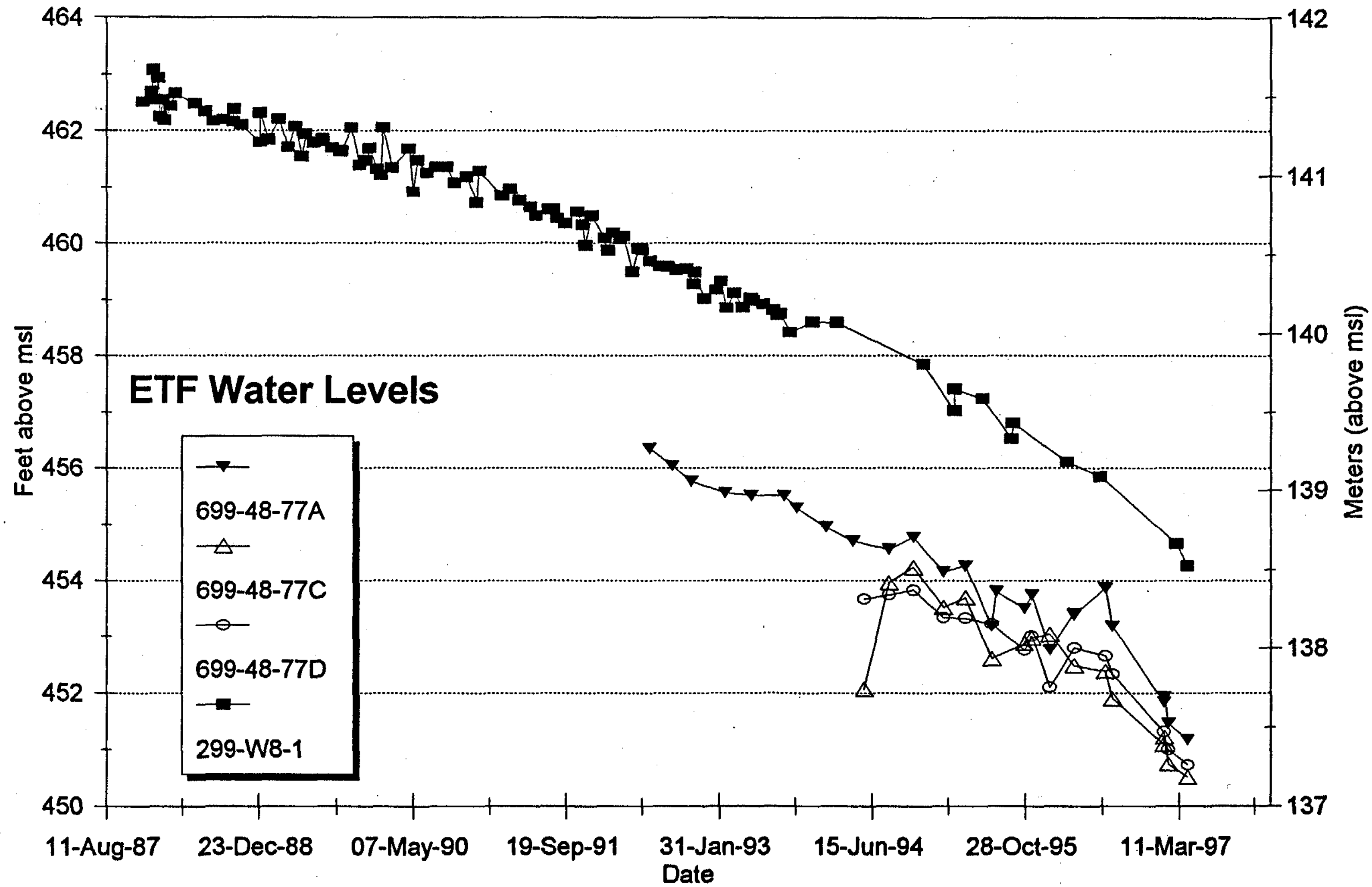


Figure 3.4. Hydrograph of the Four SALDS Groundwater Monitoring Wells through April 1997

4.0 Results of Tritium Monitoring in Groundwater at The SALDS

This section describes historical tritium monitoring and trends of tritium concentrations in wells in the current tritium tracking network (Figure 1.3). Analyses for tritium in groundwater samples from the wells drilled specifically for the SALDS began in 1992 in well 699-48-77A (77A) and in 1994 in wells 699-48-77C (77C) and 699-48-77D (77 D). These three wells are currently sampled quarterly for tritium. Tritium analyses in the new upgradient well, 299-W8-1, have been performed 1 to 4 times per year since 1988 as part of the RCRA groundwater monitoring program, but are now performed quarterly. The remaining 19 wells in the SALDS tritium-tracking network have been sampled at least annually for tritium according to various schedules of the RCRA and Operational Monitoring and/or sitewide monitoring programs (Davis et al. 1996). The results of these analyses are used by the SALDS tritium tracking project.

During 1996, it was determined that tritium analyses for 6 of the 19 wells were to be discontinued by existing groundwater monitoring programs. Hence, these wells were sampled specifically for the SALDS tritium-tracking network in December 1996 and will continue to be monitored by the SALDS tritium-tracking project (see Section 7.0).

4.1 History of Discharges to the SALDS

Effluent containing tritium was first discharged to the SALDS in December 1995. Appendix A lists the dates of these discharges and corresponding volumes. Figure 4.1 graphically illustrates the timing and volumes of these discharge events and the cumulative volumes. Points on the graph represent individual discharge events, each of which lasted 2 days. All discharges listed in Appendix A and illustrated in Figure 4.1 were process condensate and thus, contained tritium. The total inventory of tritium discharged to the facility as of March 1997 is approximately 238.5 Ci. As is evident from Figure 4.1, most of the total discharge occurred between December 1995 and June 1996.

In addition to the recorded discharges of Appendix A, a low-volume discharge of raw Columbia River water (not containing tritium) occurred in mid 1995 as a preliminary test of facility operation.

4.2 Trends of Tritium Concentrations in the SALDS Tritium-Tracking Wells

Appendix B lists all results produced for tritium in the tritium-tracking network (Figure 1.3) through April 1997. Figure 4.2 illustrates tritium concentration in each well within the network for the 1996 analyses, and the change in concentrations since 1995. Where multiple results exist for 1996, the highest result is plotted in Figure 4.2. If both 1995 and 1996 results are less than the calculated error (below quantification limits) "no change" is indicated for the trend. The result shown for Well 77A is from the April 1997 sample.

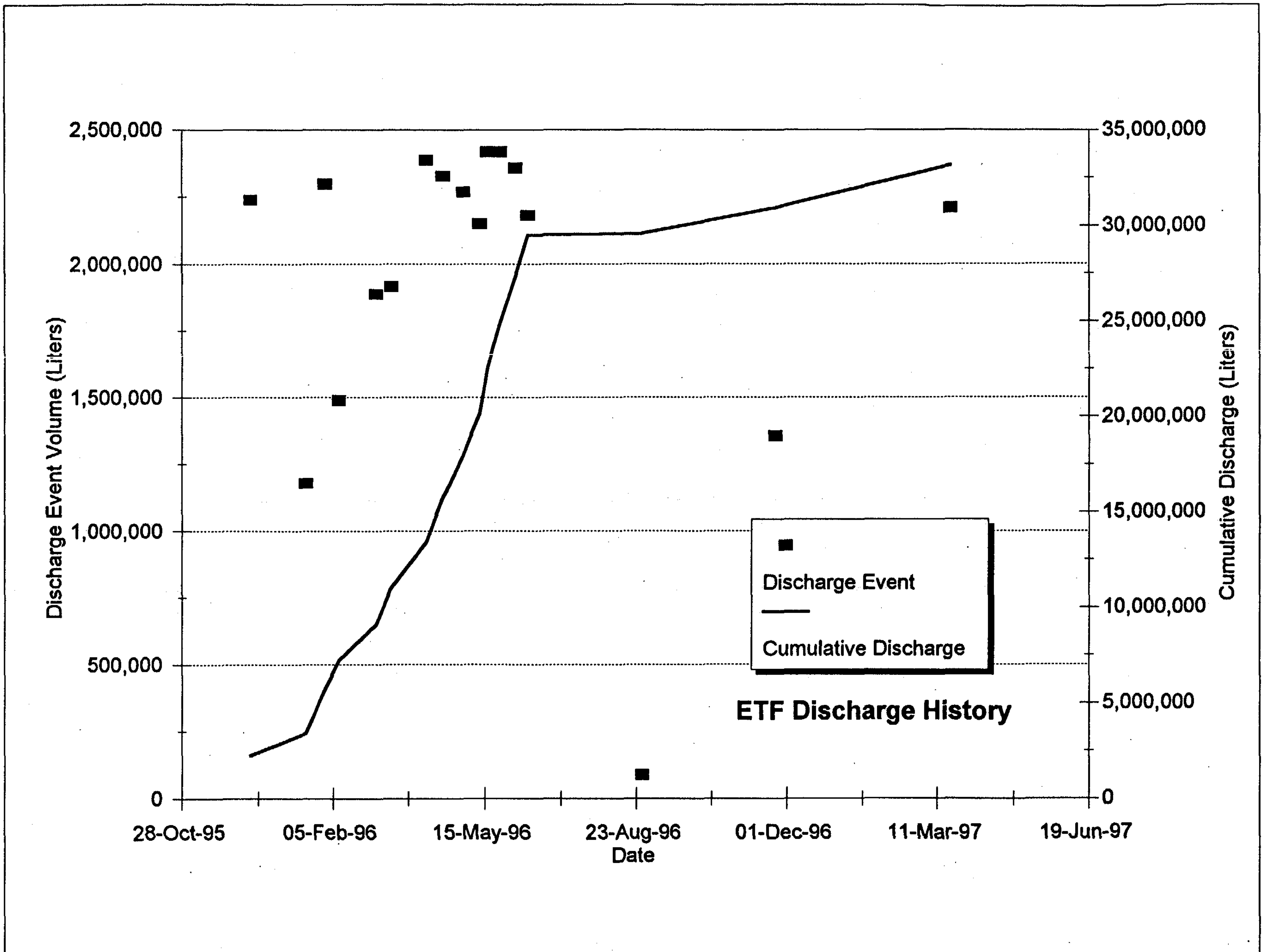


Figure 4.1. Volumes of Discharge Events and Culmulative Discharge-Volume Curve for ETF Discharges to the SALDS

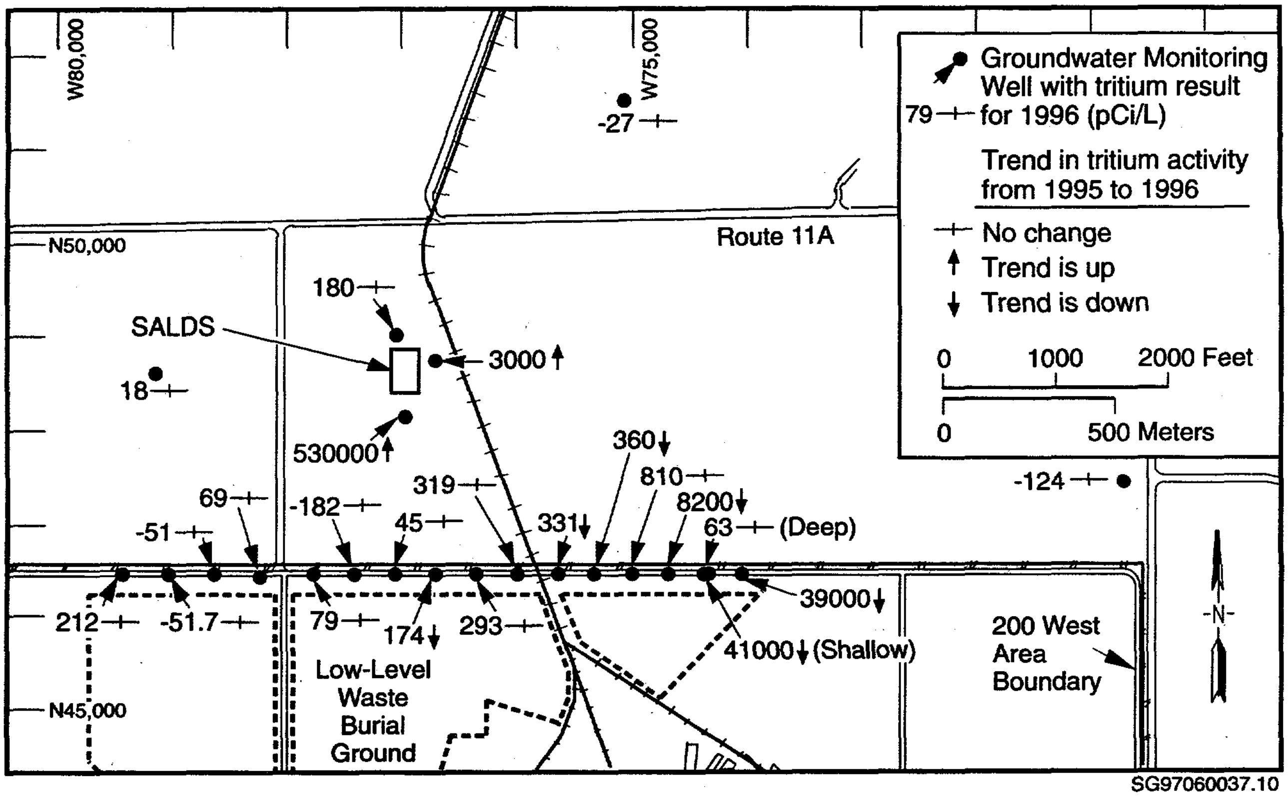


Figure 4.2. Wells in the Current SALDS Tritium-Tracking Network Showing Analytical Results for Tritium During 1996, and Change in Concentrations from 1995

With the exception of wells 77A and 77C, tritium concentrations in all wells in the network declined or were unchanged. Samples taken from well 77A in July 1996 indicated a demonstrative rise in tritium concentration from the previous analysis. Tritium concentration increased abruptly in this well from below detection in April 1996 to 74,000 pCi/L in July 1996, and subsequently rose to 530,000 pCi/L in April 1997.

The trends for tritium concentration in well 77A and the other two wells nearest the facility, 77C and 77D, are illustrated in Figure 4.3. Well 77C shows evidence of intermittent tritium incursion, although far less than 77A. Although two results for 77C are above 2000 and 3000 pCi/L, intervening and most-recent results returned to levels near detection limits. Well 77C is screened approximately 23 m lower in the aquifer than well 77A. It is possible that the trend of tritium displayed by well 77C is a result of the arrival of dilute effluent as it moves deeper into the aquifer near the facility. The effluent is then displaced and diluted by normal aquifer water, then once again briefly affected by effluent a second time before returning to normal levels (see Section 6.1).

The effects of the relatively pure water from the facility on the vadose zone is illustrated by an increase in dissolved soil components and conductivity. When tritium results from well 77A are

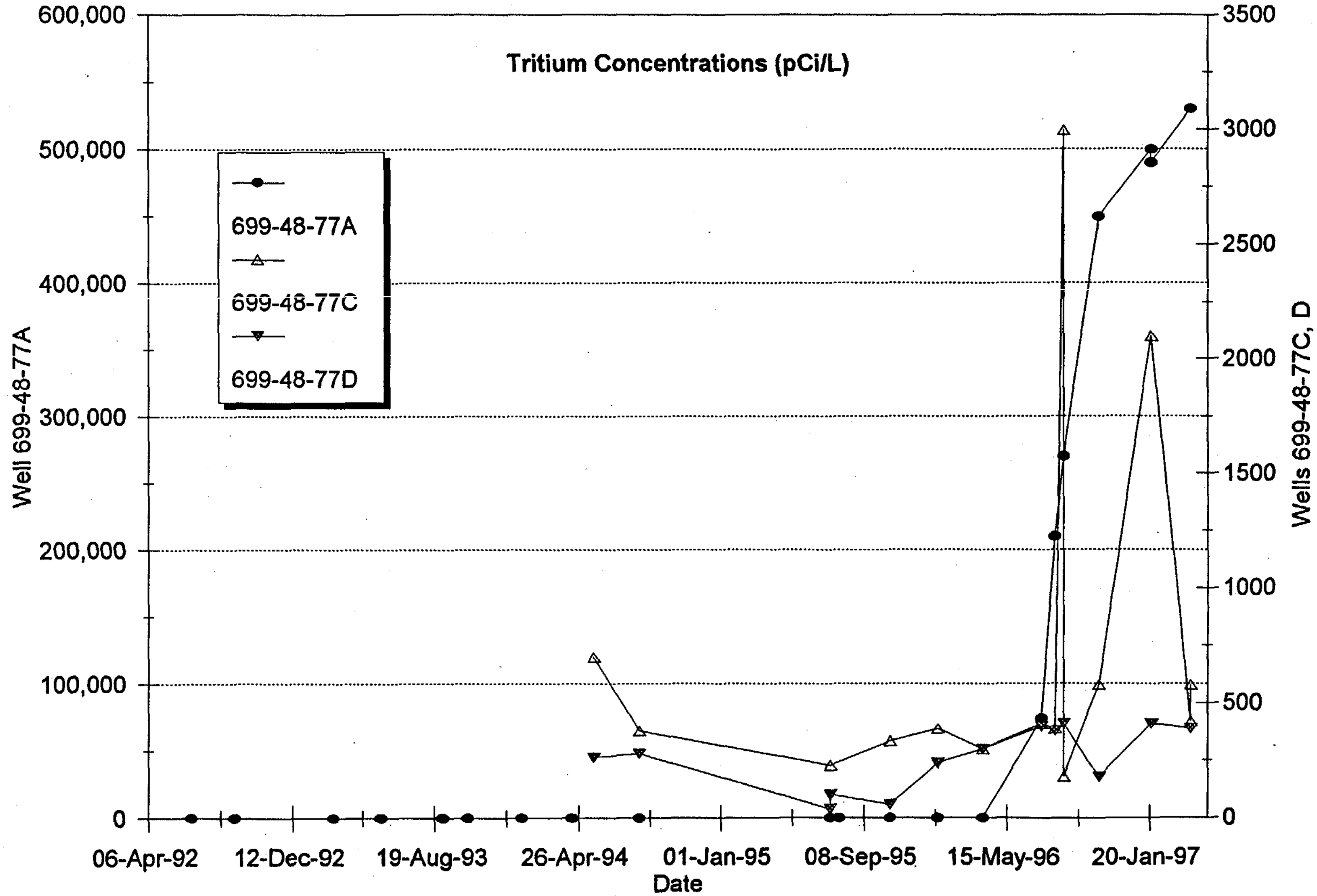


Figure 4.3. Plot of Tritium Concentrations in the Three Original Wells Adjacent to the SALDS

plotted with corresponding results for calcium, conductivity, and sulfate, a coincidence of trends is apparent (Figure 4.4). When these constituents are plotted for well 77C, tritium and sulfate show a clear correlation through time, but calcium and conductivity appear to be independent (Figure 4.5). However, as indicated by Figure 4.6, conductivity appears to rise slightly above all previous levels in July of 1996. This rise coincides with increasing tritium and sulfate of Figure 4.4.

Thornton (1997) recognized that the increased sulfate concentration in wells 77A and 77C is a result of effluent moving through the vadose zone, and that it coincided with the arrival of tritium. Thornton further illustrated that total dissolved solids and calcium concentrations rose in coincidence with sulfate and tritium in wells 77A and 77C. Earlier studies by Thornton (e.g., Reidel and Thornton 1993) established that sulfate, probably in the form of gypsum, is present within the Plio-Pleistocene unit in sufficient quantities to account for the observed concentrations of sulfate in the SALDS wells. Elevated concentrations of calcium are probably derived from the calcium-carbonate and caliche-rich layers in the Plio-Pleistocene unit.

Wells in the southeastern portion of the network produced tritium results of up to 41,000 pCi/L (well 299-W6-7) in 1996. This tritium is a remnant of a plume originating from now-discontinued operations in the northeast portion of the 200 West Area, and is reflected in several wells in this area. The wells between the remnant plume and the effluent originating from SALDS are consistently monitored to maintain resolution between the two sources. The remnant tritium plume has apparently changed little, or perhaps even contracted in the last few years (compare Dresel et al. 1994, and Hartman and Dresel 1997). Well 299-W6-6 is a deep companion well with 299-W6-7, and has consistently produced tritium results below detection. This condition suggests that tritium-contaminated groundwater is not reaching the lower portions of the aquifer at this location.

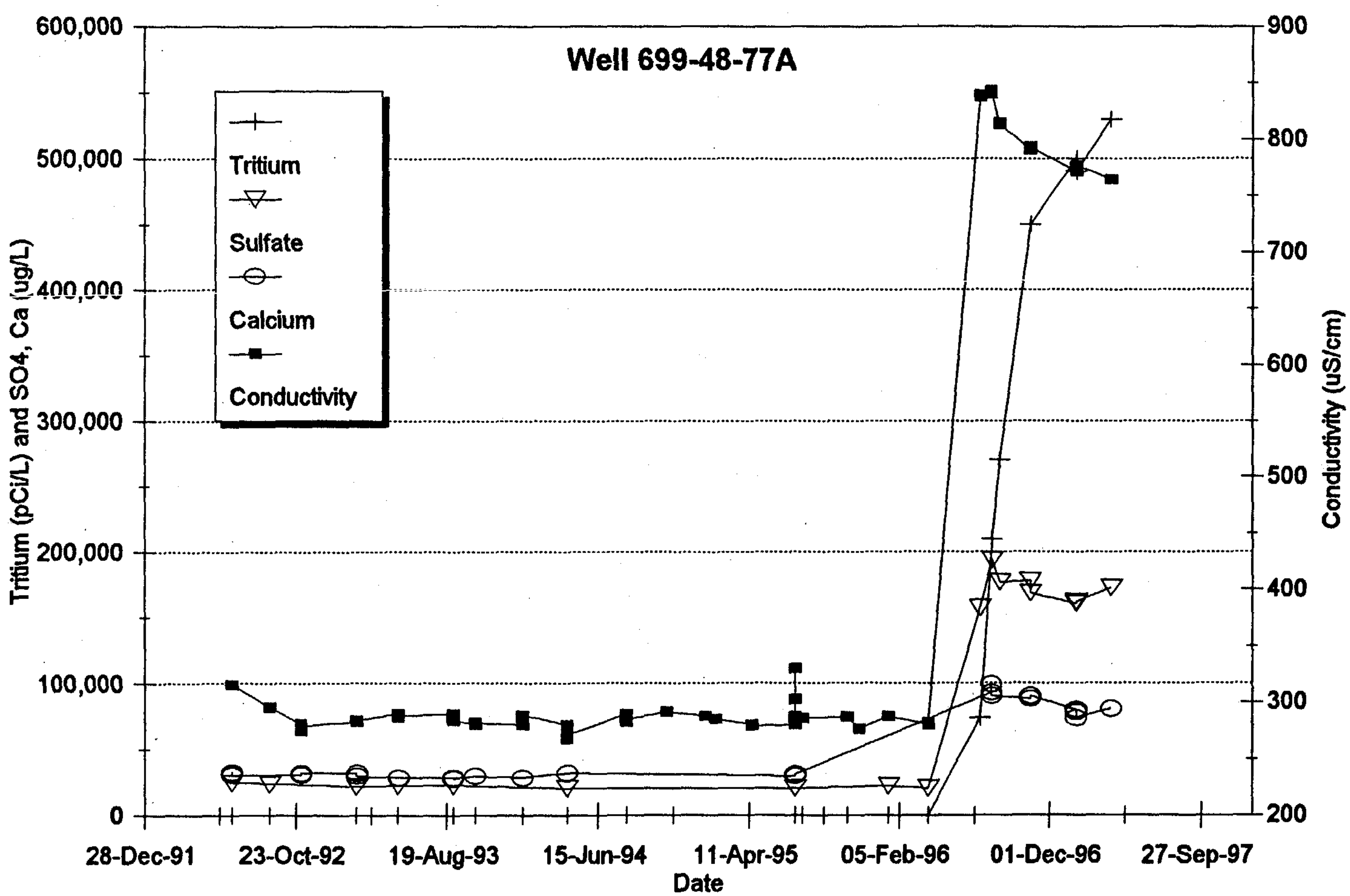


Figure 4.4. Plot of Tritium, Calcium, Sulfate, and Conductivity for Well 699-48-77A

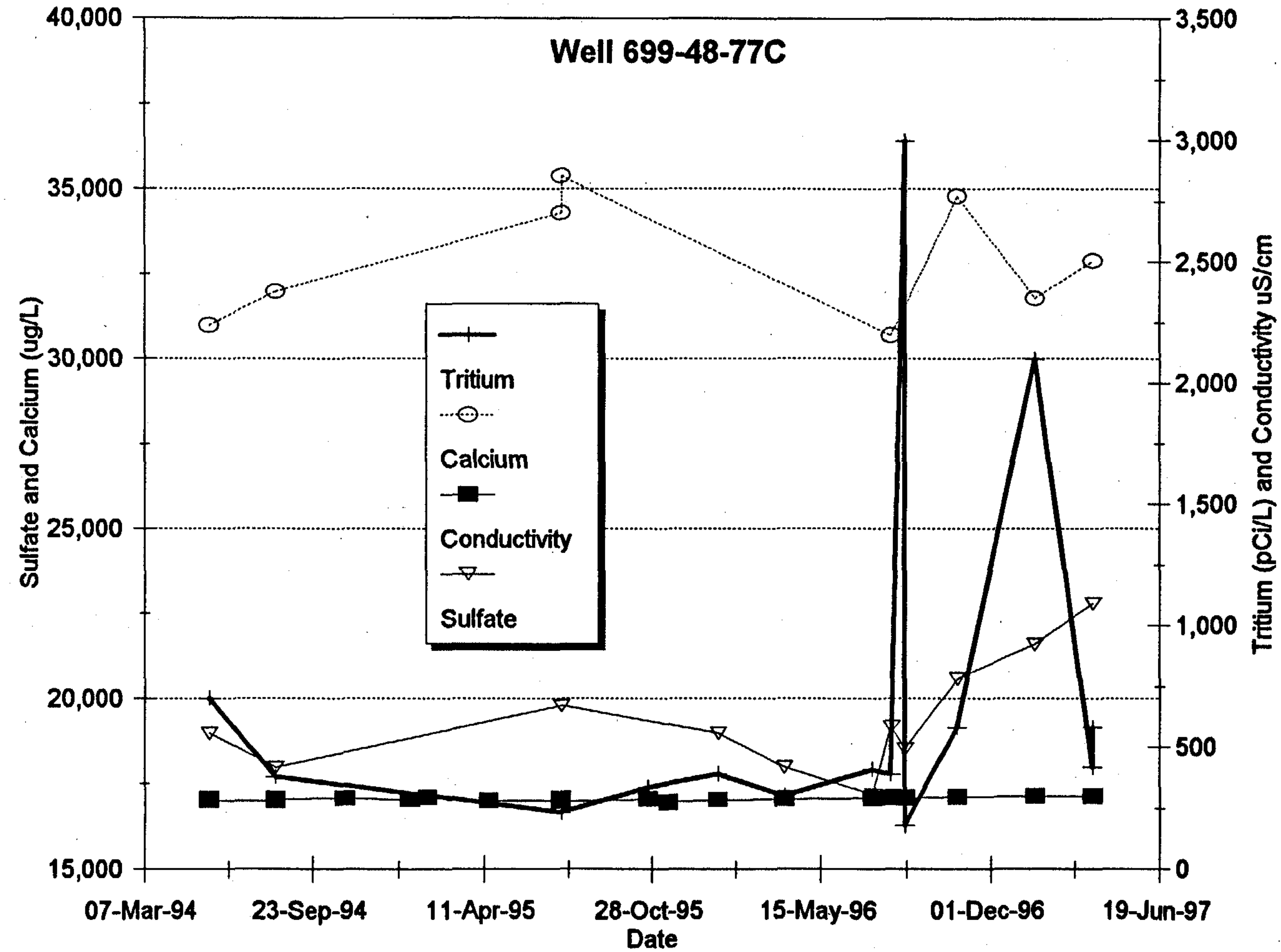


Figure 4.5. Plot of Tritium, Calcium, Sulfate, and Conductivity for Well 699-48-77C

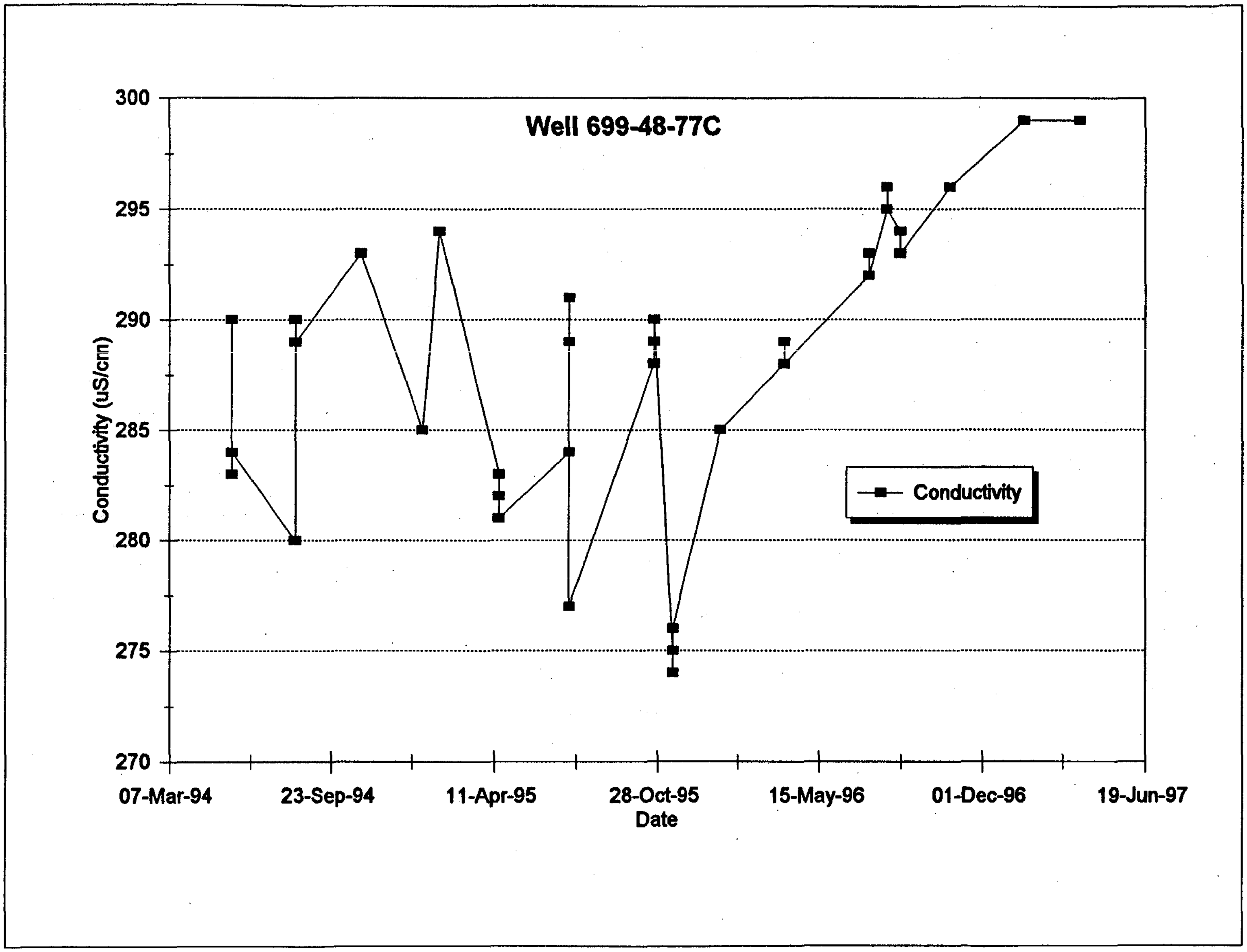


Figure 4.6. Plot of Conductivity Results for Well 699-48-77C

5.0 Summary of Groundwater and Vadose-Zone Modeling Predictions

Models of groundwater flow and contaminant transport in the unconfined aquifer at the Hanford Site have been performed to assess the effects of numerous groundwater-contaminant plumes beneath the Site on human health and the environment. Of special concern is determining if and how the movement of these areas of contamination will affect the Columbia River in the future. To address this need, conceptual and numerical models have been developed and applied at the Hanford Site since the 1970s (e.g., Kipp et al. 1972) to predict the fate and migration of contaminants in the vadose zone and groundwater for sitewide and site-specific applications.

Because of the effluent that will be discharged to the SALDS over its 30-year planned operation, tritium transport in the unconfined aquifer near the SALDS has been the focal point of some modeling efforts and an important subset of others. In this section, numerical models that have been used to evaluate the SALDS discharges with respect to tritium migration in the vadose zone and groundwater are summarized and compared. As a result of shortcomings in earlier models, a more refined groundwater model was developed and applied, incorporating more realistic assumptions. Results from this most recent effort to simulate tritium migration from the SALDS are described in greater detail.

5.1 Vadose Zone Models

As part of the initial evaluation of the SALDS, Lu et al. (1993) developed a conceptual model and a two-dimensional cross-section numerical model to predict travel time of effluent and tritium activities in the unsaturated zone beneath the facility. The computer code VAM3D-CG was used for simulations of flow and transport. Hydraulic properties of the sediments, for modeling parameters, were obtained from laboratory analyses of drilling samples from well 699-48-77A and from the literature (for the Hanford formation). A hydraulic gradient based on results of the Golder Associates (1991) model was applied in the unconfined aquifer across the model domain. The depth of the model extended to approximately 50 m below the water table.

The most prominent assumptions for the Lu et al. (1993) model included:

- continual operation of the facility at full capacity (568 L/min) during the entire simulation
- operation of the facility at full capacity for up to 125 years
- isotropic hydraulic conductivity field assumed for each soil type (model layer)
- infiltration of the effluent over the entire surface area of the facility (~2,100 m^3).

Lu et al. (1993) also assumed a volume of effluent disposed to the facility, 1.24 E+8 L by May 1997, which is roughly an order of magnitude in excess of the actual amount discharged (~4.0 E+7 L [see Figure 4.1]). The model also assumed a greater volume for future discharges than is actually planned by the most ambitious schedule. The tritium inventory assumed for the model is also greater than the actual amount discharged thus far or planned for the future. Other assumptions for the model also influence the results. Most notably, the Plio-Pleistocene unit was assumed to be a continuous, horizontal unit, with no allowances for discontinuities or structural trend (see Sections 3 and 4).

Based on the cross-section model, tritium was predicted to reach groundwater beneath the SALDS within approximately a year after start up of the facility, and a hypothetical well 100 m downgradient of the facility would first detect tritium after 9 years of operation. Near steady-state saturation and maximum tritium concentrations were established approximately 14 years from the start of tritium disposal. Significant concentrations did not spread beyond 100 m from the facility; after 19 years the maximum contour (1.4×10^7 pCi/L) propagated to approximately 75 m below and about 20 m laterally in both directions from the source.

As described in Section 4.0, tritium from the facility actually reached "upgradient" well 699-48-77A within 7 months of the beginning of discharges (December 1995). Well 699-48-77D is only a few meters downgradient from the SALDS, but has not yet detected tritium. Therefore, the Lu et al. (1993) model was nominally successful in predicting the effluent arrival at the water table. That the model did not correctly predict well-arrival time (9 years) or that an upgradient well would be affected first, may be a result of the structure and discontinuities in the Plio-Pleistocene unit for which the model did not account.

Another vadose-zone model by Collard et al. (1996) predicted rates of infiltration of low-volume discharges in the 200 West Area to several generic discharge facilities. This model incorporated discontinuities in the Plio-Pleistocene unit based on existing characterization data, but did not include contaminant transport. The model was not prepared for the SALDS specifically, but the stratigraphy of the modeled area, and thus the model layers, have similar properties to the Lu et al. (1993) model. Whereas Lu et al. used 6 specific geologic layers, the model by Collard et al. (1996) contains only 4. Using PORFLOW (Runchal et al. 1992) vertical and horizontal hydraulic conductivities in the ranges expected for clays and caliche were applied to the Plio-Pleistocene unit. The Collard et al. (1996) model predicted significant lateral spreading of effluent (156 m from the source) when a continuous Plio-Pleistocene unit was assumed, but spreading was greatly reduced when ~3-m wide "windows" were introduced into the layer every 30 m to simulate lateral discontinuities. Continuous low-volume (<0.004 L/s) discharges of water were predicted to reach the water table in less than 1 year. No simulations of groundwater flow below the water table were performed in the Collard et al. model.

Both vadose zone models predicted that liquid effluent discharged to soils in the same general region of the 200 West Area would reach groundwater within 1 year of the start of discharges. This prediction was borne out at the SALDS. The Lu et al. (1993) model considered much higher volumes of water than have been actually applied thus far, but did not incorporate discontinuities in the Plio-Pleistocene unit (as did the model by Collard et al.,1996). These two departures from reality appear to have had mutually canceling effects in the predictive capabilities of the Lu et al. model. Aside from these early predictions, both vadose-zone models probably have very limited further applicability to SALDS operation.

5.2 Previous Groundwater Models

Groundwater flow and transport models have been developed by different contractors under a variety of projects and programs at the Hanford Site. These projects and contractors include the Hanford

Groundwater Project managed by the Pacific Northwest National Laboratory (PNNL); the Environmental Restoration Project managed by Bechtel Hanford, Inc. (BHI), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program managed by the previous Site contractor Westinghouse Hanford Company (WHC). Several of these models have been applied to evaluate impacts from the SALDS discharges.

The Hanford Groundwater Project uses sitewide modeling to predict future conditions of the unconfined aquifer as it is affected by cessation of Hanford Site operations (e.g., determining which monitoring wells will become dry because of declining water levels), to assess the potential for contaminants to migrate from the Hanford Site through the groundwater pathway, and to address site-specific contaminant issues, such as the SALDS. During the past several years, a three-dimensional model of groundwater flow and contaminant transport has been developed by the Hanford Groundwater Project and its predecessor, the Hanford Groundwater Surveillance Project. This model was developed to improve simulations of groundwater flow and contaminant transport within the unconfined aquifer system over previous two-dimensional models (Wurstner and Devary 1993). Developed by PNNL, the model is based on the Coupled Fluid, Energy, and Solute Transport (CFEST) code (Gupta et al. 1987). The model includes nine geologic layers above the top of basalt to represent the major hydrogeologic units within the unconfined aquifer system.

The Environmental Restoration Contractor, BHI, developed and applied a groundwater flow and contaminant transport model of the unconfined aquifer to provide a basis for evaluation and prioritizing environmental restoration activities and remediation options. This sitewide model, which included SALDS, was applied to evaluate the migration, over the next 200 years, of eight plumes containing radionuclides and/or chemical contaminants. These model simulations were performed for three dimensions using two hydrogeologic layers. The BHI model is based on the Variably Saturated Analysis Model in Three Dimensions with Preconditioned Conjugate Gradient Matrix Solvers (VAM3DCG) code (developed by HydroGeoLogic, Inc., Herndon, Virginia).

Connelly et al. (1992) evaluated hydrology and contaminant distributions for the 200-West Area Groundwater Aggregate Area Management Study. The study, conducted by WHC, provides a comprehensive overview of groundwater flow characteristics in the 200-West Area, and identifies the extent and nature of groundwater contamination associated with historical liquid waste disposal practices as part of the Hanford Site CERCLA program. Geologic, hydrologic, and geochemical data are summarized by Connelly et al. (1992) and interpretations are made using several Dynamic Graphics Inc. (DGI) software packages. These data were used in several other modeling efforts to address fate and transport at the SALDS.

Golder Associates (1991) assessed the movement of treated effluent from the SALDS in the unconfined aquifer between the disposal site and the Columbia River to support the groundwater screening evaluation/monitoring plan for SALDS (Davis et al. 1996). The model was based on the Golder Associates proprietary two-dimensional codes, Aquifer Porous Media (AFPM) and Solute Transport (SOLTR). In their analysis, Golder Associates assumed two-dimensional flow and solute transport, steady-state flow conditions, and a constant flux of water and tritium to the SALDS for the entire simulation period of 205 years. Under these assumed conditions, a tritium plume was projected to develop between the SALDS and the Columbia River, with the plume extending north through Gable

Gap to between the 100-B,C and 100-K Areas. Maximum tritium concentrations in the unconfined aquifer after 205 years were predicted to be greater than 2,000,000 pCi/L, but maximum concentrations predicted to reach the Columbia River were less than the 20,000 pCi/L DWS.

Dresel et al. (1995) report the results of applying the two-dimensional flow model of the unconfined aquifer based on CFEST to evaluate pathlines from the SALDS to the Columbia River. The model was applied under transient conditions from 1980 through 2040 and steady-state conditions were assumed after 2040. The pathlines from the SALDS under these assumed conditions were predicted to extend eastward to the Columbia River near the old Hanford Townsite or slightly north of Gable Mountain. A one-dimensional analytical transport code was used to predict concentrations along several of the pathlines. The source of tritium was assumed to be a pulse lasting for 60 years (i.e., the facility was assumed to operate for 60 years). With these assumptions, and by restricting the contaminant transport along one-dimensional pathlines, tritium was predicted to reach the Columbia River, but in concentrations far below DWS.

Chiaramonte et al. (1996) performed simulations of tritium transport for a 200-year period under transient flow conditions using VAM3DCG. These simulations included discharges from the SALDS, which was assumed to receive 50.3 L/min (72 m^3/day) for the first 10 years of operation and 410.3 L/min (590 m^3/day) from 10 to 20 years. Tritium concentrations input to the SALDS were assumed to be 5.6 million pCi/L per year for 20 years. Under these assumed conditions, only a small amount of tritium is predicted to remain beneath the SALDS after 100 years. The peak concentration of 800,000 pCi/L is predicted to occur 20 years into the simulation. Chiaramonte et al. (1996) predict that tritium from the SALDS will not leave the central (200 Area) plateau at levels above the 20,000 pCi/L DWS. The tritium plume from SALDS is predicted to stay close to its source, then shrink as a result of decay.

Hartman and Dresel (1997) report an initial application of the three-dimensional CFEST model described by Wurstner et al. (1995) to simulation of tritium transport from the SALDS. This simulation used a feature of CFEST that allows definition of subregion models and transfer of boundary conditions to the subregion from the regional model. In this simulation, disposal of tritium from the SALDS was assumed to begin in 1995 and continue for 20 years until 2015. The maximum concentrations from the disposal were predicted to occur in 2015. The results also indicated that the tritium would extend to the bottom of the unconfined aquifer in the vicinity of the SALDS. This simulation extended to 2050.

5.3 Current Groundwater Model of the SALDS

Predictions of the impacts from water and tritium disposal to the SALDS were recently performed with the three-dimensional CFEST model using updated model input parameters. Simulations are based on the three-dimensional conceptual model described in detail by Wurstner et al. (1995) and are derived in conjunction with the current Hanford sitewide composite model now in preparation. Applications of this three-dimensional model to simulation of SALDS discharges are described in this section.

Background Information

The three-dimensional model is based on the geologic layering defined by Lindsey (1995), regrouped into nine hydrogeologic units based on similarity in expected groundwater-flow properties, which correlate to texture and degree of cementation. The lateral extent and thickness distribution of each hydrogeologic unit were defined based on information from well driller's logs, geophysical logs, and an understanding of the geologic environment.

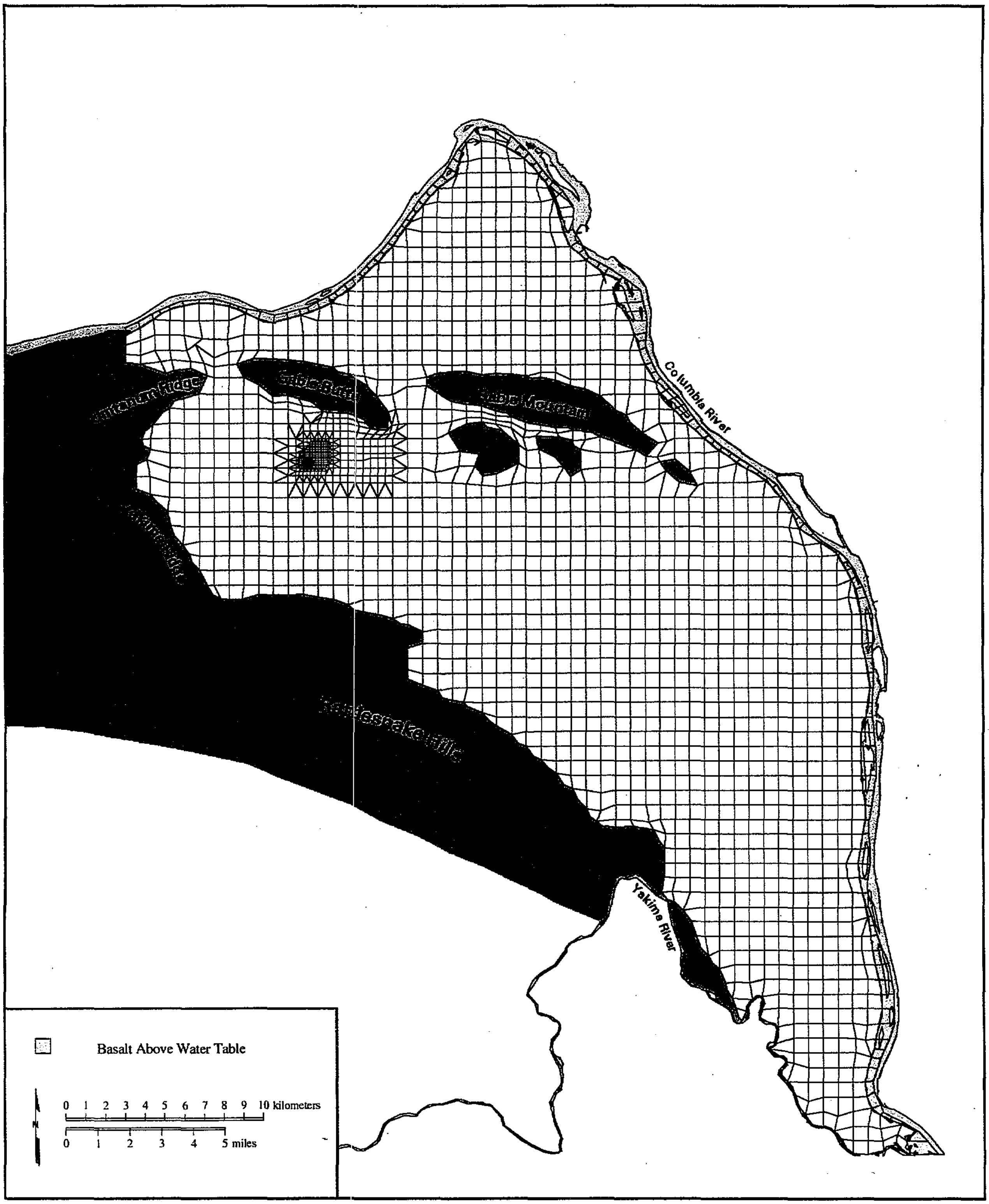
Both natural and artificial recharge to the unconfined aquifer were incorporated into the model. Natural recharge to the unconfined aquifer system occurs as a result of 1) infiltration from precipitation falling across the Site, 2) runoff from elevated regions along the western boundary, and 3) spring discharges from the basalt-confined aquifer system. Areal recharge from precipitation is highly variable, both spatially and temporally, and depends on local climate, soil type, and vegetation.

Flow system and model boundaries are formed by the Columbia River on the north and east and by the Yakima River and basalt ridges on the south and west. The Columbia River is represented as a prescribed-head boundary, based on river stage elevations calculated for the mean annual discharge of the river. Some portions of the Yakima River are represented as a constant-head boundary, while other portions are separated from the unconfined aquifer system by a no-flow boundary (representing subsurface exposures of basalt above the water table). At the Cold Creek and Dry Creek valleys, the boundary is represented as a prescribed flux condition established by first running the flow model with a prescribed head condition and calculating the flux across the boundary. That flux is then used to represent the prescribed flux boundary. The uppermost units of basalt underlying the unconfined aquifer system represent the lower boundary of the model. The potential for interflow (recharge and discharge) between the basalt-confined aquifer system and the unconfined aquifer system is largely unquantified. Therefore, interflow with underlying basalt units is not included in the current three-dimensional model.

The three-dimensional flow model was developed and calibrated based on the transmissivity distribution from calibration of the two-dimensional model. Information on hydraulic conductivities and thicknesses of the nine individual layers in the model was used to divide transmissivity between the layers. Hydrogeologic units below the water table were assigned a constant hydraulic conductivity while the hydrogeologic unit containing the 1979 water table was assigned a variable hydraulic conductivity that preserves the total transmissivity from the inverse calibration. The inverse method is an automated procedure for calibrating numerical groundwater flow models that account for past water level data, boundary conditions, pumping rates, and previous knowledge of transmissivities and recharge. As in Wurstner et al. (1995), the database of geologic and hydrologic information was developed to be independent of the model grid.

The model grid for the SALDS (Figure 5.1) was constructed on a square grid with 350 m spacing to minimize numerical dispersion during transport predictions. The grid was refined to 45-m spacing to better represent the tritium transport and head differences near the SALDS. Rather than creating a subregion model, the grid was refined within a region of the Hanford sitewide model.

In addition to the horizontal refinement, the grid was refined vertically in the vicinity of the SALDS to represent the contaminant plume. Based on results reported in Hartman and Dresel (1997), additional vertical layering was added to reduce the potential amount of vertical dispersion. The grid was refined to 6-m spacing over the entire vertical profile (from the water table to the basalt).



97skw036.eps July 30, 1997

Figure 5.1. Finite-Element Grid Used in the Current Numerical-Model Simulations for the SALDS.

After a steady-state solution based on 1979 flow conditions was generated for the three-dimensional model, transient simulations were performed for 1980 through 2100. The SALDS was assumed to receive tritium discharges over 30 years from 1996 through 2025, and treated effluent without tritium through 2034. Discharge rates ranged from approximately 1 m^3/day to 350 m^3/day. Actual discharges to the SALDS began in December 1995, but these discharges were combined with 1996 discharges for modeling purposes. Because yearly time steps were used, this combination more accurately simulates startup of effluent discharges to SALDS. Based on current projections of operation, the assumed discharge rates for SALDS are shown in Table 5.1. This discharge was applied to the southern 2/3 of the area covered by the SALDS, based on the assumption that the entire facility was not involved in draining the liquids to the soil column (see Section 6.1). As with the volume of water, the tritium concentrations were assumed to be variable and are illustrated in Table 5.1. For the most part, the tritium concentrations in the effluent decrease from the maximum in the first four years, 1996 through 1999.

For this simulation, the only source of tritium for the unconfined aquifer was from the SALDS. Other sitewide tritium plumes are being simulated as part of the Composite Analysis in response to Recommendation 94-2 of the Defense Nuclear Facility Safety Board, and will be reported there.

Modeling Results

Results of the transient flow part of the analysis indicated that the unconfined aquifer would require well in excess of 100 years (from 1980 to 2080) to reach steady-state conditions. Contours of the water table at the end of the simulation period at year 2100, presented in Figure 5.2, show that groundwater will flow in an easterly direction toward the Columbia River, and that the overall hydraulic gradient of the unconfined aquifer will decrease well below present day conditions as the water table declines in response to the cessation of artificial recharge at the Hanford Site.

The hydraulic heads predicted in the upper layer of the model in the vicinity of the SALDS are illustrated in Figures 5.3 through 5.16. Contours of predicted tritium concentrations in the upper model layer are illustrated in Figures 5.17 through 5.30. The tritium plume originating at the SALDS is shown on a broader scale at its largest extent in Figure 5.31. A cross-section of a portion of the modeled domain, illustrating sequential vertical distributions of tritium in the unconfined aquifer from 1996 to 2095, is shown in Figures 5.32 through 5.45. The location and orientation of the cross-section are shown in Figure 5.46.

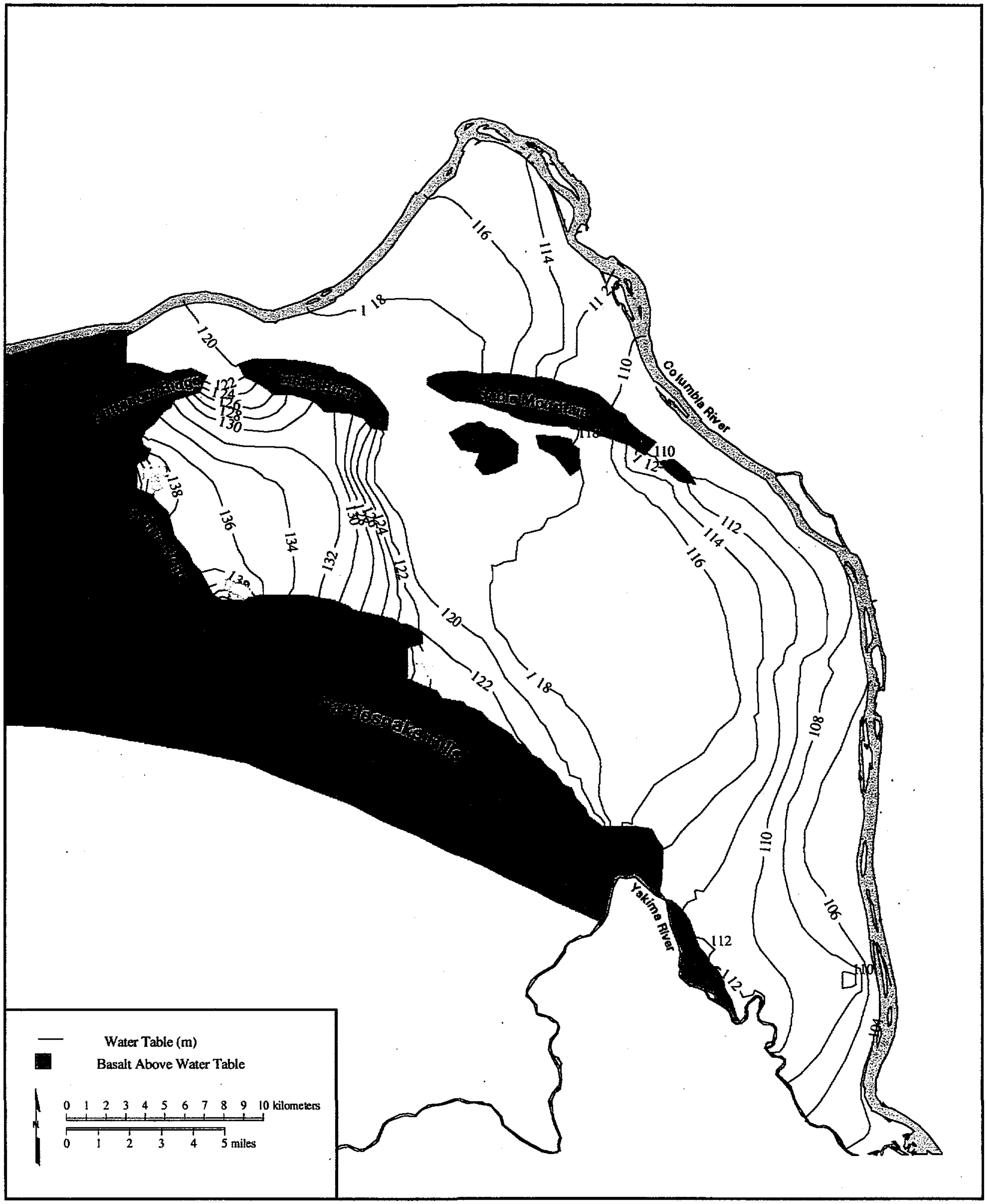
In vicinity of the SALDS, results of the flow modeling show that the water level rises about 2 m above preoperational levels, resulting in a groundwater mound below the SALDS.

The mound creates a radial pattern of flow around the SALDS during the period of discharges. At the cessation of discharges, the mound dissipates and water levels near SALDS decline in response to the regional water table decline. Groundwater flow directions change first to northeasterly and then more easterly toward the Columbia River.

Table 5.1. Actual (1996) and projected effluent volumes for discharge to SALDS

Year	Total volume [Gal]	Total H-3 Ci	Year	Model Flux (m3/day)	Total H-3 Ci
1996		222.14	1996	84.77	222.140
1997	2.278E+07	2.148E+02	1997	236.10	214.847
1998	3.394E+07	1.205E+02	1998	351.75	120.456
1999	5.930E+06	9.193E+01	1999	61.46	91.932
2000	3.370E+06	2.866E+01	2000	34.93	28.658
2001	3.300E+06	2.756E+01	2001	34.20	27.557
2002	7.003E+06	1.675E+01	2002	72.58	16.747
2003	1.414E+07	1.906E+01	2003	146.52	19.063
2004	1.473E+07	1.881E+01	2004	152.64	18.806
2005	1.429E+07	3.837E+01	2005	148.08	38.367
2006	1.424E+07	3.708E+01	2006	147.56	37.080
2007	1.396E+07	2.987E+01	2007	144.66	29.873
2008	1.396E+07	2.987E+01	2008	144.66	29.873
2009	1.392E+07	2.884E+01	2009	144.24	28.844
2010	1.308E+07	7.224E+00	2010	135.54	7.224
2011	1.015E+07	2.035E+01	2011	105.17	20.350
2012	1.829E+07	1.703E-02	2012	189.59	0.017
2013	1.816E+07	1.703E-02	2013	188.21	0.017
2014	1.811E+07	1.703E-02	2014	187.69	0.017
2015	1.811E+07	1.703E-02	2015	187.69	0.017
2016	1.811E+07	1.703E-02	2016	187.69	0.017
2017	1.811E+07	1.703E-02	2017	187.69	0.017
2018	1.791E+07	1.703E-02	2018	185.62	0.017
2019	1.791E+07	1.703E-02	2019	185.62	0.017
2020	1.641E+07	1.703E-02	2020	170.08	0.017
2021	1.641E+07	1.703E-02	2021	170.08	0.017
2022	1.656E+07	1.703E-02	2022	171.63	0.017
2023	1.661E+07	1.703E-02	2023	172.15	0.017
2024	1.661E+07	1.703E-02	2024	172.15	0.017
2025	1.661E+07	1.703E-02	2025	172.15	0.017
2026	1.658E+07	0.000E+00	2026	171.84	0.000
2027	1.638E+07	0.000E+00	2027	169.76	0.000
2028	1.638E+07	0.000E+00	2028	169.76	0.000
2029	4.170E+06	0.000E+00	2029	43.22	0.000
2030	1.000E+05	0.000E+00	2030	1.04	0.000
2031	1.000E+05	0.000E+00	2031	1.04	0.000
2032	1.000E+05	0.000E+00	2032	1.04	0.000
2033	1.000E+05	0.000E+00	2033	1.04	0.000
2034	2.500E+04	0.000E+00	2034	0.26	0.000

Concentration of tritium was estimated for 1997 through 2025



97skw44.eps August 06, 1997

Figure 5.2. Hydraulic Heads Predicted in the Unconfined Aquifer in Year 2100

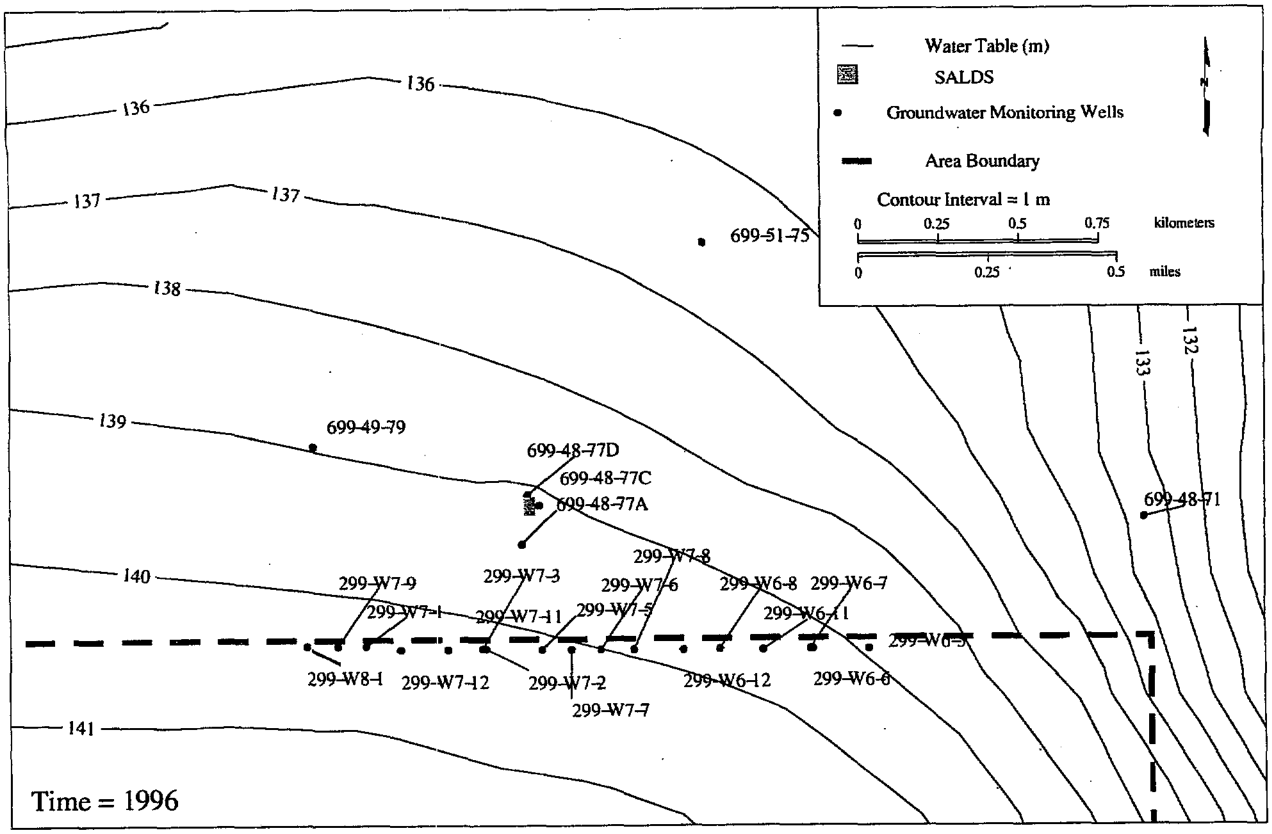


Figure 5.3. Hydraulic Heads Predicted in the Vicinity of SALDS in 1996

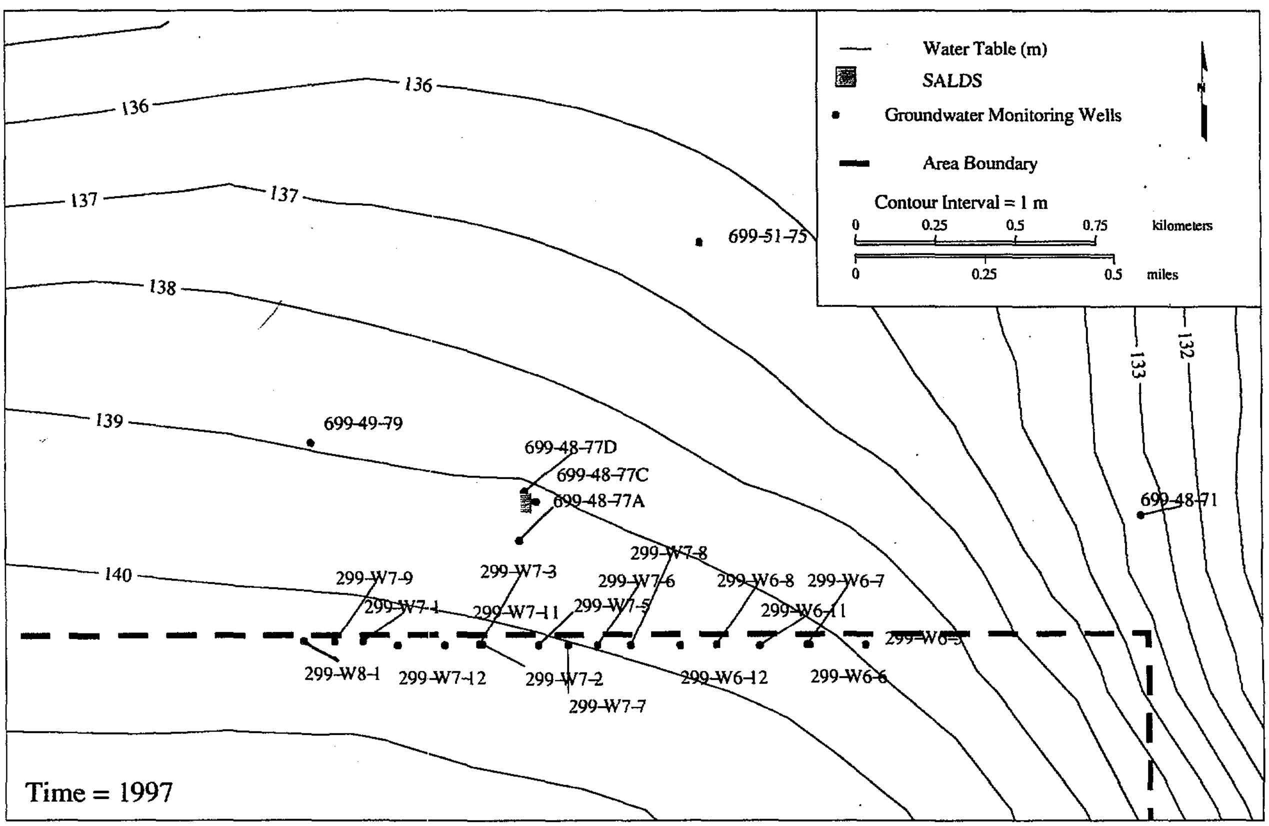


Figure 5.4. Hydraulic Heads Predicted in the Vicinity of SALDS in 1997

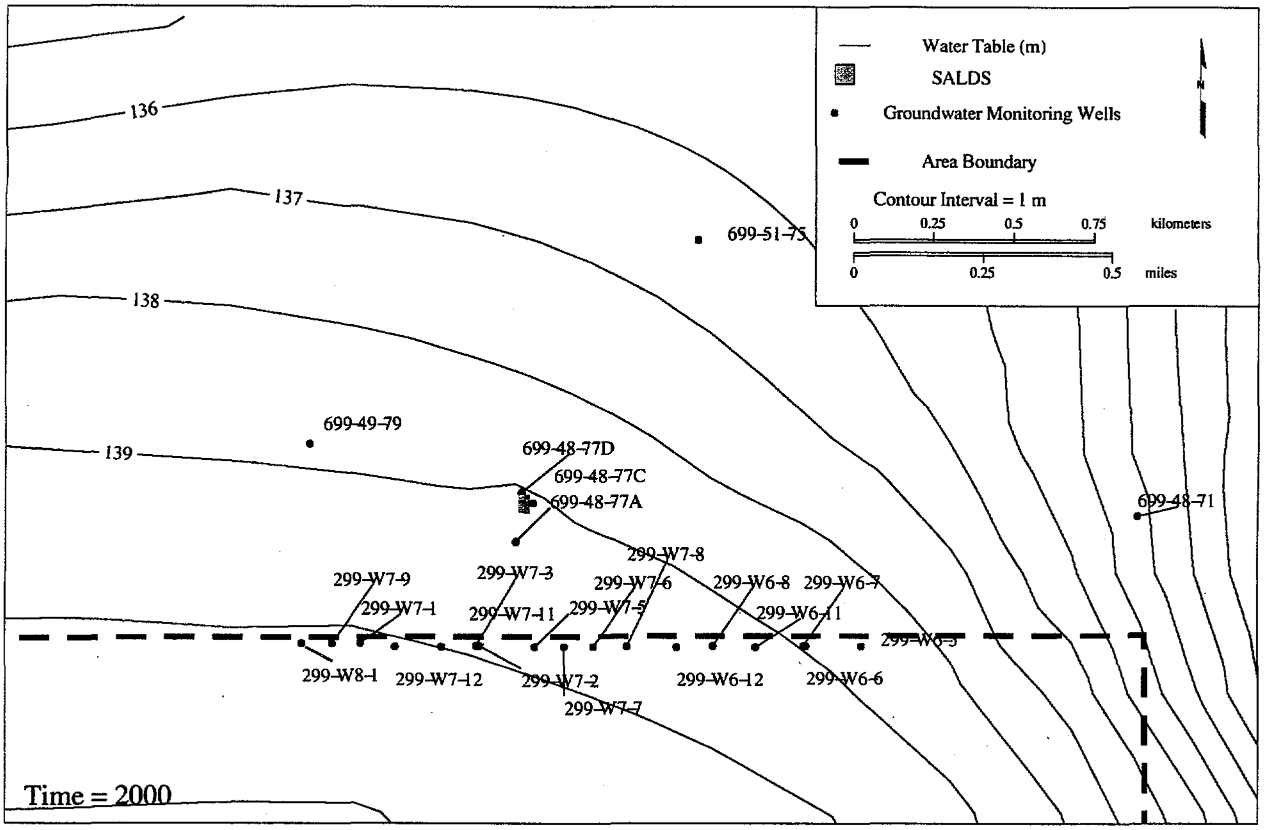


Figure 5.5. Hydraulic Heads Predicted in the Vicinity of SALDS in 2000

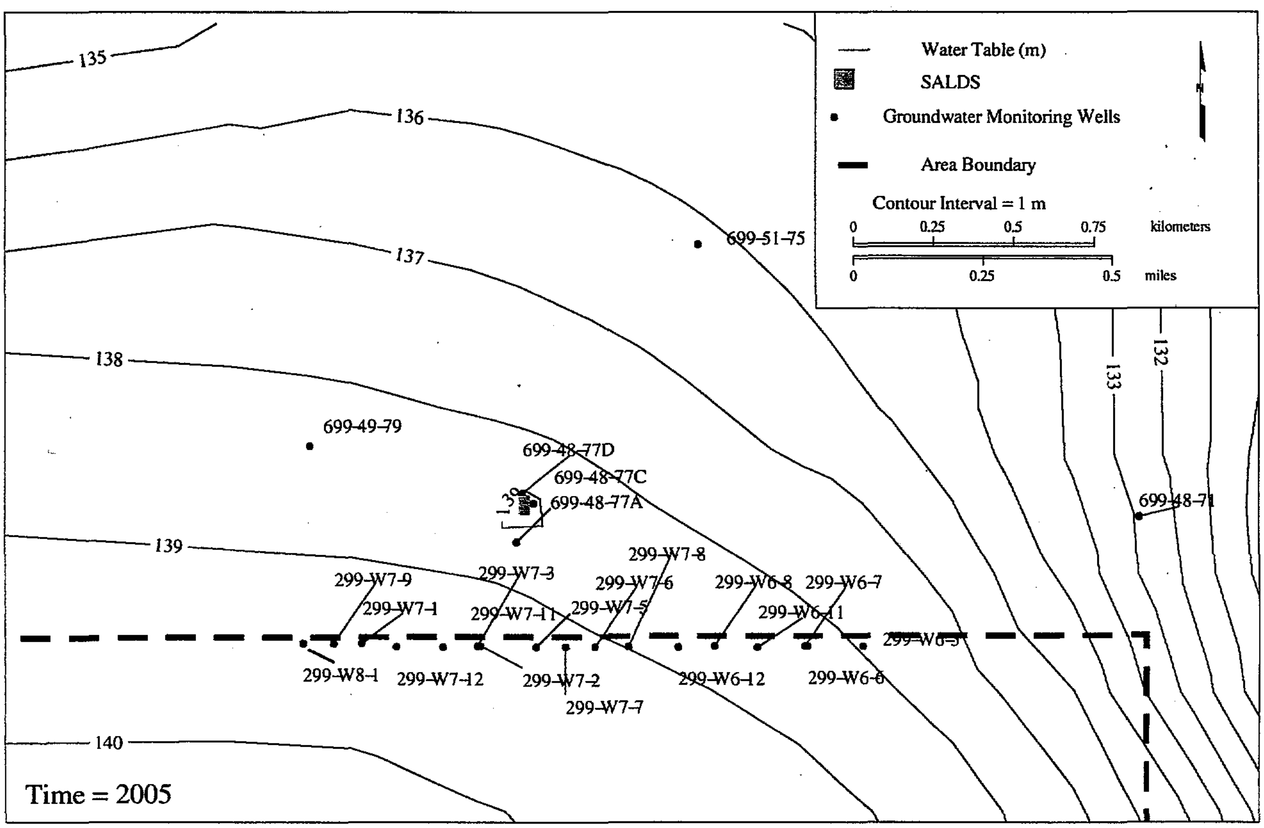


Figure 5.6. Hydraulic Heads Predicted in the Vicinity of SALDS in 2005

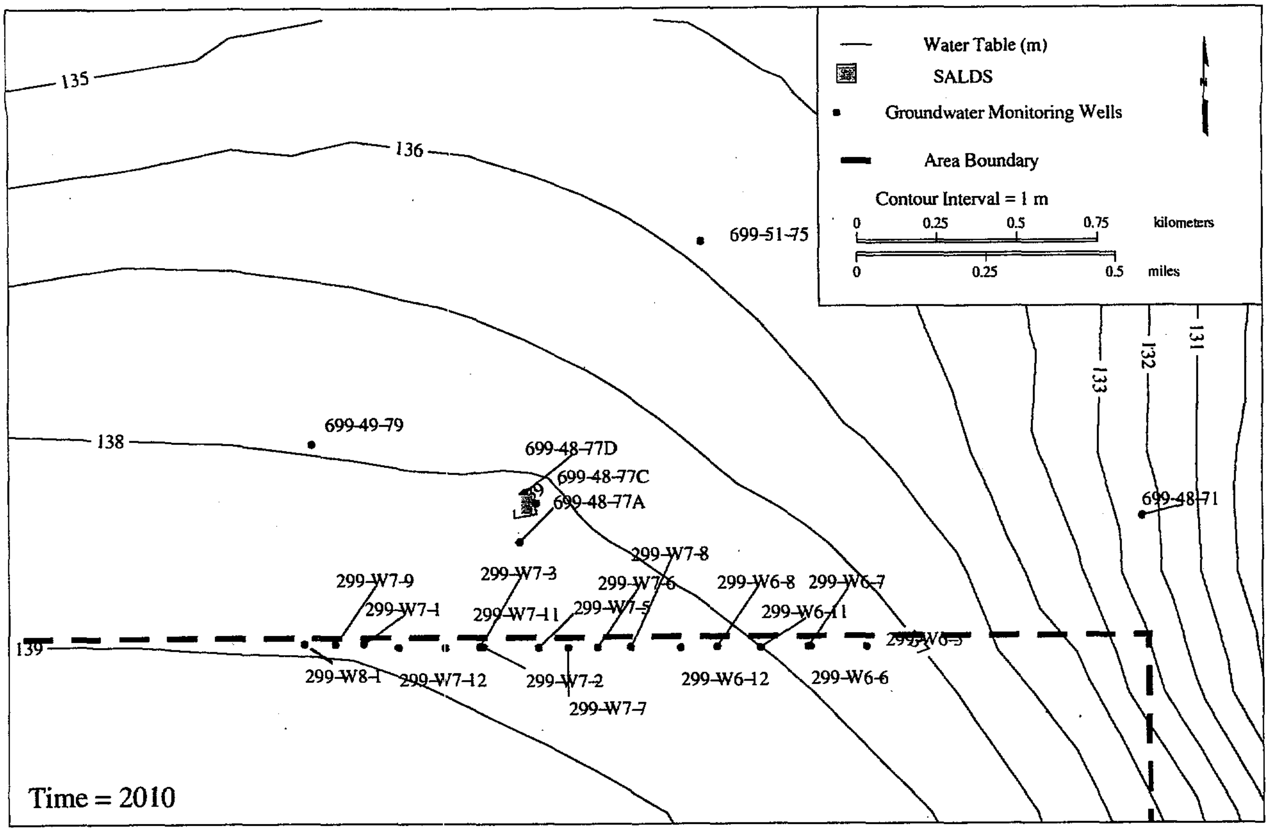


Figure 5.7. Hydraulic Heads Predicted in the Vicinity of SALDS in 2010

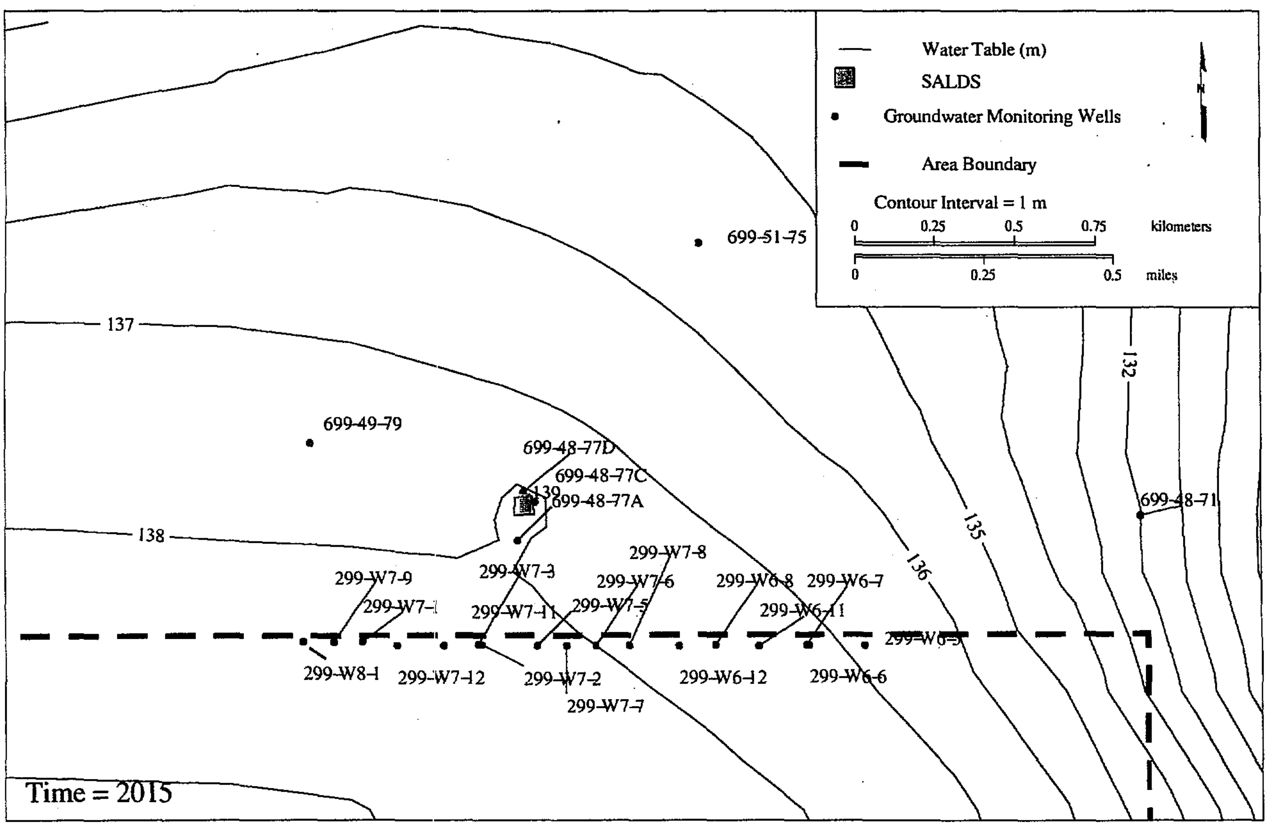


Figure 5.8. Hydraulic Heads Predicted in the Vicinity of SALDS in 2015

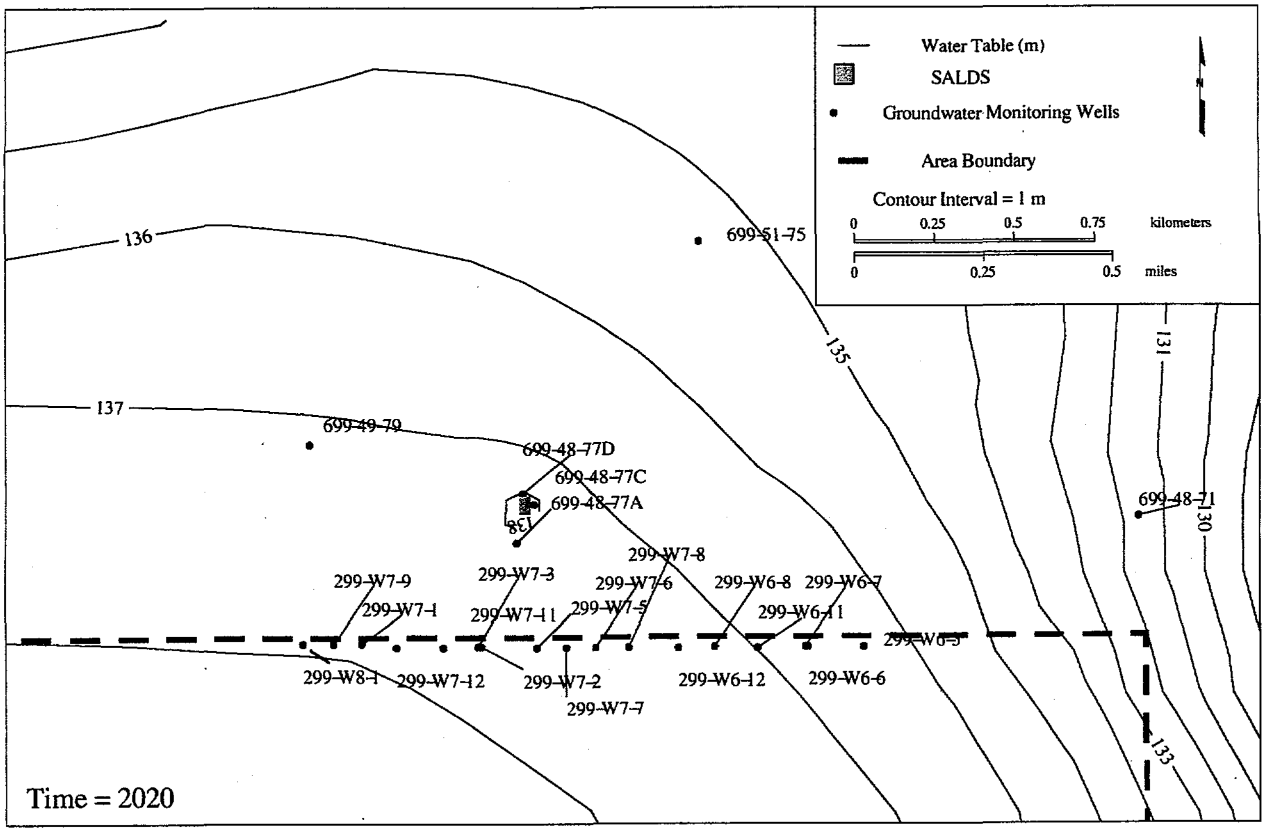


Figure 5.9. Hydraulic Heads Predicted in the Vicinity of SALDS in 2020

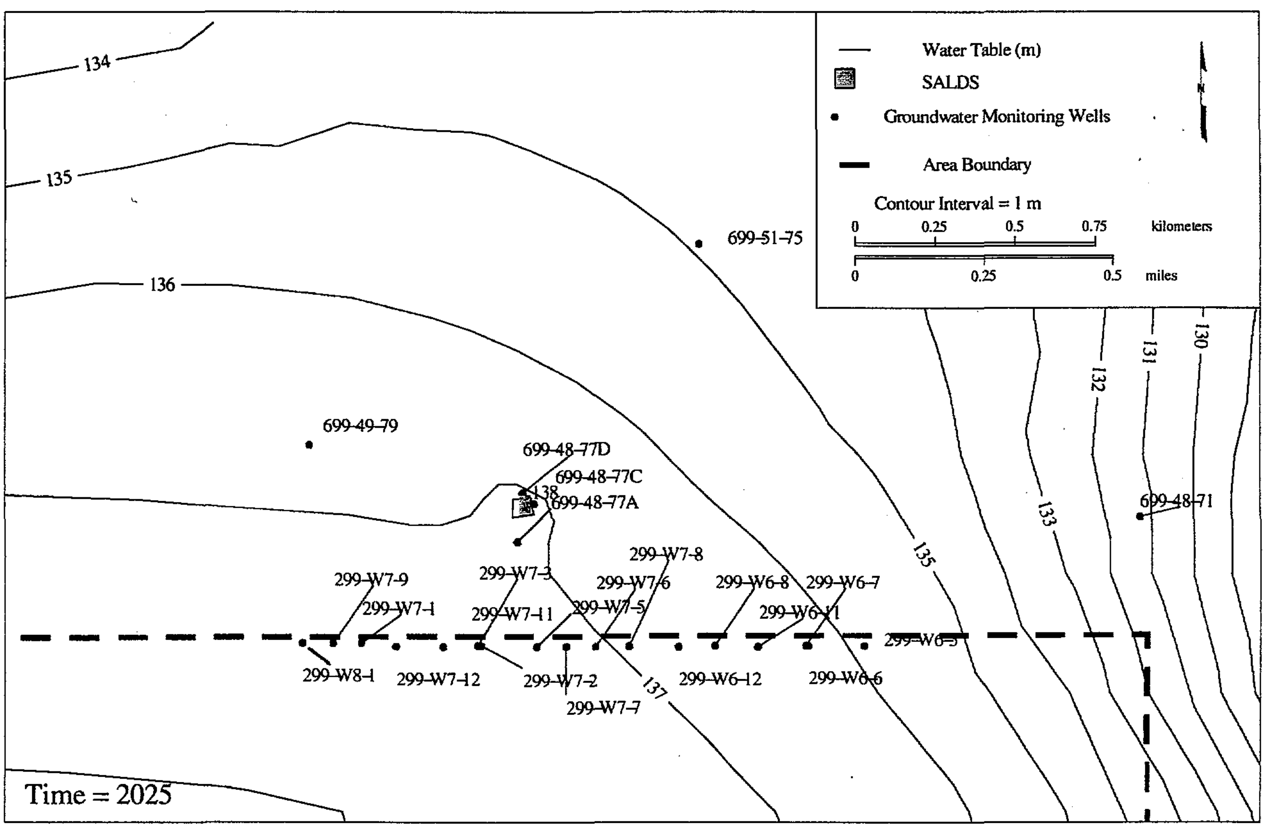


Figure 5.10. Hydraulic Heads Predicted in the Vicinity of SALDS in 2025

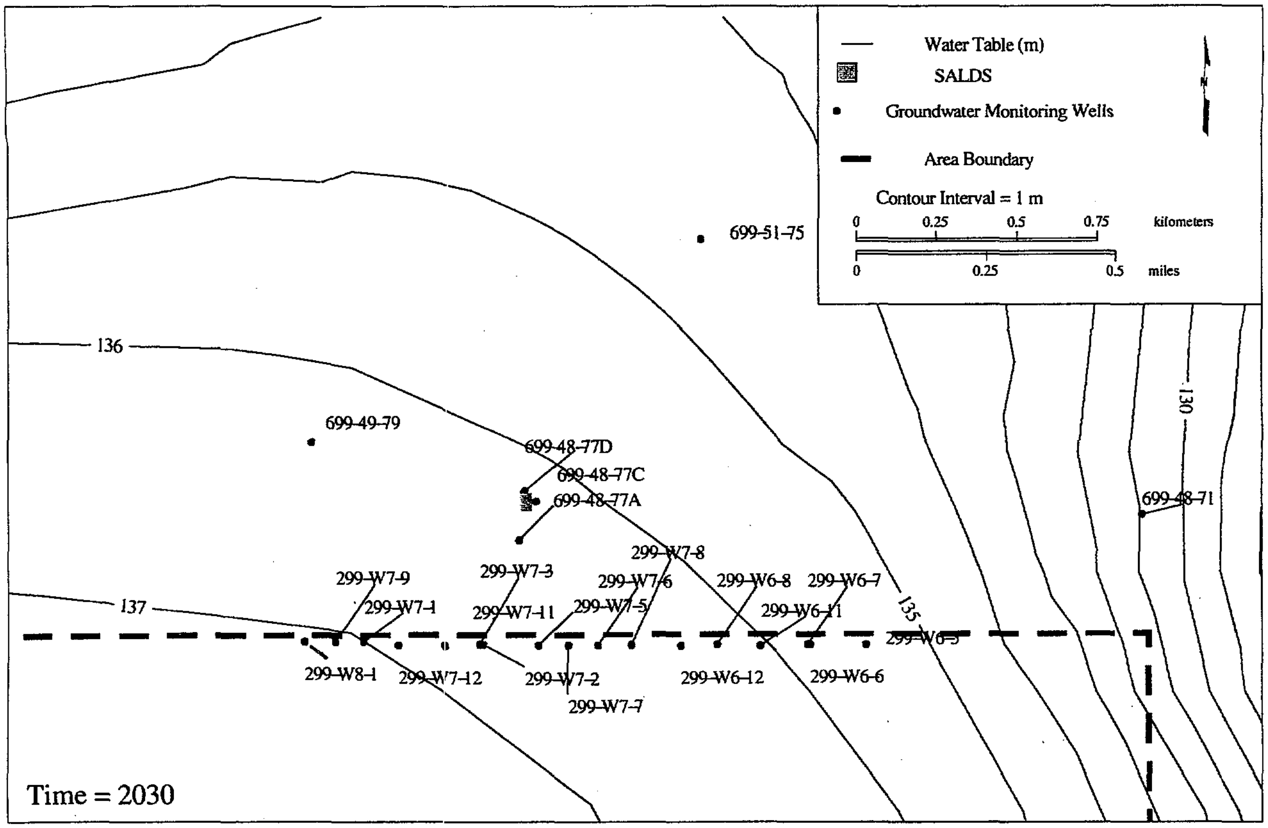


Figure 5.11. Hydraulic Heads Predicted in the Vicinity of SALDS in 2030

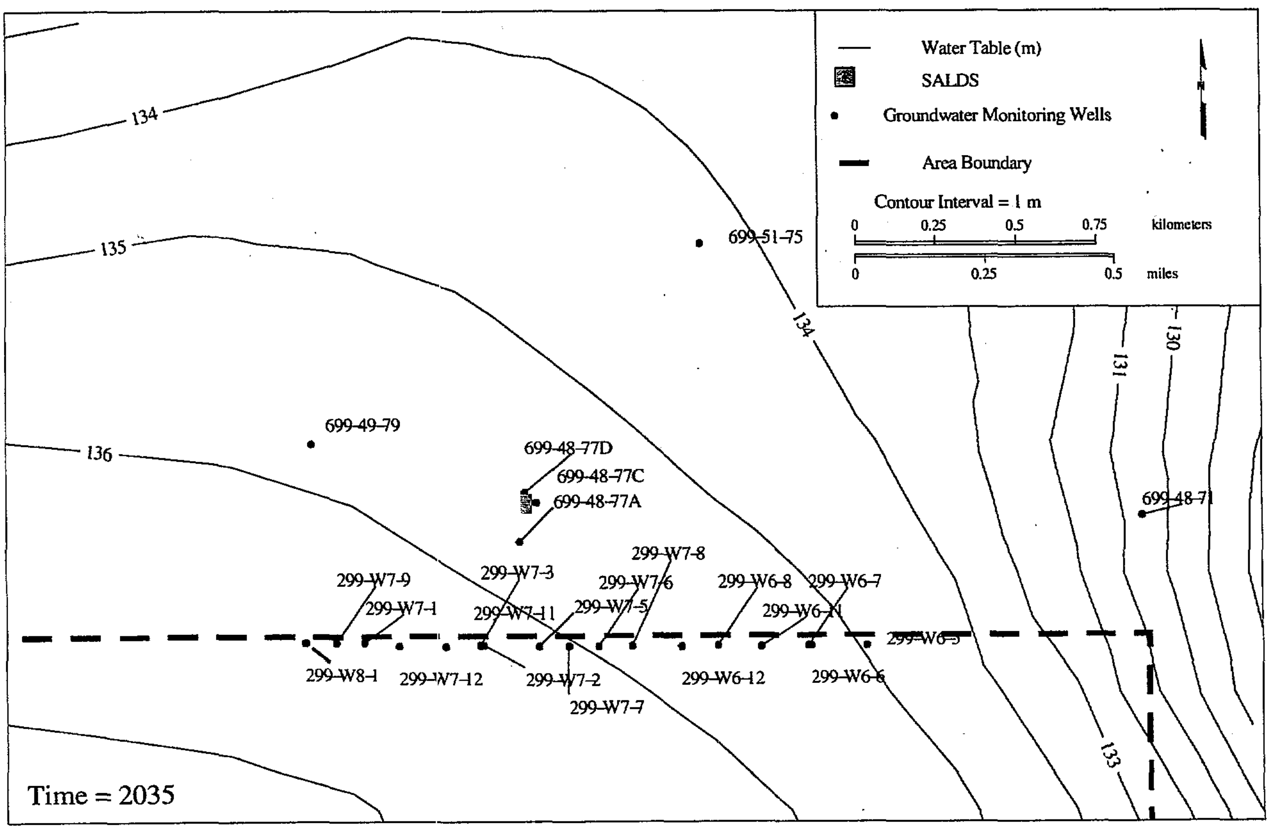


Figure 5.12. Hydraulic Heads Predicted in the Vicinity of SALDS in 2035

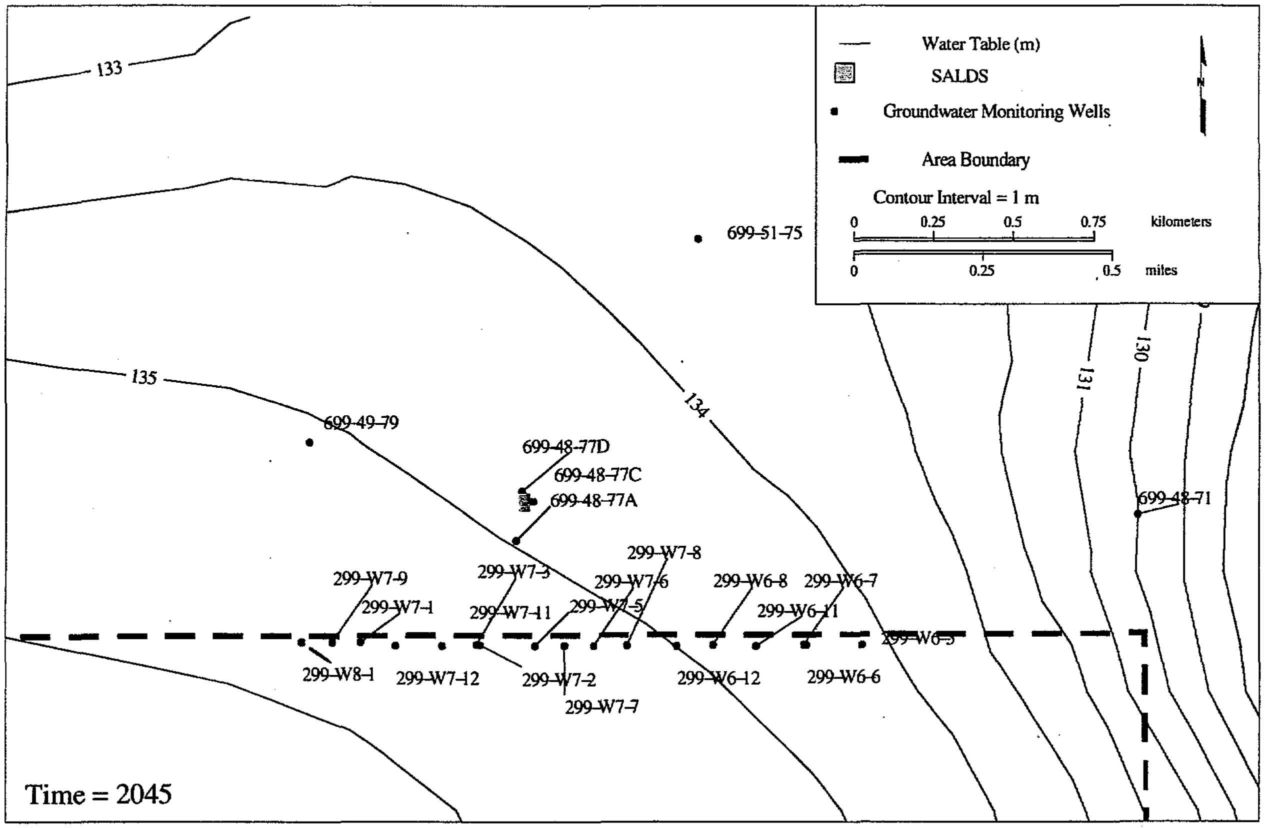


Figure 5.13. Hydraulic Heads Predicted in the Vicinity of SALDS in 2045

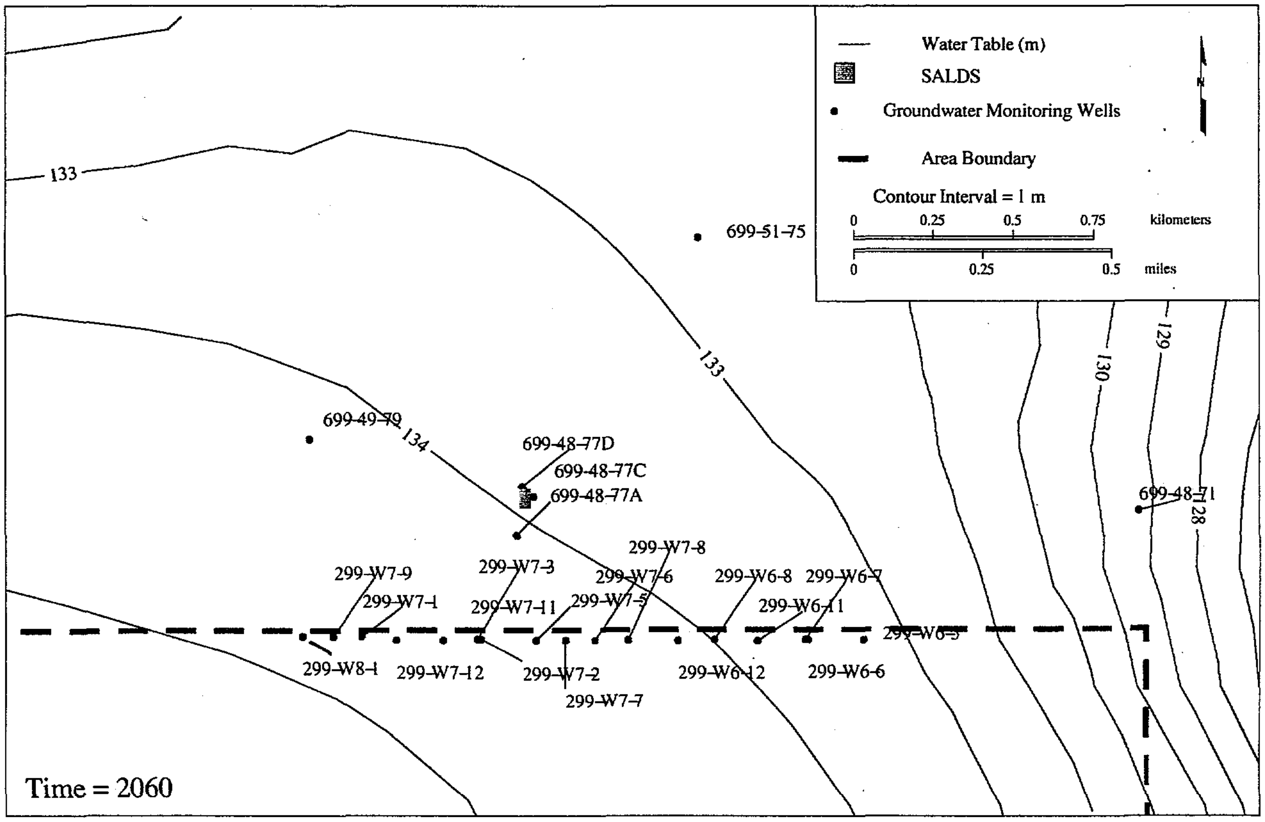


Figure 5.14. Hydraulic Heads Predicted in the Vicinity of SALDS in 2060

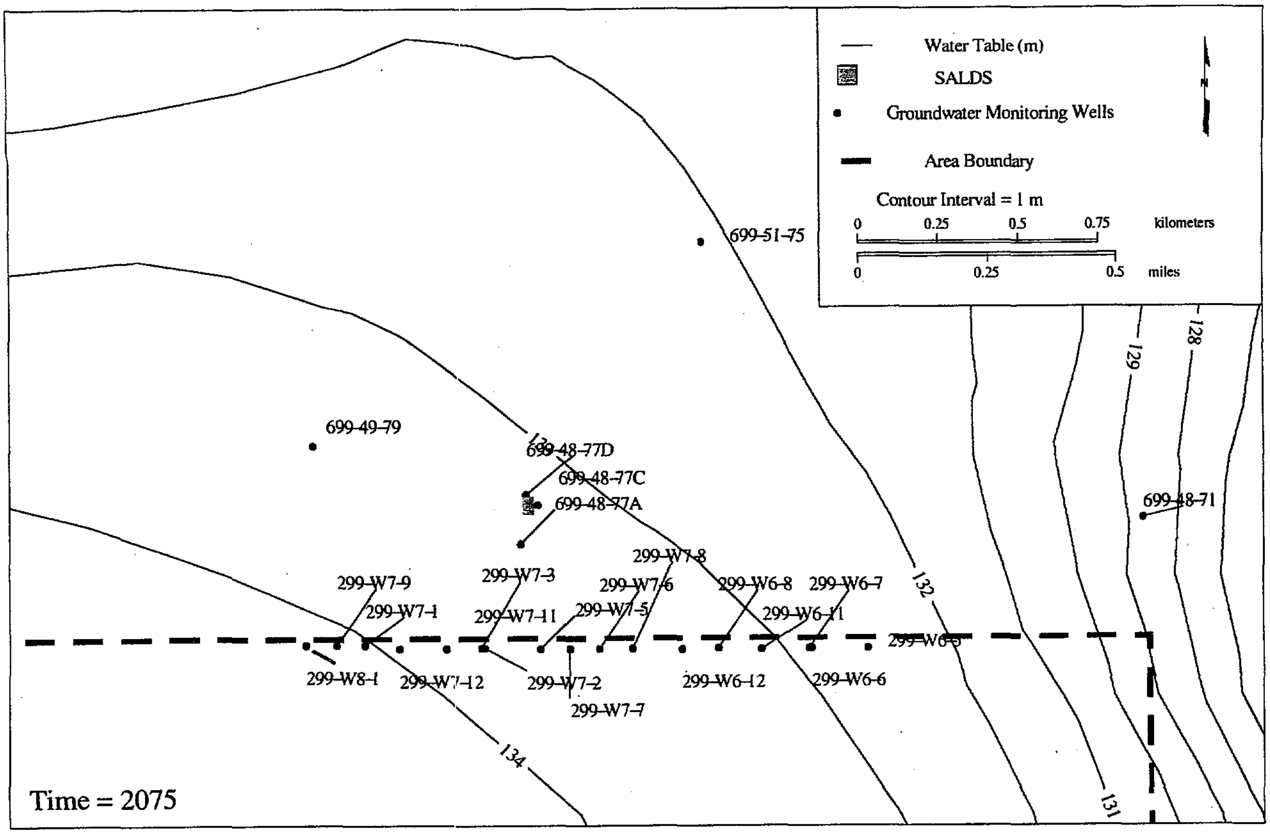


Figure 5.15. Hydraulic Heads Predicted in the Vicinity of SALDS in 2075

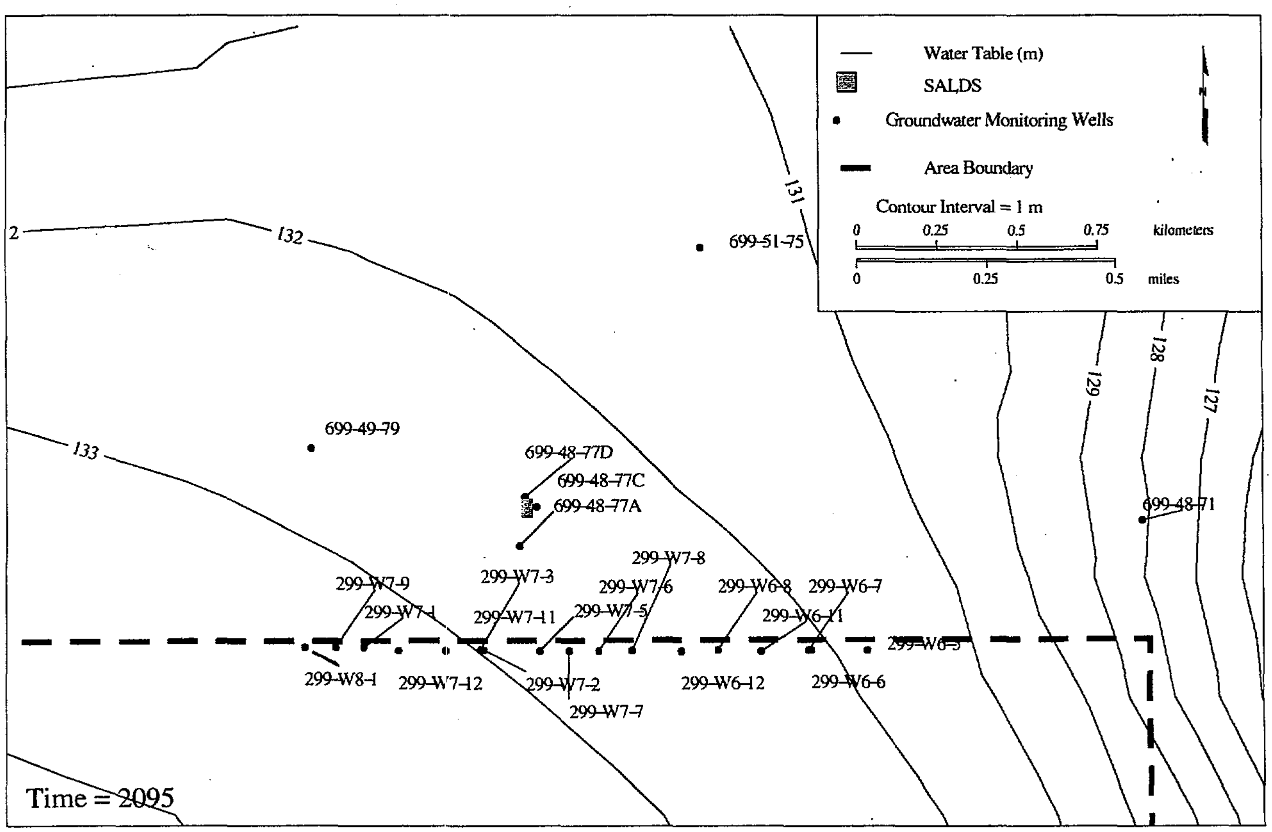


Figure 5.16. Hydraulic Heads Predicted in the Vicinity of SALDS in 2095

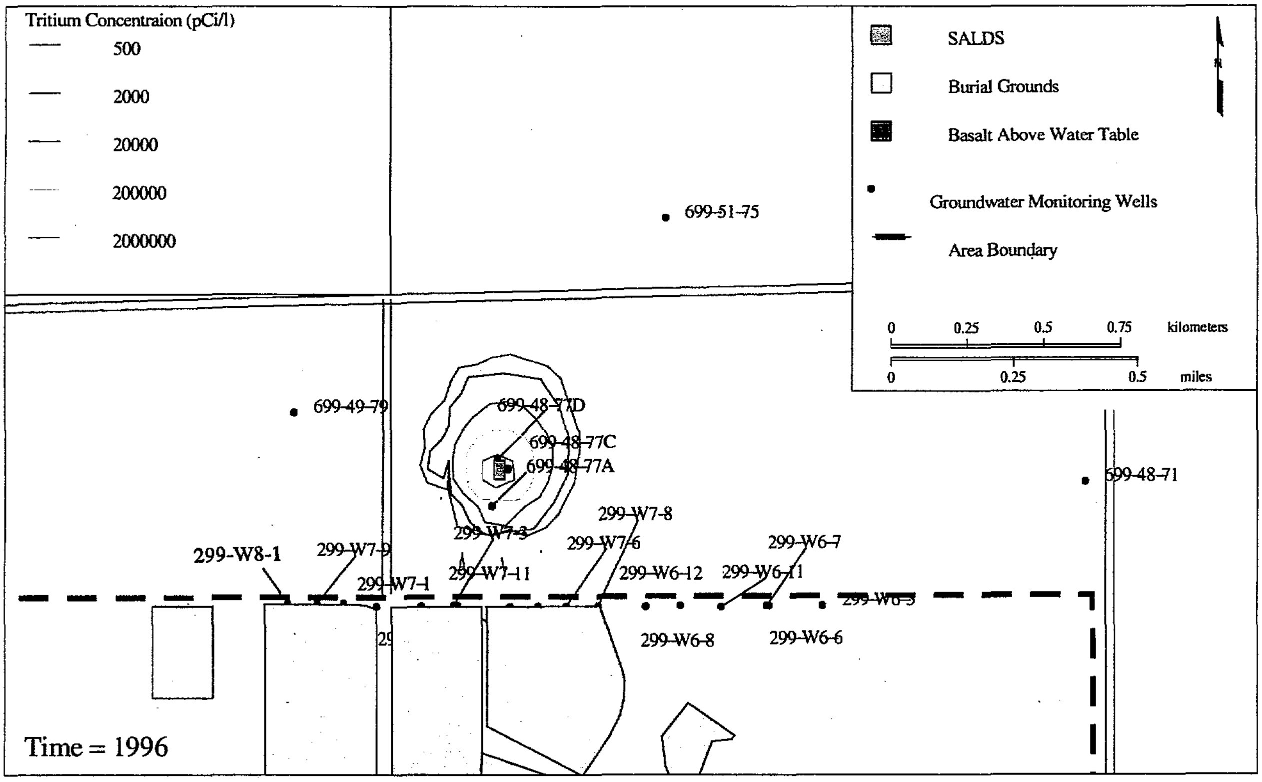


Figure 5.17. Tritium Concentrations Predicted in the Vicinity of SALDS in 1996

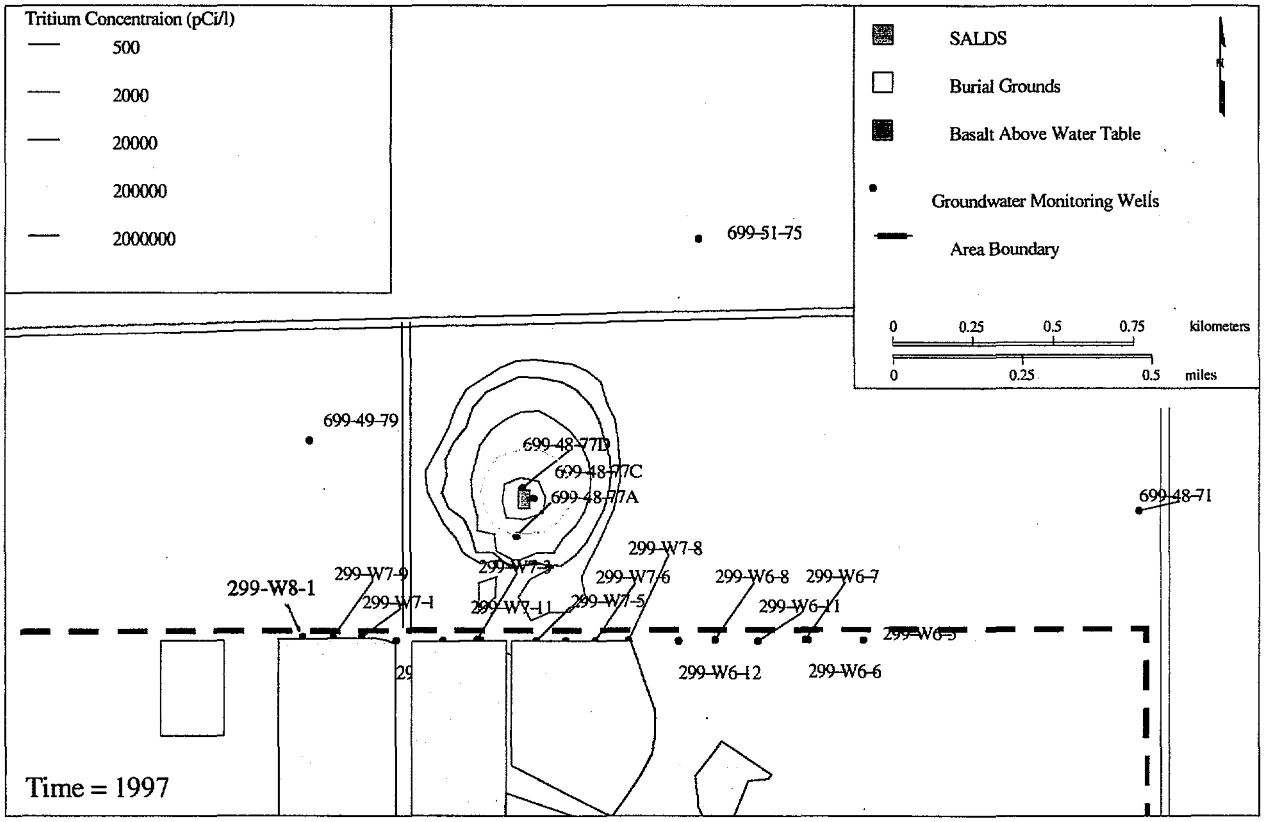


Figure 5.18. Tritium Concentrations Predicted in the Vicinity of SALDS in 1997

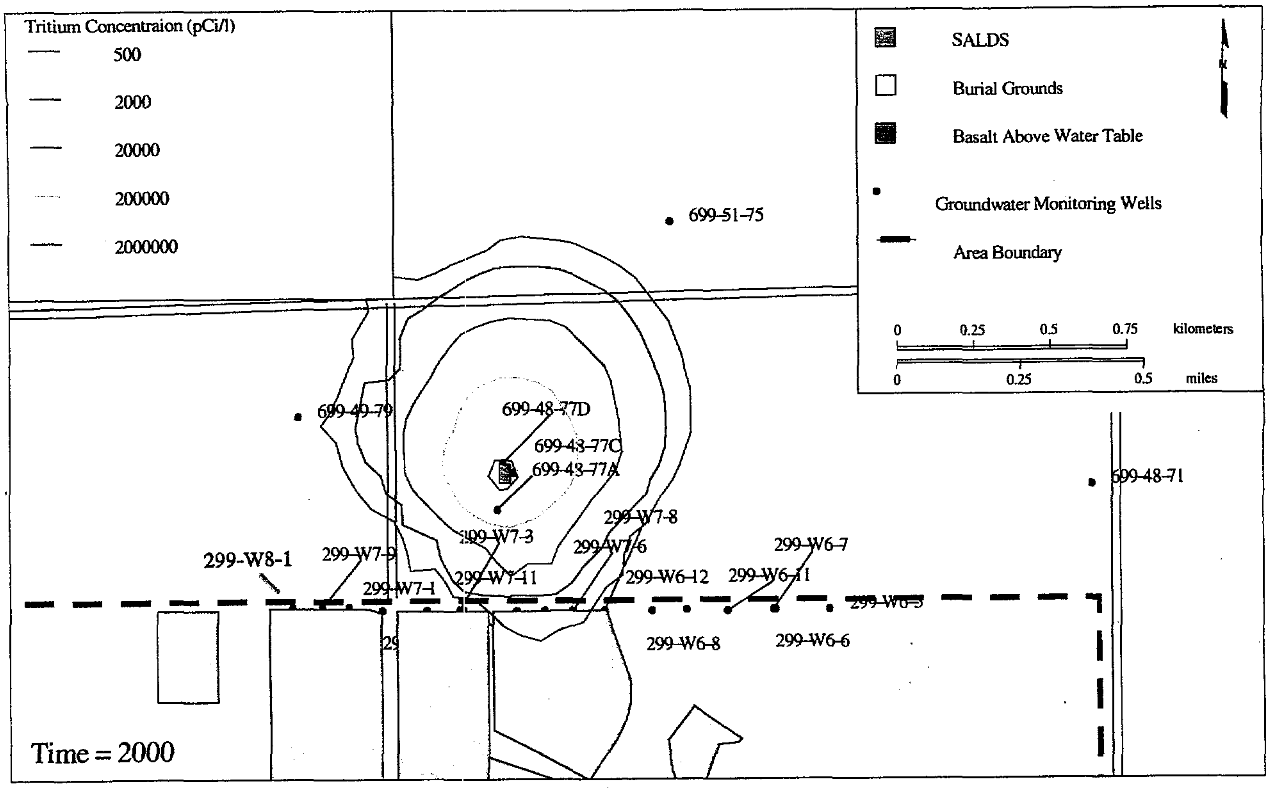


Figure 5.19. Tritium Concentrations Predicted in the Vicinity of SALDS in 2000

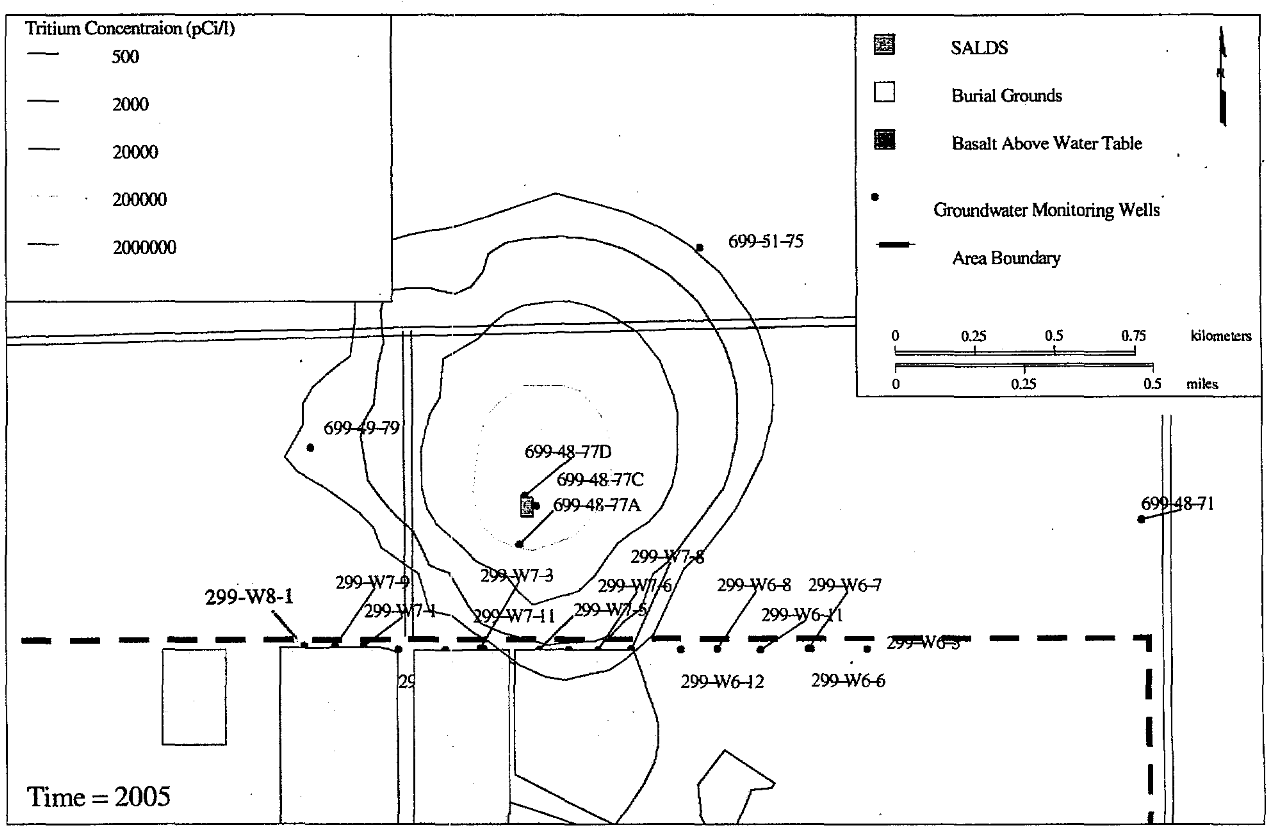


Figure 5.20. Tritium Concentrations Predicted in the Vicinity of SALDS in 2005

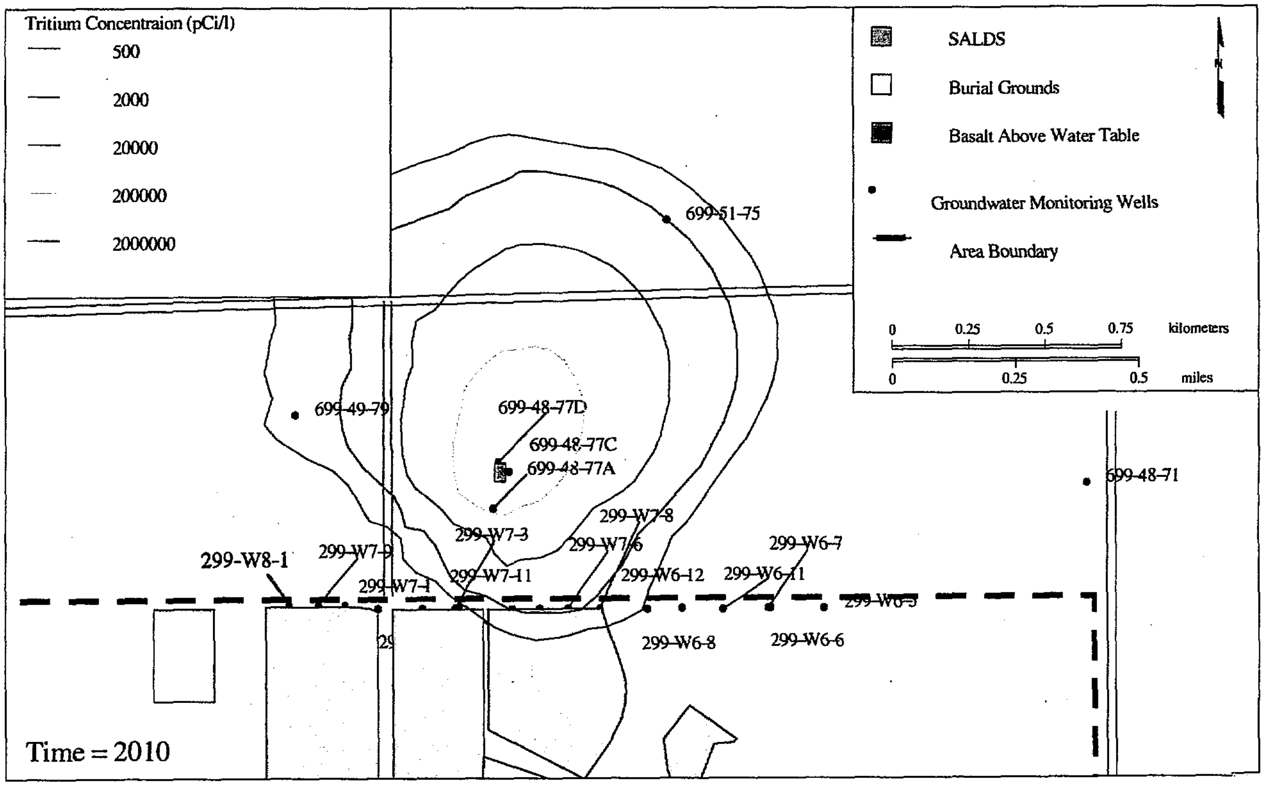


Figure 5.21. Tritium Concentrations Predicted in the Vicinity of SALDS in 2010

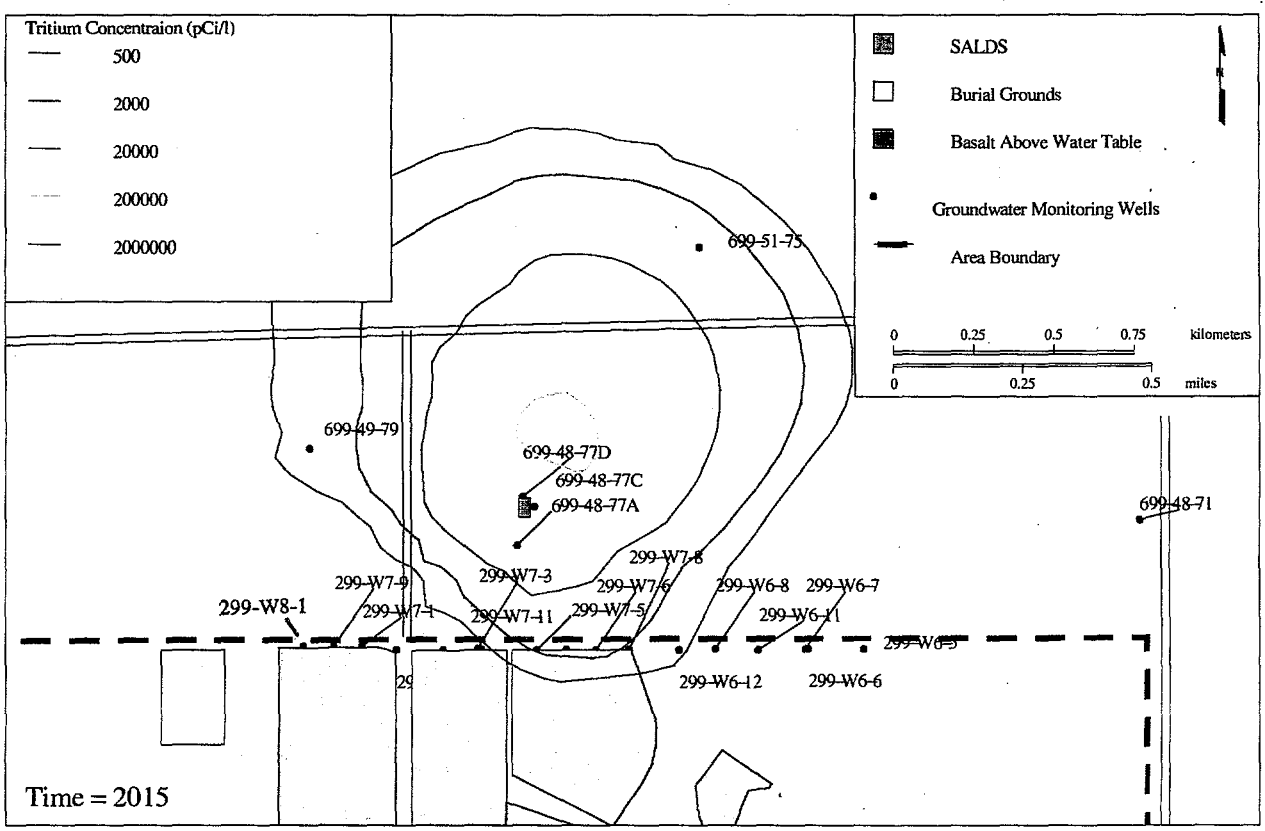


Figure 5.22. Tritium Concentrations Predicted in the Vicinity of SALDS in 2015

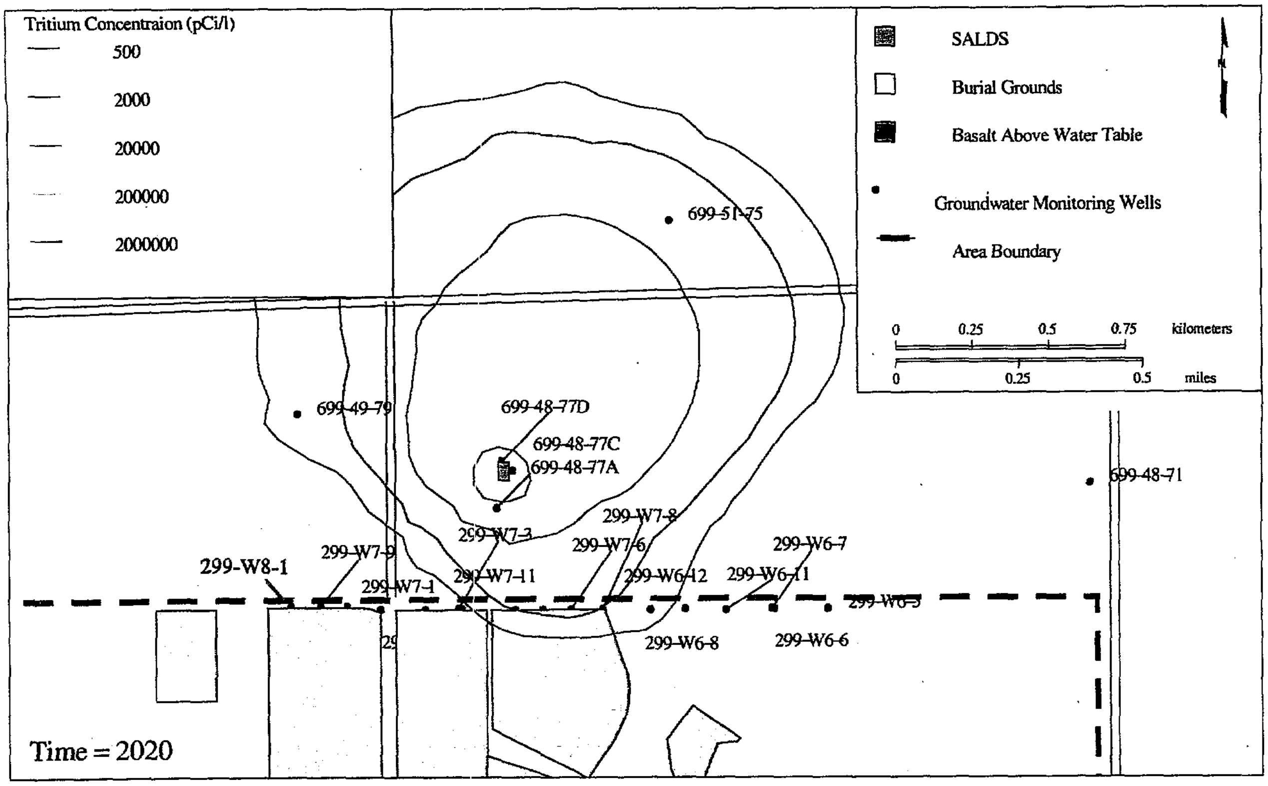


Figure 5.23. Tritium Concentrations Predicted in the Vicinity of SALDS in 2020

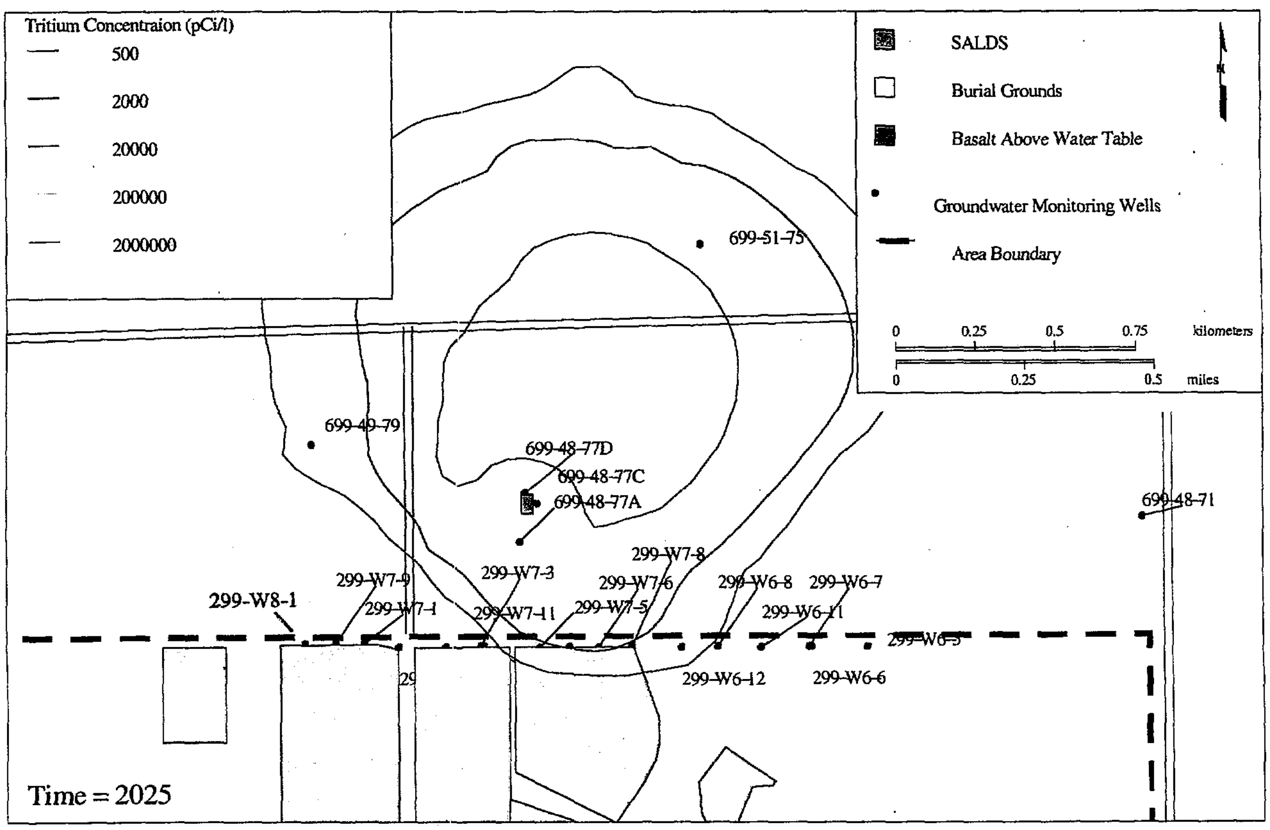


Figure 5.24. Tritium Concentrations Predicted in the Vicinity of SALDS in 2025

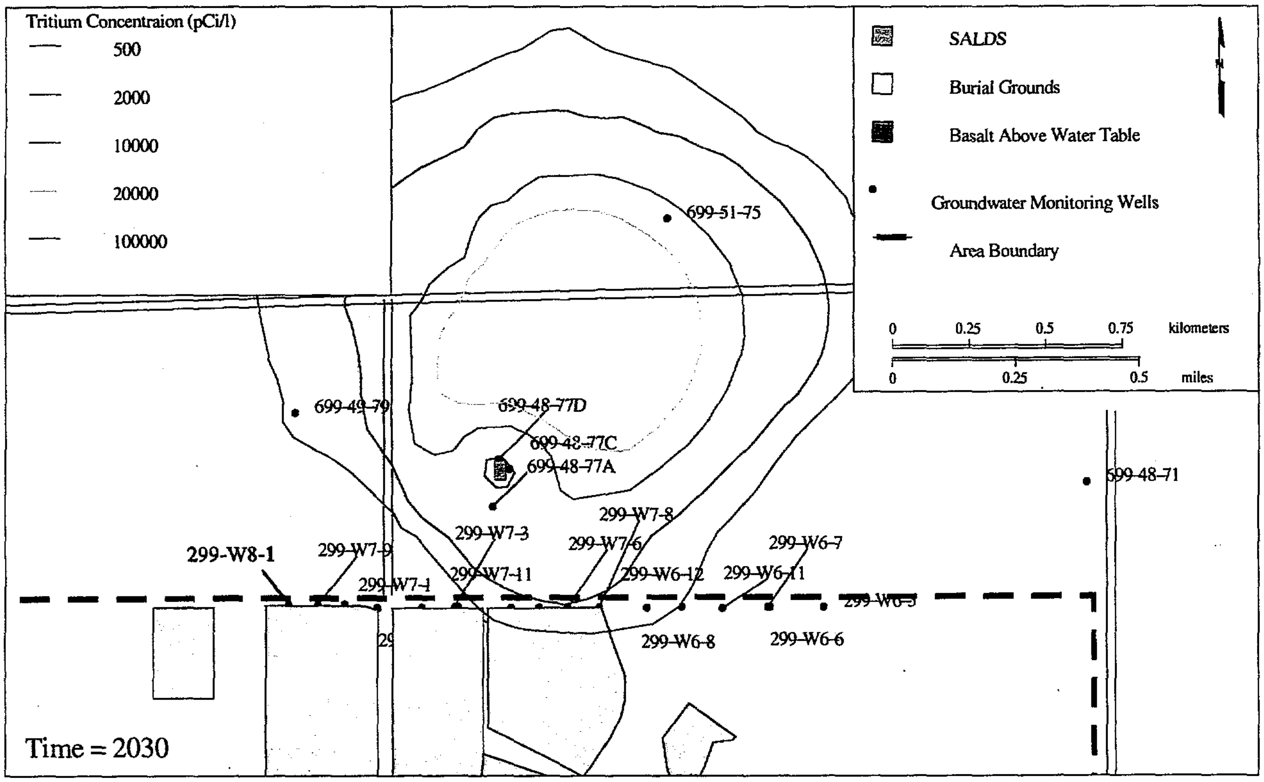


Figure 5.25. Tritium Concentrations Predicted in the Vicinity of SALDS in 2030

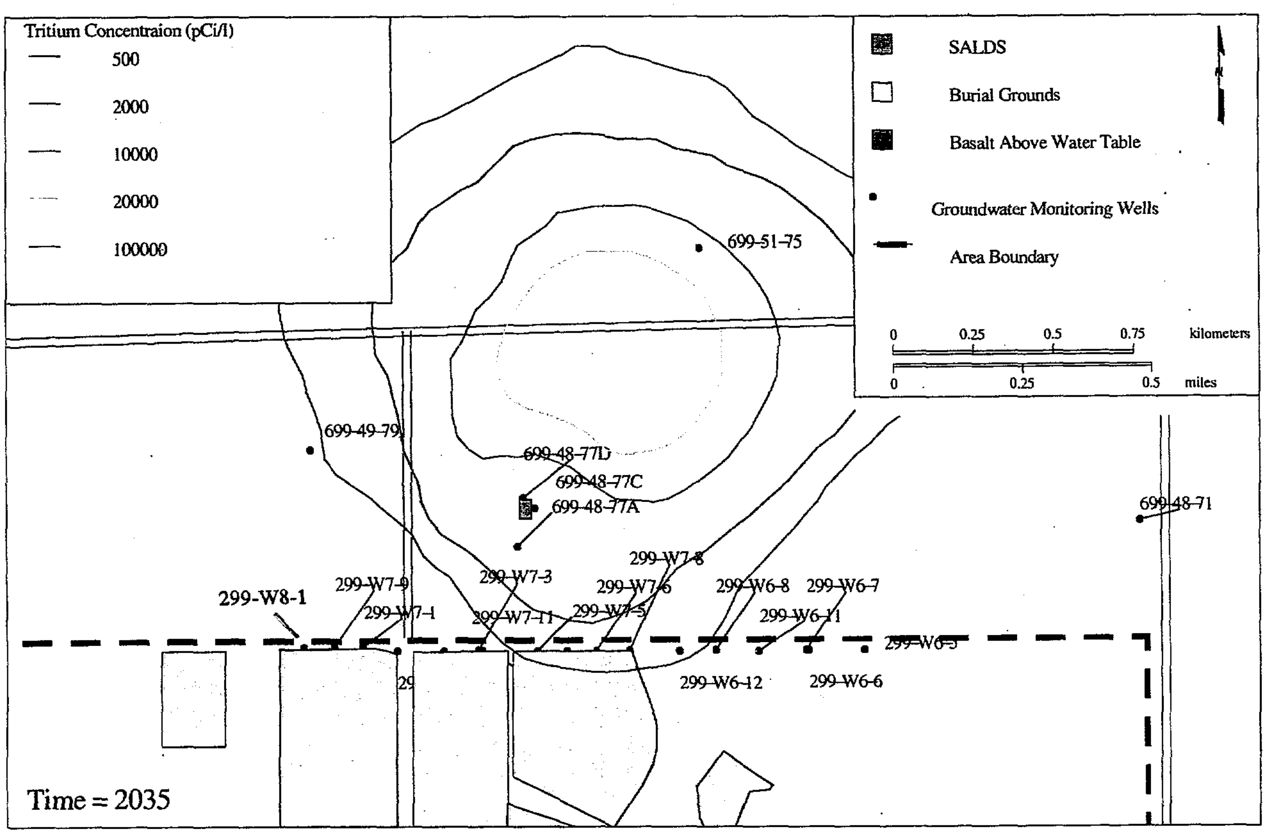


Figure 5.26. Tritium Concentrations Predicted in the Vicinity of SALDS in 2035

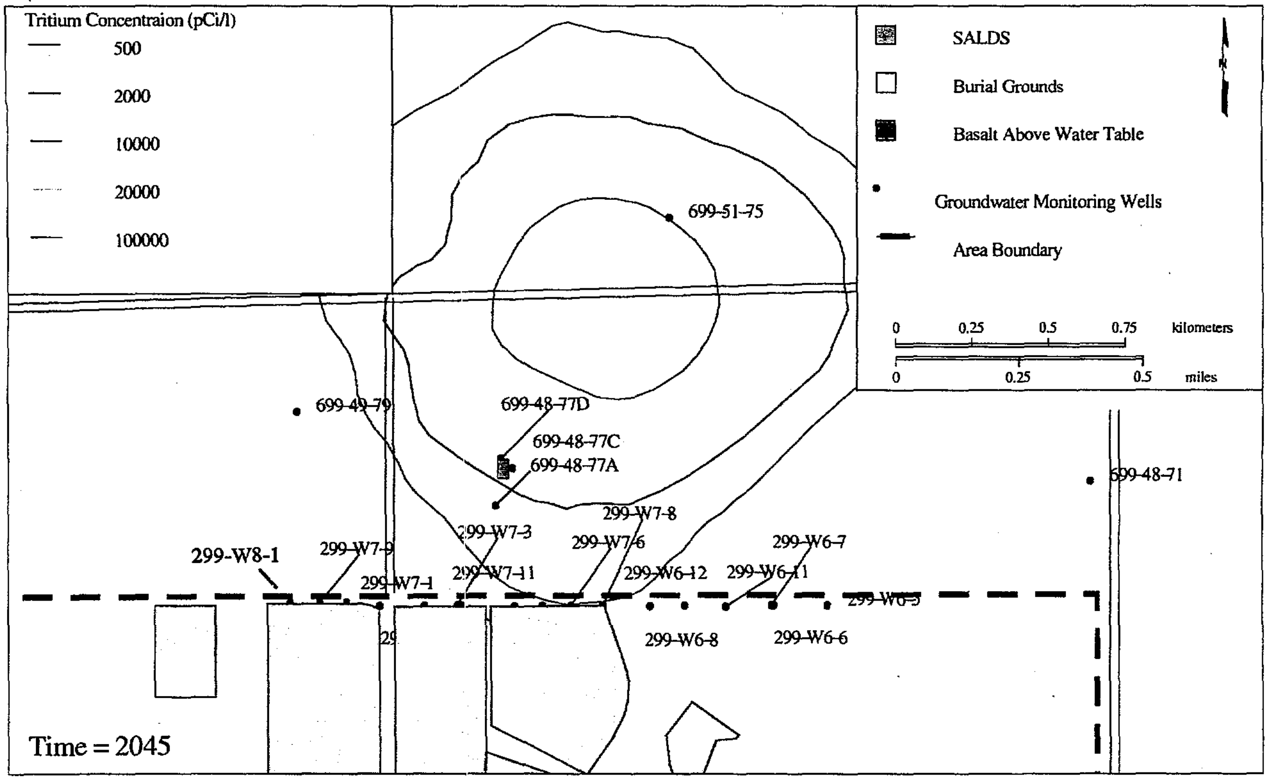


Figure 5.27. Tritium Concentrations Predicted in the Vicinity of SALDS in 2045

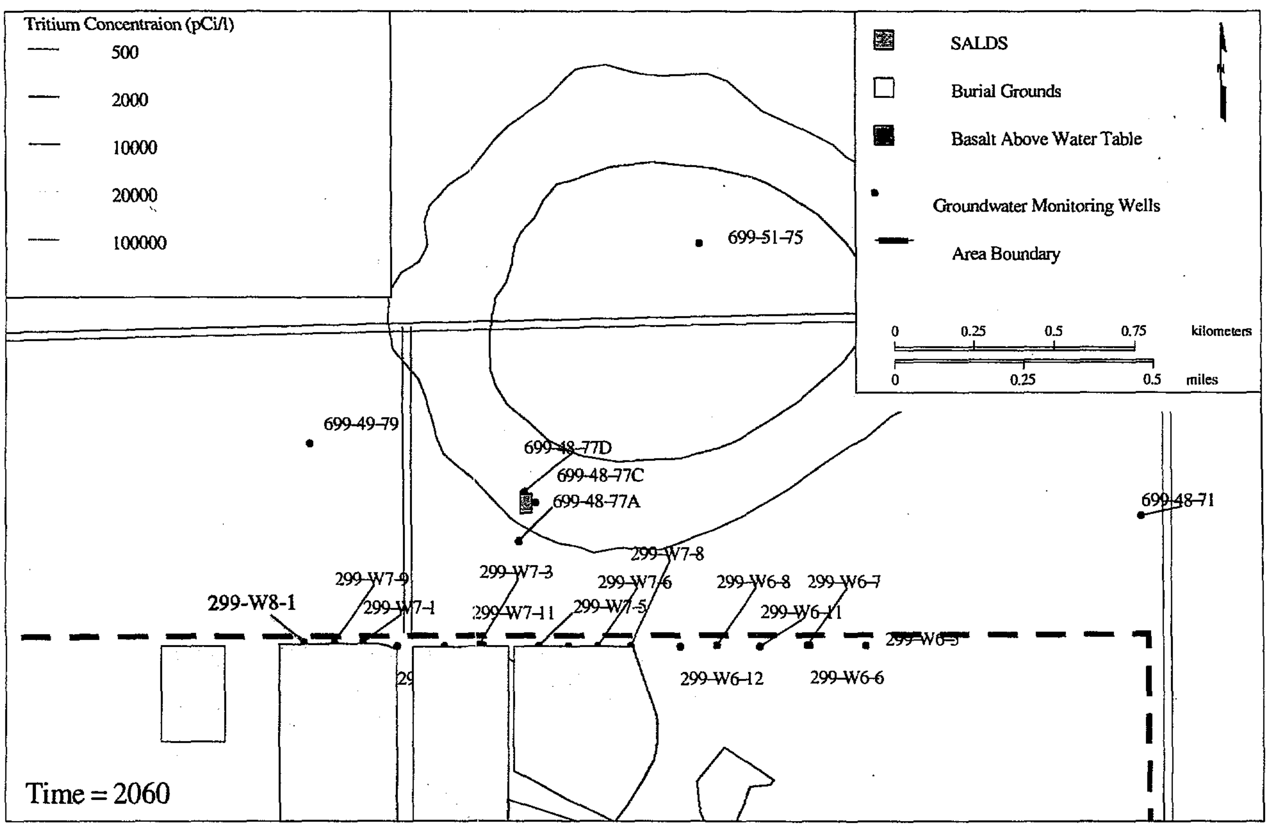


Figure 5.28. Tritium Concentrations Predicted in the Vicinity of SALDS in 2060

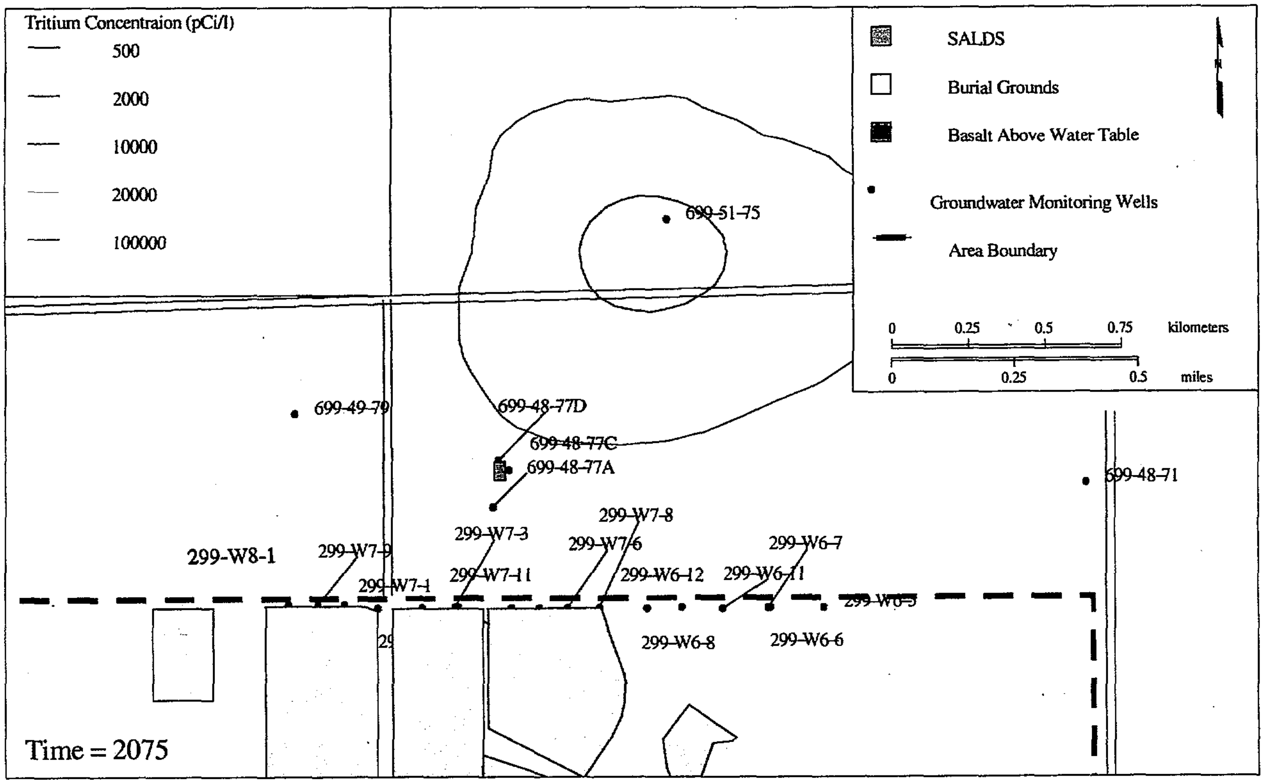


Figure 5.29. Tritium Concentrations Predicted in the Vicinity of SALDS in 2075

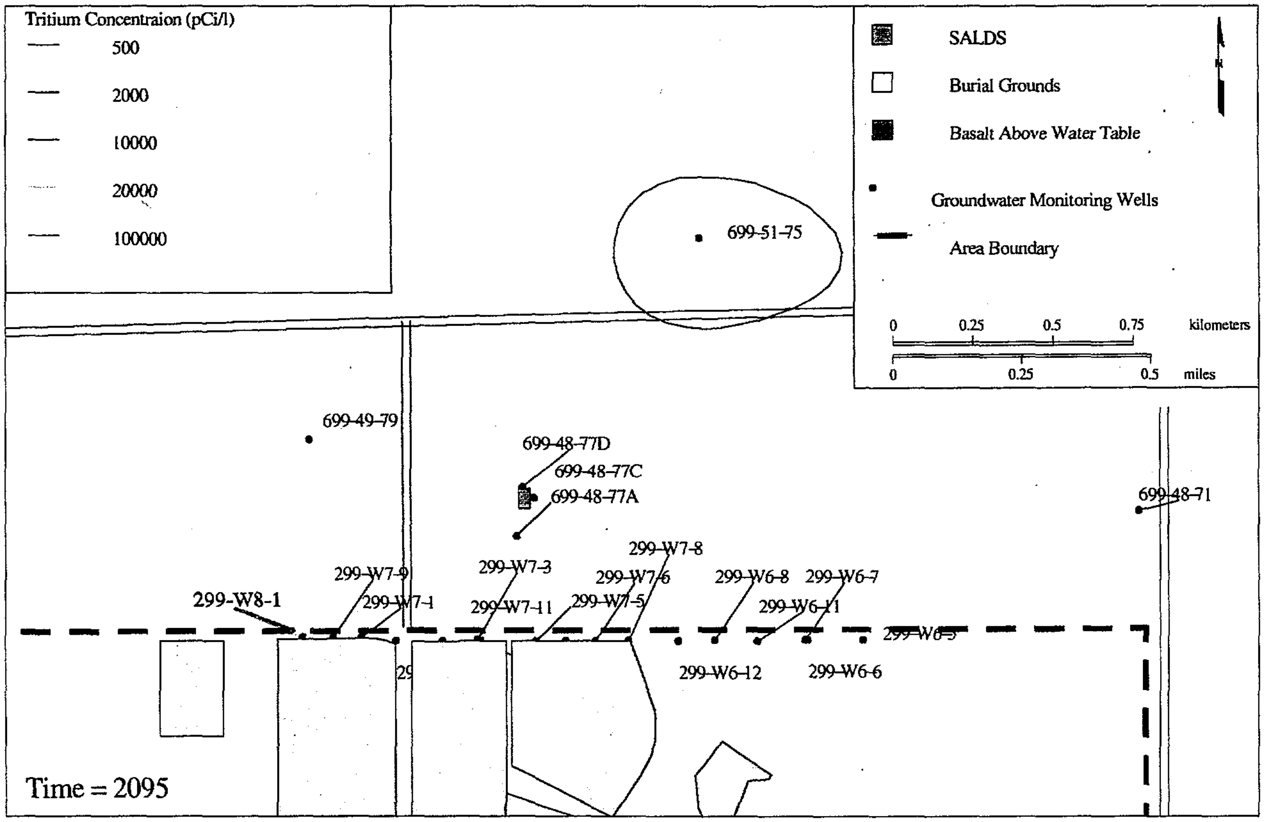


Figure 5.30. Tritium Concentrations Predicted in the Vicinity of SALDS in 2095

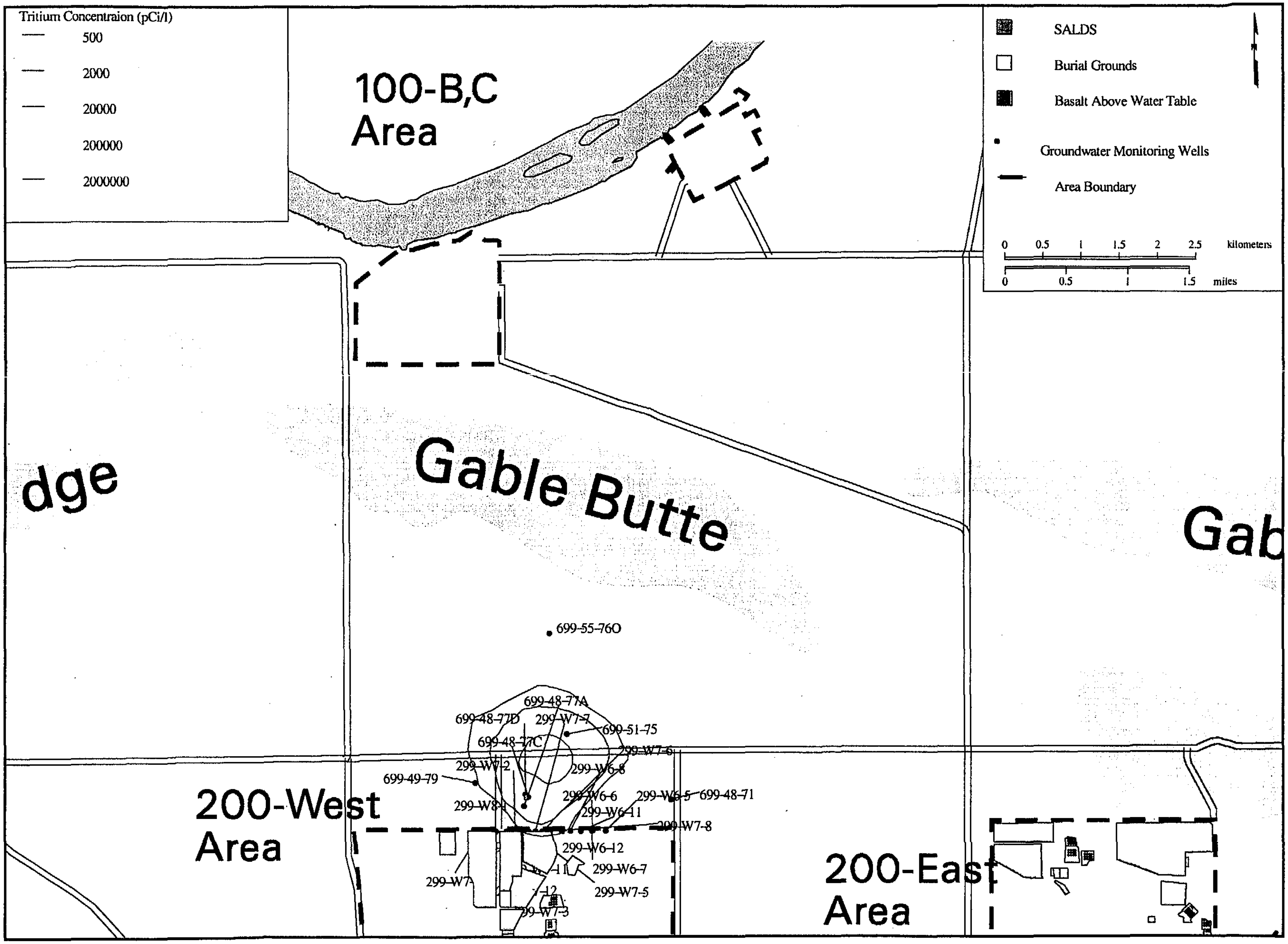


Figure 5.31. Tritium Concentrations for the SALDS at 2035 Illustrated at a Sitewide Scale

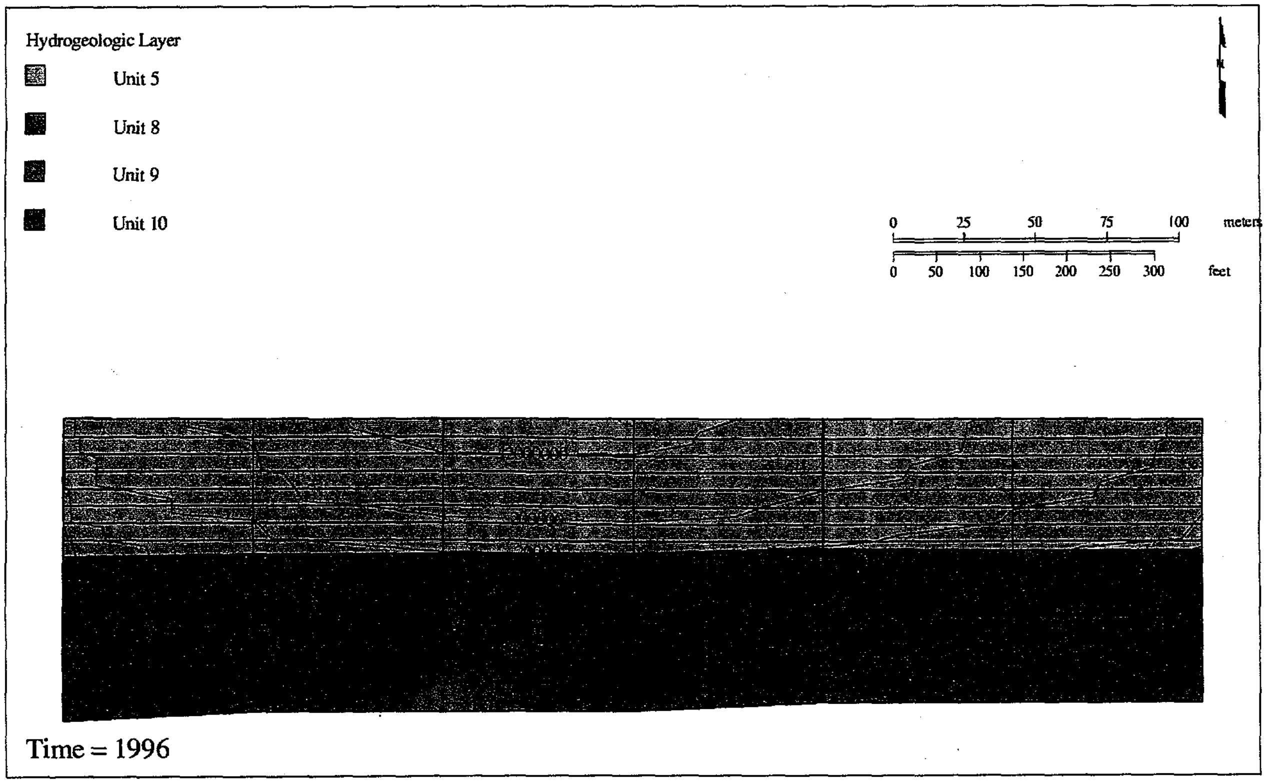


Figure 5.32. Cross Section Illustrating the Vertical Distribution of Tritium in 1996

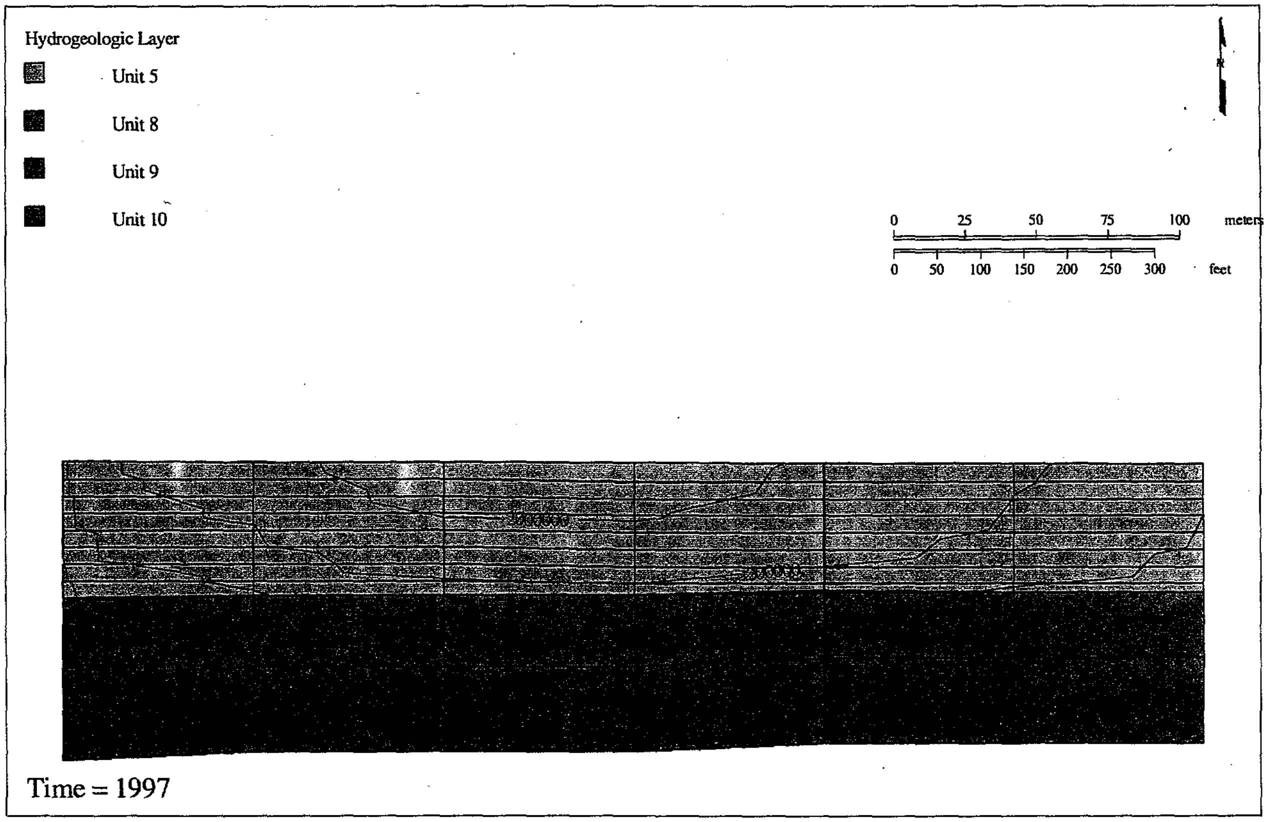


Figure 5.33. Cross Section Illustrating the Vertical Distribution of Tritium in 1997

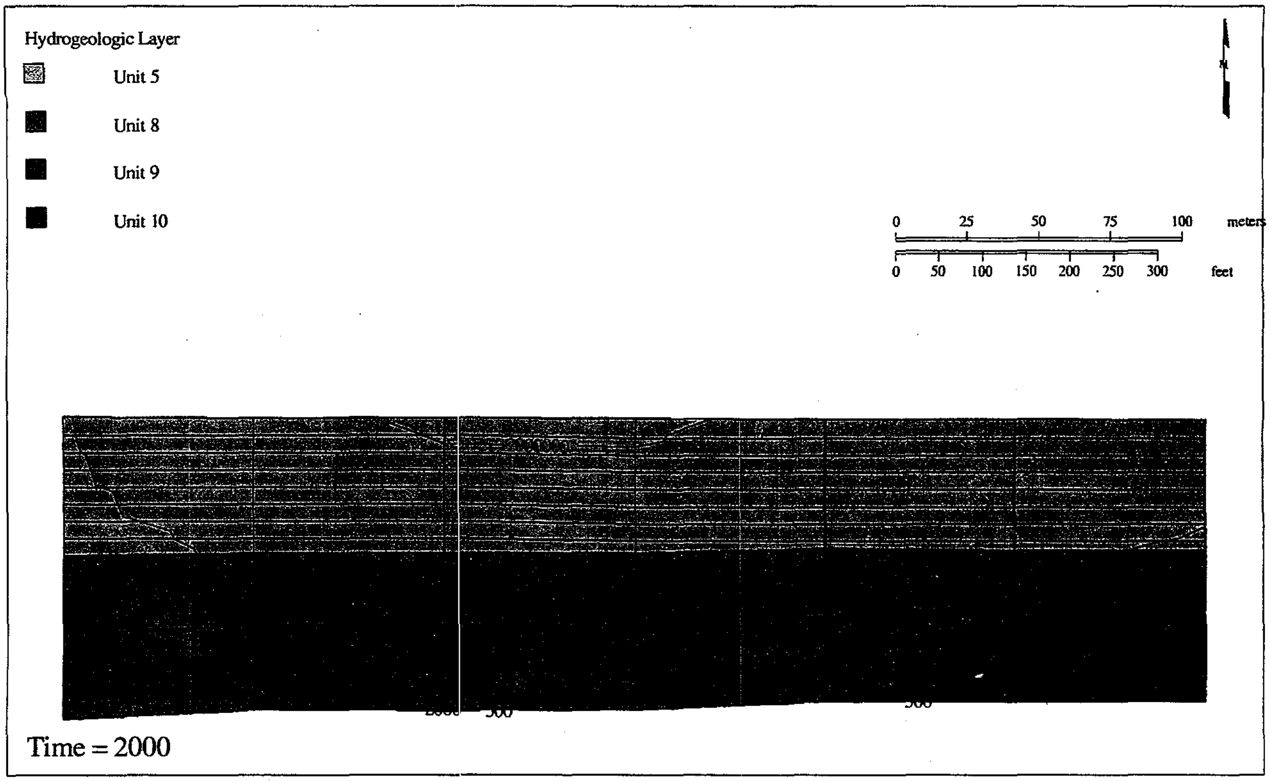


Figure 5.34. Cross Section Illustrating the Vertical Distribution of Tritium in 2000

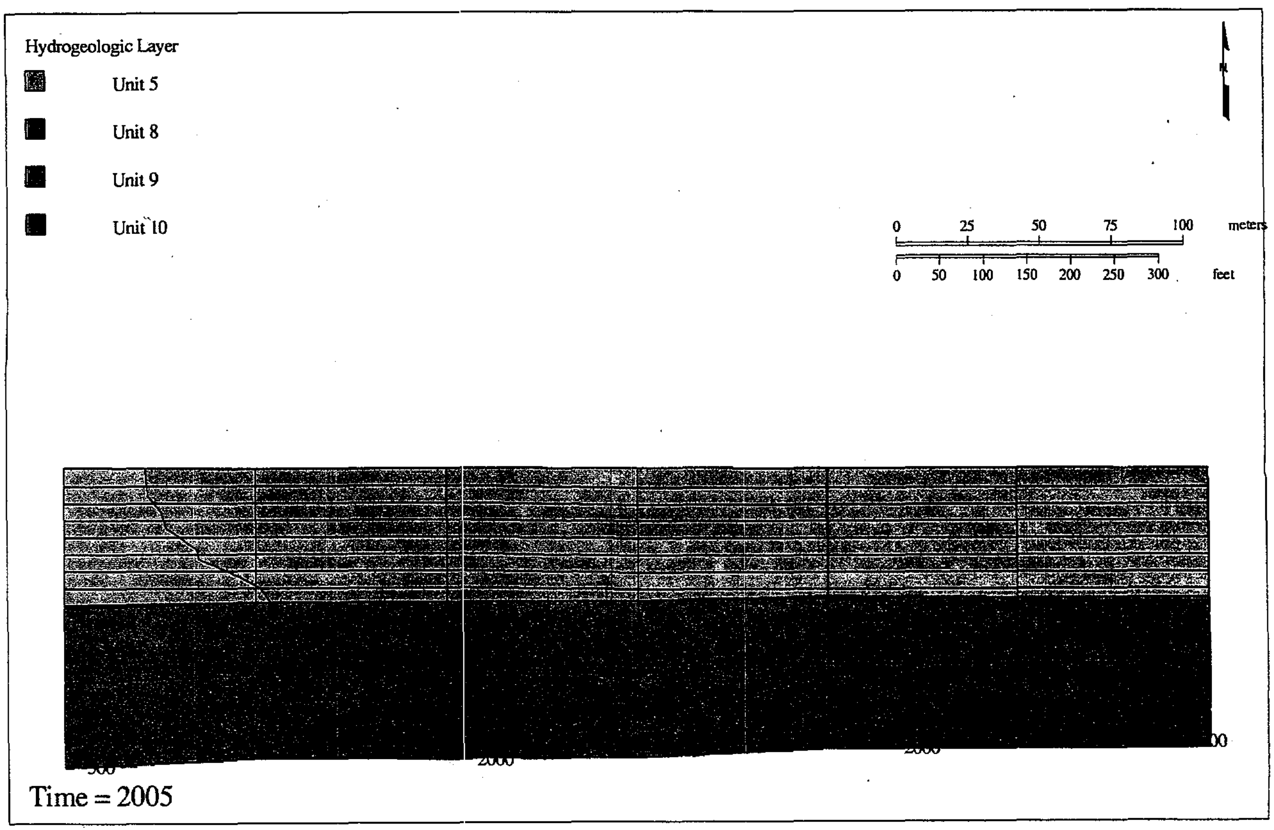


Figure 5.35. Cross Section Illustrating the Vertical Distribution of Tritium in 2005

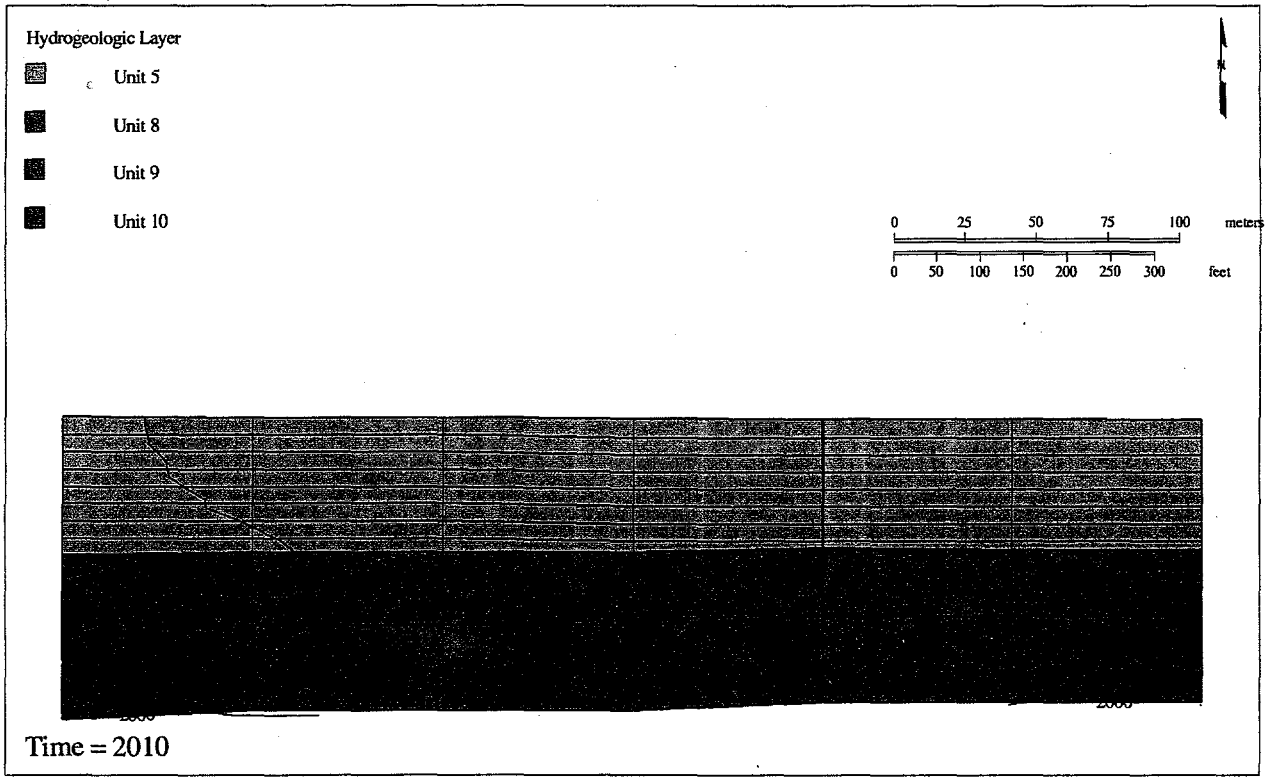


Figure 5.36. Cross Section Illustrating the Vertical Distribution of Tritium in 2010

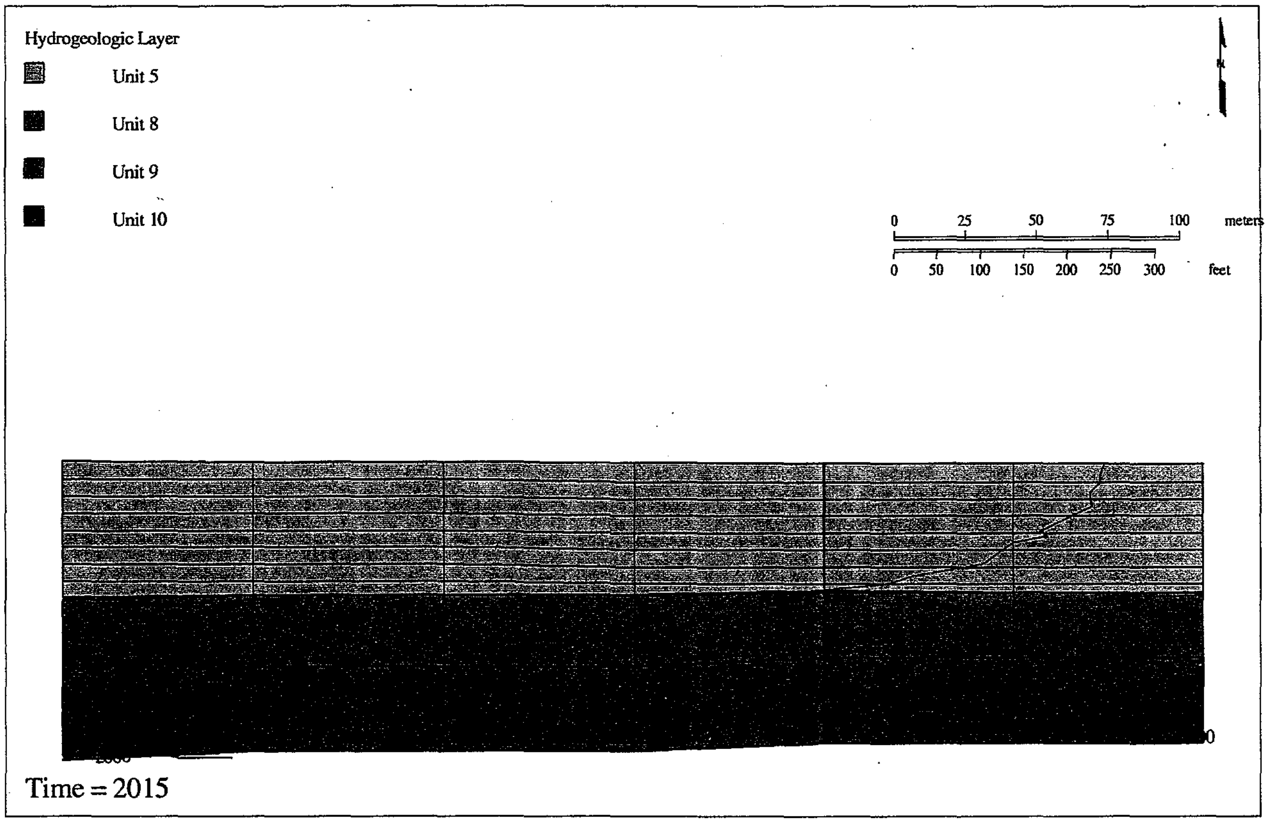


Figure 5.37. Cross Section Illustrating the Vertical Distribution of Tritium in 2015

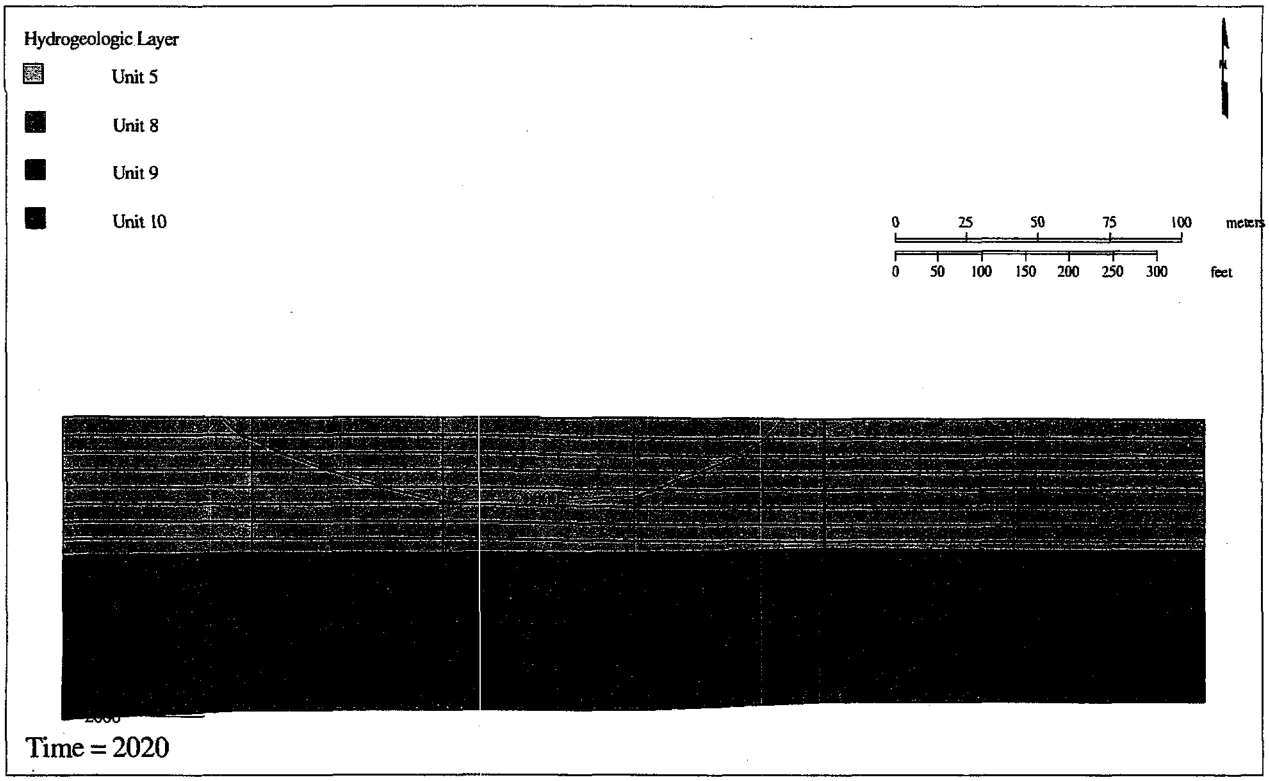


Figure 5.38. Cross Section Illustrating the Vertical Distribution of Tritium in 2020

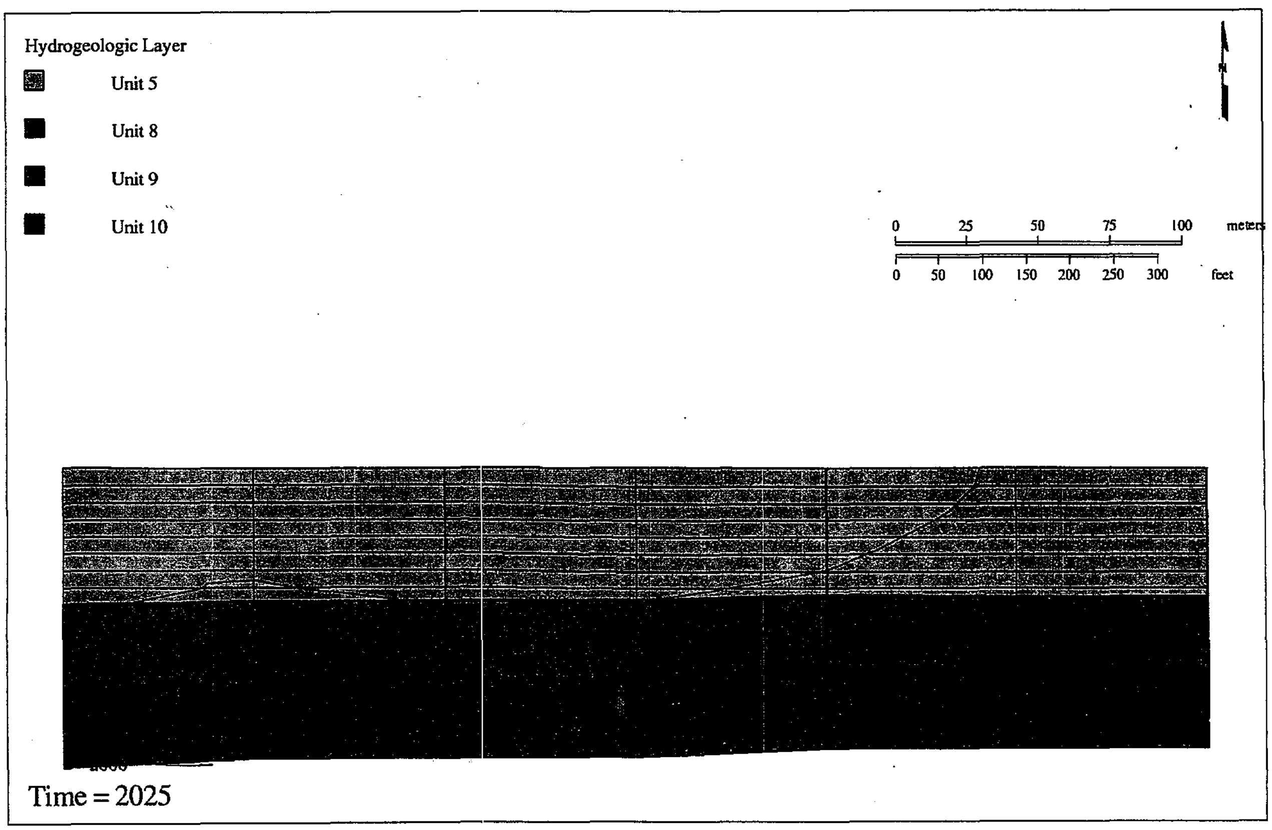


Figure 5.39. Cross Section Illustrating the Vertical Distribution of Tritium in 2025

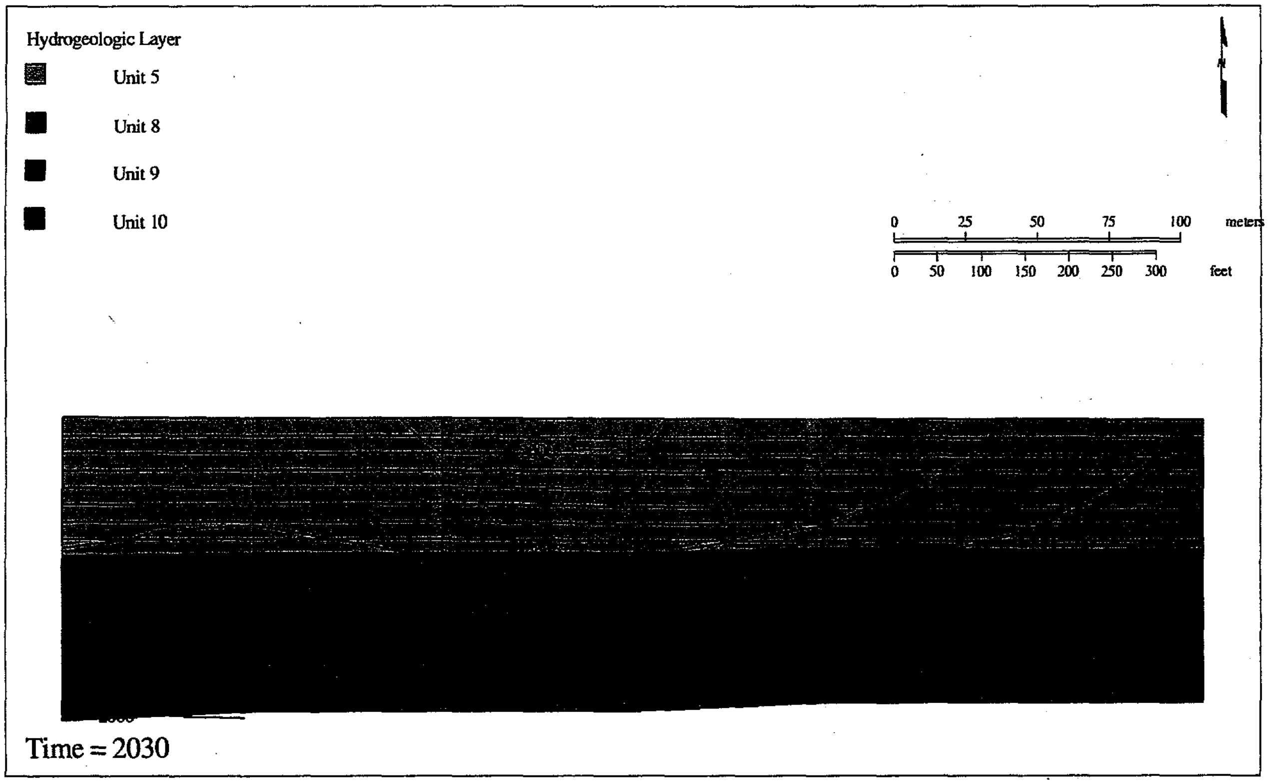


Figure 5.40. Cross Section Illustrating the Vertical Distribution of Tritium in 2030

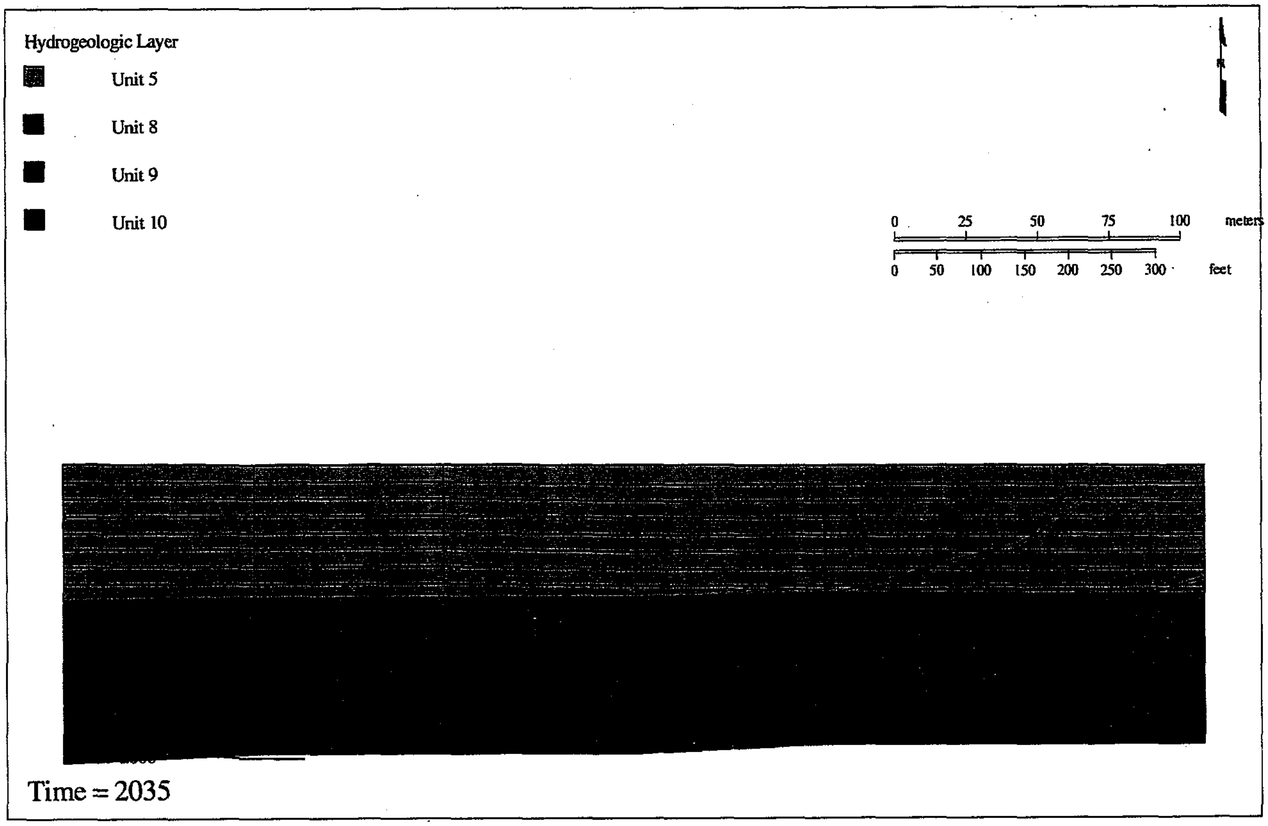


Figure 5.41. Cross Section Illustrating the Vertical Distribution of Tritium in 2035

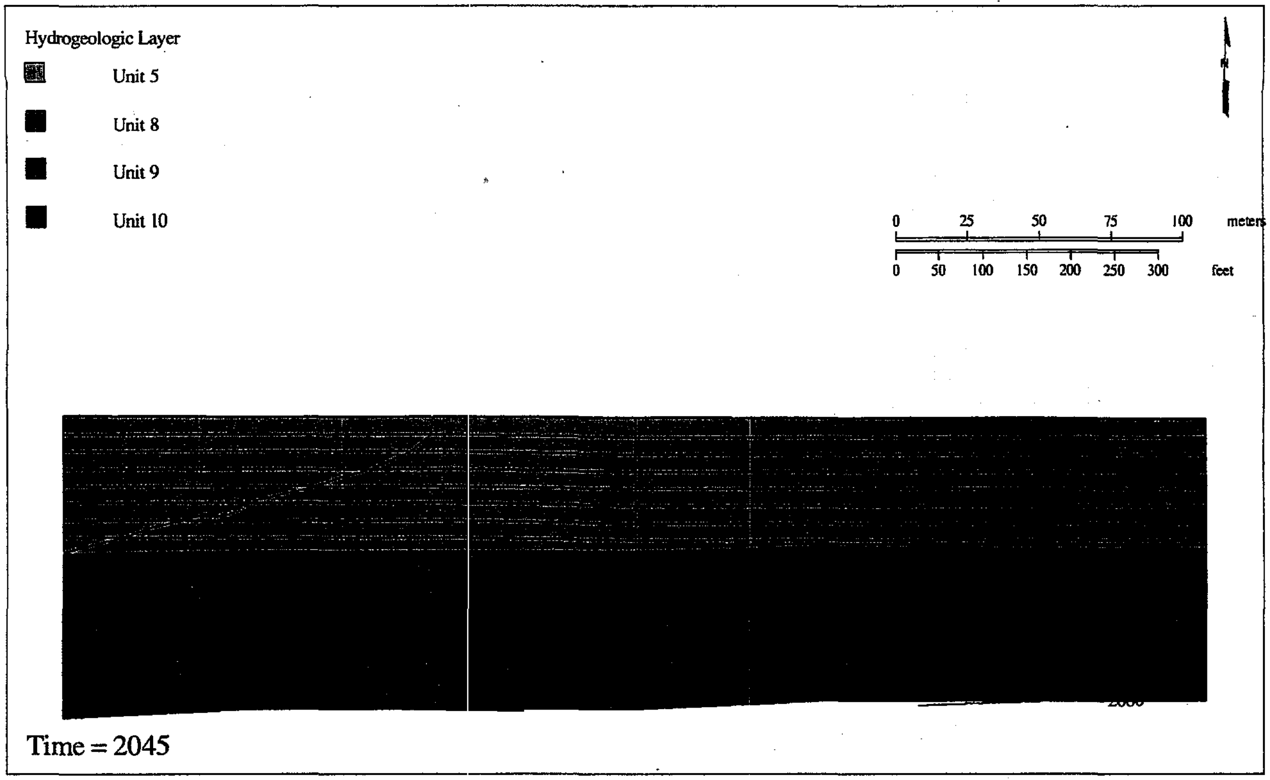


Figure 5.42. Cross Section Illustrating the Vertical Distribution of Tritium in 2045

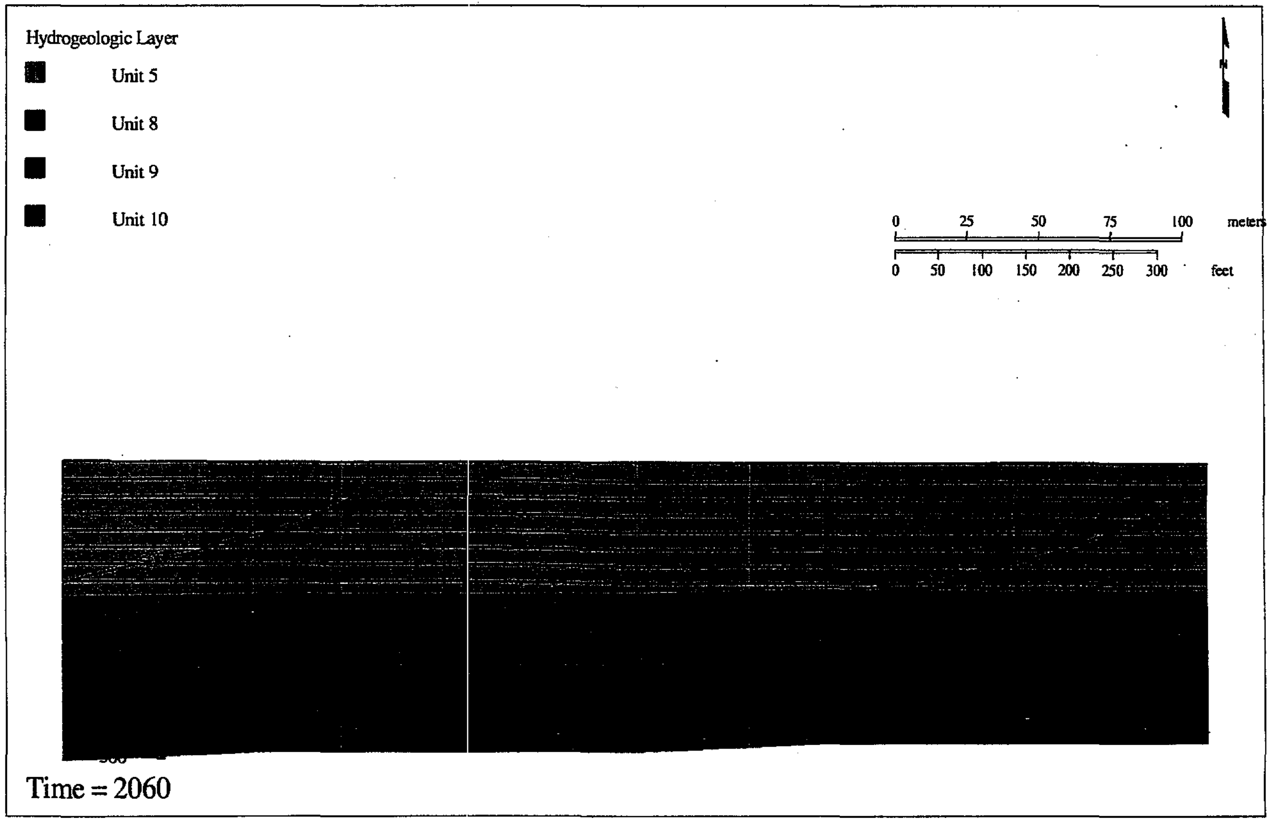


Figure 5.43. Cross Section Illustrating the Vertical Distribution of Tritium in 2060

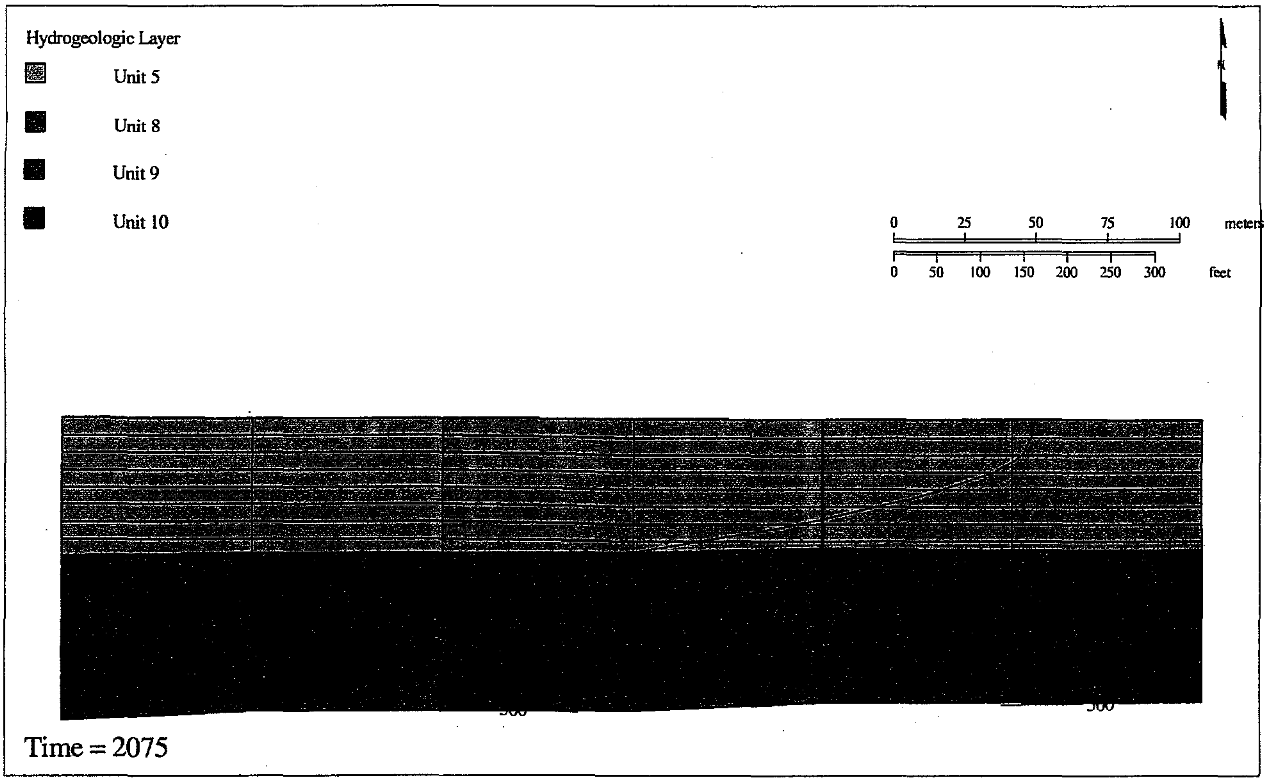


Figure 5.44. Cross Section Illustrating the Vertical Distribution of Tritium in 2075

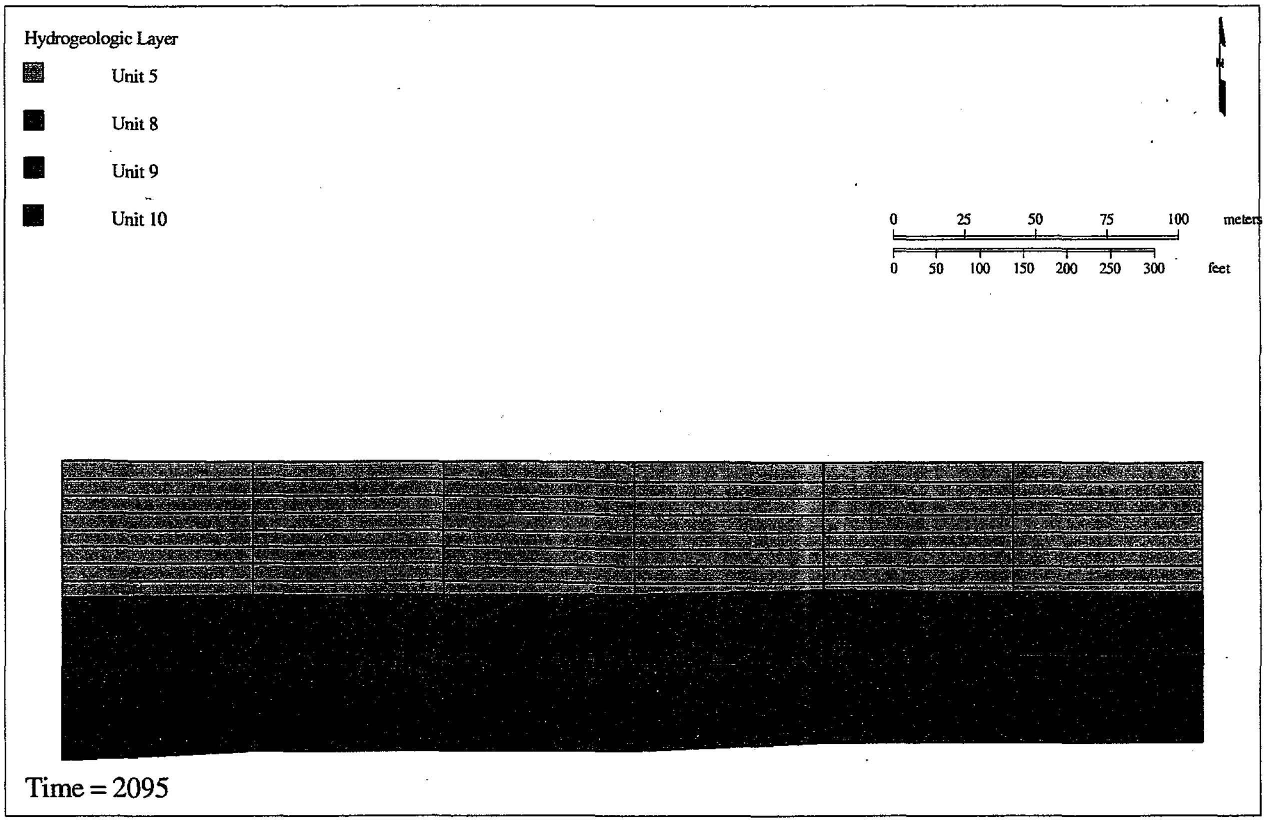


Figure 5.45. Cross Section Illustrating the Vertical Distribution of Tritium in 2095

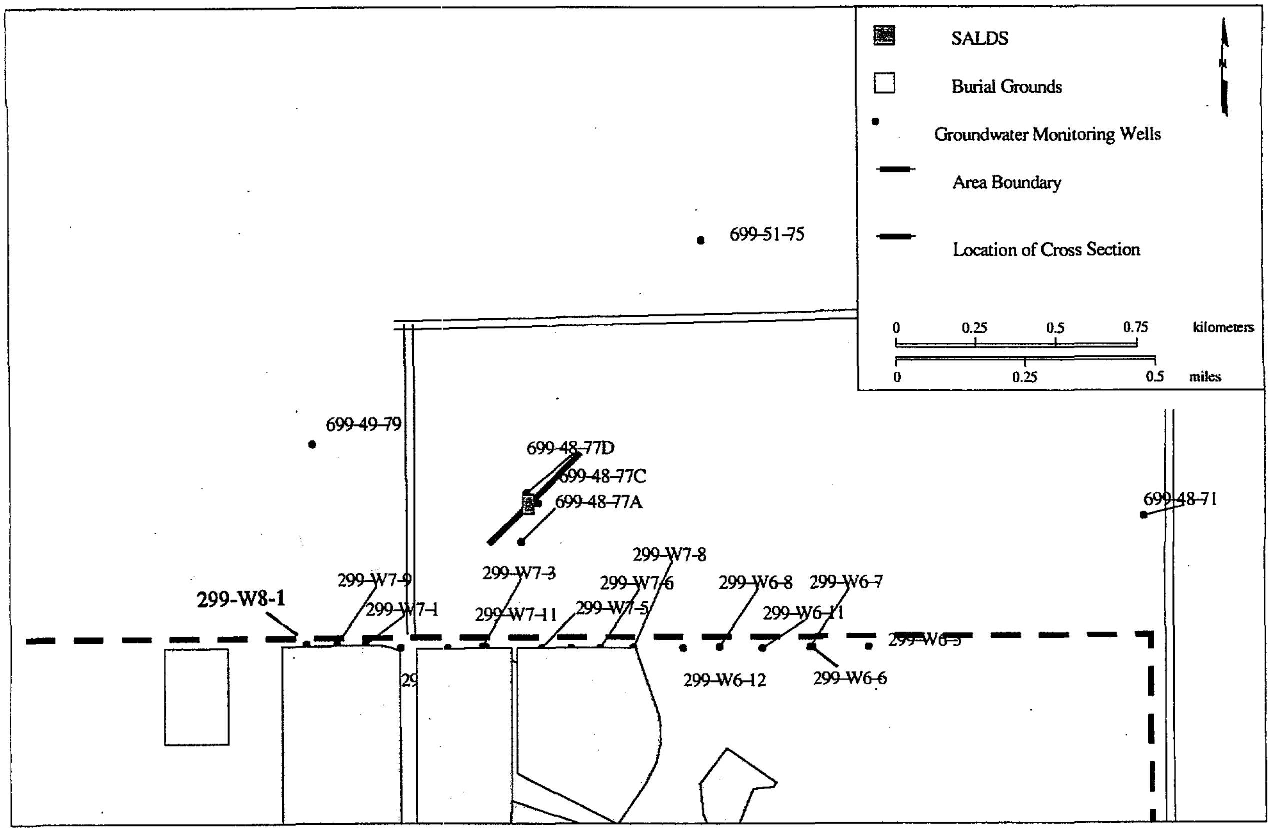


Figure 5.46. Location of the cross section illustrated in Figures 5.32-5.45.

Flow conditions beneath the SALDS cause tritium to spread in a radial pattern in the vicinity of the facility (Figures 5.17 to 5.30). Tritium reaches maximum concentrations in the first four years, 1996 through 1999. Predicted concentrations for 1997, illustrated in Figure 5.18, coincides with the time of maximum concentration where the peak concentration in the aquifer occurs in the upper layer and is predicted to be 3.4 million pCi/L. The average concentration at the node immediately beneath the SALDS, is 1.15 million pCi/L at the same time.

The model predicts that the 500 pCi/l tritium concentration contour will migrate outward a maximum distance of approximately 1.5 km from the facility by the year 2035 (Figure 5.26). As with the previous CFEST modeling effort reported by Hartman and Dresel (1997), the model predicts that planned discharges would create a groundwater mound in vicinity of the SALDS that cause the tritium plume to reach the bottom of the aquifer in the vicinity of the SALDS. However, maximum values of tritium concentration are predicted to occur in the uppermost layer of the modeled system.

5.4 Discussion and Comparison of Modeling Results

Each of the modeling efforts for determining the impacts of tritium discharges to the SALDS are based on different sets of assumptions. The Golder Associates model is based on the assumptions of a constant discharge of water and tritium to the SALDS over their entire simulation period (205 years) and steady-state flow conditions. This resulted in a projection of the tritium plume marginally reaching the Columbia River near the DWS by the 205th year of simulation. The assumptions of the Golder

Associates model are unjustifiably robust in that SALDS operation is scheduled to terminate after 30 years (not 205 years) and the facility will not discharge continuously at peak capacity.

The assumptions and results for the BHI modeling effort and both of the PNNL efforts are similar in that the plumes both remain near the SALDS source. The peak concentrations in the aquifer are higher in both of the PNNL efforts reported by Hartman and Dresel (1997) and in the current model, than those reported by Chiaramonte et al. (1996). This can be explained by a number of reasons related to model construction and input parameters. The discharge may have been applied to a smaller area in the PNNL models than in the BHI model. The flow rates associated with the tritium discharges were larger in the BHI model than in the PNNL model, although each varied differently. The finite-element grids in both of the PNNL simulations were finer in the vicinity of the SALDS than in previous models, which would result in less dispersion and higher peak concentrations. In the BHI model, the longitudinal and transverse dispersivities were assumed to be 30.5 m and 3 m, respectively, while in the PNNL models they were assumed to be 20 m and 2 m, respectively. Thus, greater dispersion overall can be expected from the BHI model than in either PNNL model, resulting in prediction of higher peak concentrations in the PNNL models and greater lateral spread of the plume in the BHI model. In spite of these differences, both models project that only a small amount of tritium remains beneath the SALDS at 100 years at a concentration of 500 pCi/L or less.

Both of the PNNL models predicted plumes that have similar areal extents, with the current PNNL model predicting a somewhat smaller plume than those reported in Hartman and Dresel (1997) because of increased grid refinement in the current model. Both models demonstrated that tritium is present at the bottom of the unconfined aquifer beneath the SALDS, even with the refined vertical layering in the current model. This result is caused by the vertical gradient that is predicted to develop beneath the SALDS from the volume of wastewater discharged.

6.0 Discussion and Conclusions

Tritium in groundwater originating from the SALDS was first detected in well 77A, a former upgradient well ~90 m south of the drainfield. That this well was the first to detect tritium is attributed largely to the structural peculiarities of the Plio-Pleistocene unit beneath the facility and the pattern of infiltration of effluent. Lower concentrations of tritium were also detected in well 77C, a deeper well, but nearer the facility than 77A. Arrival of the tritium in these wells was accompanied by elevated levels of other dissolved species, derived from leaching of the natural soil components in the vadose zone beneath the SALDS.

Vadose zone modeling conducted prior to SALDS operation (Lu et al. 1993) predicted higher hydraulic head values than observed, probably because of overestimation of discharge volumes. The vadose zone model also did not predict arrival of the first effluent at upgradient well 699-48-77A because the model could not account for structural details of the Plio-Pleistocene unit. The model did correctly predict that effluent would reach the water table within one year of the beginning of operations. Vadose zone modeling performed by Collard et al. (1996) for adjacent areas of the 200 West Area supports this prediction.

Some previous groundwater models predicted tritium would reach the Columbia River in ~100 years, but these models assumed unrealistic operating parameters for the SALDS. The most current ground-water model indicates that tritium at the 500-pCi/L level or above will extend a maximum horizontal distance less than 1.5 km from the facility using current, reasonable estimates of SALDS operation. The horizontal pattern of dispersion of the tritium plume created by the model indicates that not all of the wells in the current tritium-tracking network will be affected by the plume. Predictions of the vertical distribution of tritium beneath the SALDS and vicinity indicate that tritium will reach the bottom of the unconfined aquifer, but the greatest activities of tritium will remain in the upper portions thereof. This prediction is important in that most wells in the tritium-tracking network are screened within the upper regions of the unconfined aquifer.

Successive interpretations of the geometry of a nearby tritium plume created by past practices in the northeast corner of the 200 West Area illustrates what may be expected of the fate of tritium discharges in this region (compare Dresel et al. 1994 and Hartman and Dresel 1997). This plume has apparently changed very little in position and configuration over the last several years, and may be a gauge of how a plume originating from SALDS might develop.

If necessary, resolution between the SALDS tritium and the 200 West Area plume may be aided by trending other dissolved components in the groundwater, such as sulfate and calcium or by measuring total dissolved solids and conductivity (see Section 4.2). Other dissolved components may be eventually recognized as originating in the vadose zone beneath the SALDS.

6.1 Infiltration of Effluent at the SALDS

The proximity of the SALDS to the three original monitoring wells is illustrated in Figure 1.2. Although well 77A is several times more distant from the facility than the other two wells, it was the first well to detect high concentrations of tritium. Furthermore, the screen in well 77D is closer to the facility both vertically and horizontally than wells 77A and 77C, yet has shown no effects of effluent incursion. This circumstance may be explained by the pathways of infiltration taken by the effluent.

Figure 6.1 illustrates a hypothetical pattern of infiltration at the SALDS. This stylized conceptual model is based on what is known of the subsurface geologic structure and stratigraphy in the vicinity of the SALDS and the construction of the facility (see Section 3.1). Figure 6.1 indicates the near-surface Plio-Pleistocene unit partially intercepting the infiltrating effluent in the upper portion of the vadose zone, and thus diverting the water a short distance down the structural trend of the unit within the vadose zone before it penetrates to groundwater.

A drain manifold extends along the entire length of the facility to distribute effluent along the drainfield in a north-south direction. Effluent enters from the southern (left in Figure 6.1) end of the facility. Because of the low discharge rates to the facility, it is likely that the distal portion of the distribution system was not fully utilized, thus allowing most of the effluent to infiltrate within the southern half of the drainfield. This condition might enhance the southward displacement of the site of effluent infiltration through the vadose zone. Periodic monitoring of piezometers installed to the bottom of the gravel fill in the drainfield has not detected any water, even during operation. This observation supports the supposition of rapid drainage of effluent from the SALDS.

The conceptual model of infiltration presented in Figure 6.1 could explain why well 77A detected high concentrations of tritium; it is screened at the water table and would have received largely undiluted effluent. Well 77C is screened ~20 m below the water table and thus may have detected only dilute effluent that has mixed with groundwater. Fine-grained strata in the Ringold Formation described by Swanson (1994) may also inhibit effluent travel to well 77C. So far, well 77D has apparently lain just outside the areas of infiltration and mixing.

6.2 Evaluation of the Tritium-Tracking Network

The current tritium-tracking network of wells (Figure 1.3) has thus far proved adequate to constrain the boundaries of the tritium plume created by SALDS. Based on current projections of ETF operation and refined model predictions, the current network may indeed be sufficient for the duration of the life of the facility. The closely spaced line of wells along the 200 West Area boundary will intercept any tritium incursion that might potentially occur in that area from the effects of the Plio-Pleistocene unit structural bias or from groundwater mounding. The interception of tritium in well 77A suggests that effluent does move preferentially along the surface of the Plio-Pleistocene unit, but that discontinuities in the unit and the spacing of the well network allow for adequate detection of the effluent in that direction. Current model predictions of vertical and horizontal dispersion of effluent in the aquifer indicate that

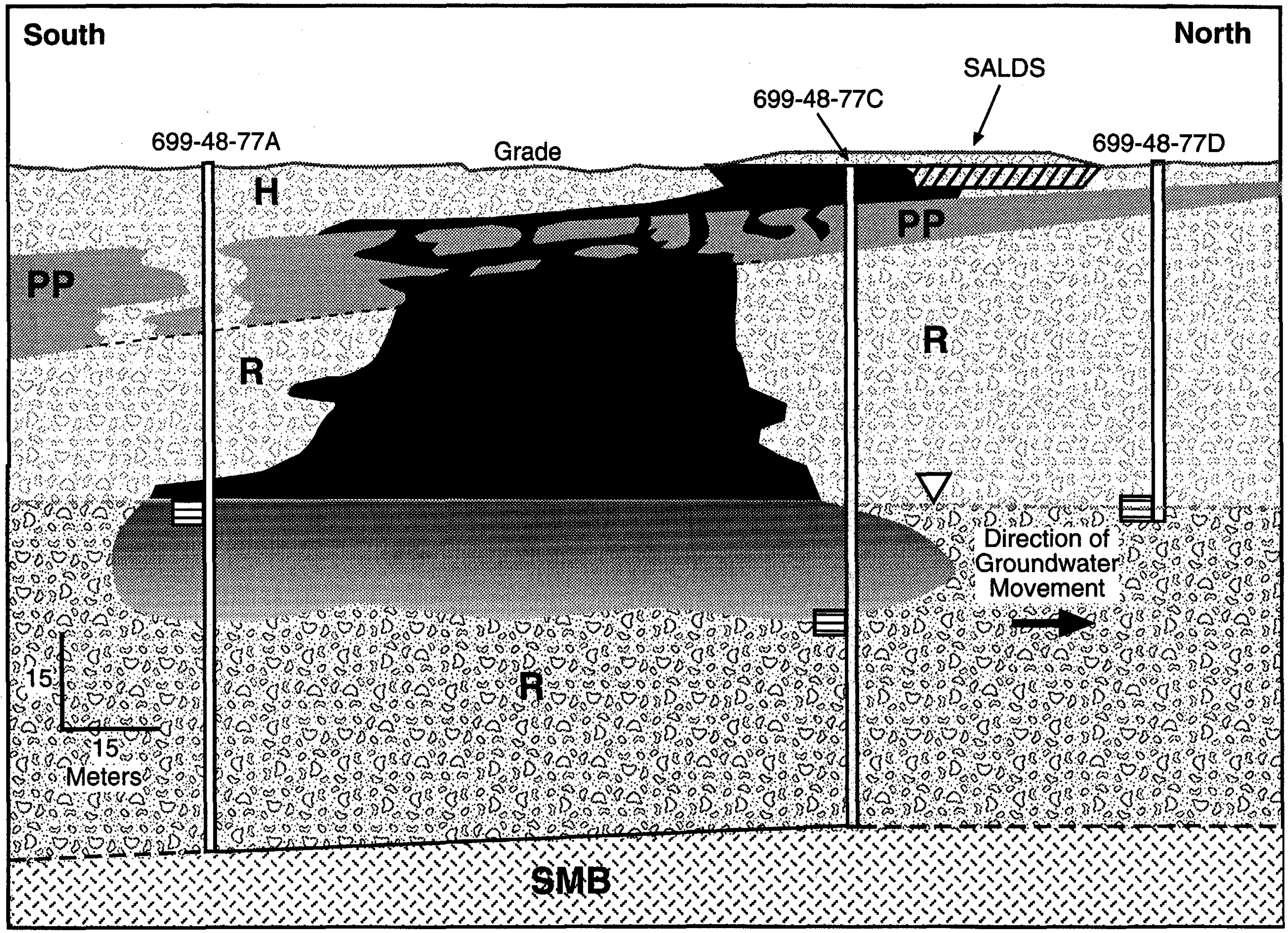


Figure 6.1. Schematic Interpretation of Effluent Pathways through the Vadose Zone Beneath the SALDS (H=Hanford Formation, PP=Plio-Pleistocene, R=Ringold Formation, SMB=Elephant Mountain Member of Saddle Mountains Basalt Formation)

tritium will be present in sufficient concentrations for detection by the current spacing of wells and the existing vertical distribution of well screens. In the event that effluent is moving downgradient more rapidly than predicted, well 699-51-75 is in an advantageous position immediately downgradient from the effluent already detected in wells 77A and 77C. Thus, Well 699-51-75 would be expected to detect tritium from the SALDS even if well 77D were temporarily bypassed by the plume.

Hydraulic head measurements indicate that a downward-directed hydraulic gradient exists between the unconfined aquifer and upper-basalt confined aquifer in the vicinity of the SALDS (Hartman and Dresel 1997). The current numerical model predicts that tritium will reach the interface between the unconfined aquifer and the upper-basalt confined aquifer. However, travel times for groundwater in the upper-basalt confined aquifer are generally estimated to be much greater than travel times in the overlying unconfined aquifer (Spane and Webber 1995). This factor, the short half-life of tritium (12.3 years), and the limited duration and extent of the plume predicted for the unconfined aquifer suggest that tritium from the SALDS potentially entering the upper-basalt confined aquifer is not a concern.

7.0 Recommendations

Based on results of groundwater monitoring in the SALDS tritium-tracking network since 1995 and current numerical modeling results, the following recommendations are made for continuation of monitoring.

- Tritium monitoring will be increased from annually to semiannual frequency in critical wells in the current tritium-tracking network (Figure 1.3), to be put into effect as of October 1997. In addition to the four facility wells (299-W8-1, 699-48-77A, 699-48-77C, 699-48-77D), the wells that may be monitored semiannually are: 299-W6-8, 299-W7-1, 299-W7-2, 299-W7-6, and 299-W7-11. These wells will serve as an early warning of tritium incursion into the 200 West Area, should this occur.

- To maintain resolution between tritium in groundwater originating from the SALDS and tritium from the 200 West Area, special scrutiny of monitoring results should be afforded the portion of the tritium-tracking network southeast of the SALDS. This resolution will be aided by observing levels of certain dissolved parameters (e.g., sulfate).

- Water levels will be measured monthly, at minimum, in wells 699-48-77A, 699-48-77C, 699-48-77D, and 299-W8-1 to more closely link discharge events with observed effects in the groundwater. Water levels in all other wells in the current tritium-tracking network will be measured annually, at minimum.

- Model(s) using the level of discretization of the current model, with reasonable but conservative assumptions may be used henceforth for predictive updates for the remainder of the permit period.

- The SALDS groundwater monitoring plan will be updated annually, beginning in FY 1998. The plan will address all applicable permit requirements and other activities dictated by ongoing monitoring results. Attached as an appendix will be a report summarizing results of the most recent tritium monitoring, describing analytical results and comparing model predictions with observations, as appropriate.

Installation of additional monitoring wells is not recommended nor justifiable at this time. Actual spreading of tritium observed thus far in groundwater from SALDS operations appears to be more conservative than predictions and has not yet affected all three wells nearest the facility, most notably, well 77D. The portion of the tritium-tracking network south of the SALDS is densely furnished with wells. An existing well, 699-51-75, is located immediately downgradient of wells 77A and 77C, which have already detected tritium from the facility. Additionally, dispersion patterns predicted by modeling indicate that existing wells in the current tritium-tracking network (Figure 1.4) should eventually intercept a tritium plume originating from SALDS before the plume dissipates. In the improbable event that the aforementioned conditions proved inadequate for confident monitoring, or that the model is inaccurate, the extended ("far field") array of monitoring wells (Figure 1.3) is sufficiently dense that migrating tritium would be inevitably detected before reaching the Gable Mountain area. Furthermore, out-year predictions of hydraulic head across the Hanford Site indicate that groundwater flow will become increasingly easterly. This circumstance would further improve the probability of plume detection because of the density of monitoring wells already existing in an easterly direction from the SALDS. Current distributions of wells for the sitewide monitoring of other Hanford Site plumes (see Hartman and Dresel 1997) should serve as a minimum guideline for well spacings of the tritium monitoring network for the SALDS. At present, well density in the current and proposed ("far-field") networks for the SALDS exceeds the level of coverage for the sitewide monitoring program.

8.0 References

Chiaramonte, G.R., C.W. Denslow, A.J. Knepp, R.D. Landon, and S. Panday. 1996. *Hanford Sitewide Groundwater Remediation Strategy - Groundwater Contaminant Predictions.* BHI-00469, Rev. 0, Bechtel Hanford Inc., Richland, Washington.

Collard, L.B., J.D. Davis, and D.B. Barnett. 1996. *Potential Effects of Low-Volume Effluent Discharges on Past-Practice Vadose-Zone Contamination.* WHC-SD-LEF-ER-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Connelly, M.P., B.H. Ford, and J.V. Borghese. 1992. *Hydrogeologic Model for the 200 West Groundwater Aggregate Area.* WHC-SD-TI-014, Westinghouse Hanford Company, Richland, Washington.

Davis, J.D., D.B. Barnett, C.J. Chou, and P.B. Freeman. 1996. *Ground-Water Screening Evaluation/Monitoring Plan -- 200 Area Effluent Treatment Facility (Project C-018H).* WHC-SD-C018H-PLN-004, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Delaney, C.D., K.A. Lindsey, S.P. Reidel. 1991. Geology and Hydrology of the Hanford Site: A Standardized Text for Use in Westinghouse Hanford Company Documents and Reports, WHC-SD-ER-TI-003, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

DOE (U.S. Department of Energy). 1988. *Consultation Draft, Site Characterization Plan, Reference Repository Location, Hanford Site, Washington.* Vol. 1, DOE/RW-0164, U.S. Department of Energy, Office of Civilian Radioactive Waste Management, Washington, D.C.

DOE-RL (U.S. Department of Energy - Richland Operations Office). 1993. *State Waste Discharge Permit Application for the 200 Area Effluent Treatment Facility and the State-Approved Land Disposal Site.* DOE/RL-93-44, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Dresel, P.E., S.P. Luttrell, J.C. Evans, W.D. Webber, P.D. Thorne, M.A. Chamness, B.M. Gillespie, B.E. Opitz, J.T. Rieger, J.K. Merz. 1994. *Hanford Site Ground-Water Monitoring for 1993.* PNL-10082, Pacific Northwest Laboratory, Richland, Washington.

Dresel, P.E., P.D. Thorne, S.P. Luttrell, B.M. Gillespie, W.D. Webber, J.K. Merz, J.T. Rieger, M.A. Chamness, S.K. Wurstner, B.E. Opitz. 1995. *Hanford Site Ground-Water Monitoring for 1994.* PNL-10698, Pacific Northwest Laboratory, Richland, Washington.

Ecology. 1986. State Waste Discharge Program, WAC 173-216, Washington State Department of Ecology, Olympia, Washington.

Ecology. 1990. Water Quality Standards for Ground Waters of the State of Washington, WAC 173-200, Washington State Department of Ecology, Olympia, Washington.

Ecology (Washington State Department of Ecology). 1995. *State Waste Discharge Permit No. ST-4500*. Issued June 26, 1995 to the U.S. Department of Energy, Richland Operations Office: Washington State Department of Ecology, Olympia, Washington.

Gephart, R.E., R.C. Arnett, R.G. Baca, L.S. Leonhart, F.A. Spane. 1979. Hydrologic Studies Within the Columbia Plateau, Washington: An Integration of Current Knowledge, RHO-BWI-ST-5, Rockwell Hanford Operations, Richland, Washington.

Golder Associates, Inc. 1994. Migration of Nondecaying and Nonretarding Constituents from the State-Approved Land Disposal Site, Hanford Site, Washington, Prepared for Westinghouse Hanford Company through WHC Contract No. MLW-SVV-073750, Westinghouse Hanford Company, Richland, Washington.

Gupta, S.K., C.R. Cole, C.T. Kincaid, and A.M. Monti. 1987. *Coupled Fluid, Energy, and Solute Transport (CFEST) Model: Formulation and User's Manual*. BMI/ONWI-660, Battelle Memorial Institute, Columbus, Ohio.

Hartman, M.J., and P.E. Dresel, eds. 1997. *Hanford Site Groundwater Monitoring for Fiscal Year 1996*. PNNL-11470, Pacific Northwest National Laboratory, Richland, Washington.

Kipp, K.L., A.E. Reisenauer, C.R. Cole, and L.A. Bryan. 1972. *Variable Thickness Transient Groundwater Flow Model: Theory and Numerical Implementation*. BNWL-1703, Pacific Northwest Laboratory, Richland, Washington.

Lindsey, K.A. 1995. *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*. BHI-00184, Rev. 0, Bechtel Hanford Co., Richland, Washington.

Lindsey, K.A., and S.P. Reidel. 1992. *Suprabasalt Geology of Soil Column Disposal Candidate Site Number 1: A Preliminary Evaluation of the Site Geology and Recommendations for Number of Boreholes*. WHC-MR-0291, Westinghouse Hanford Company, Richland, Washington.

Lindsey, K.A., J.L. Slate, G.K. Jaeger, K.J. Swett, and R.B. Mercer. 1994. *Geologic Setting of the Low-Level Burial Grounds*. WHC-SD-EN-TI-290, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Lu, A.H., R. Khaleel, D.L. Harris. 1993. *Vadose Zone Flow and Transport Modeling: C-018H Soil Column Disposal Siting Evaluation*. Appendix D of WHC-SD-C018H-RPT-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Myers, C.W., S.M. Price, J.A. Caggiano, M.P. Cochran, W.J. Czimer, N.J. Davidson, R.C. Edwards, K.R. Fecht, G.E. Holmes, M.G. Jones, J.R. Kunk, R.D. Landon, R.K. Ledgerwood, J.T. Lillie, P.E. Long, T.H. Mitchell, E.H. Price, S.P. Reidel, and A.M. Tallman. 1979. Geologic Studies of the Columbia Plateau: A Status Report, RHO-BWI-ST-4, Rockwell Hanford Operations, Richland, Washington.

Reidel, S.P. 1993. *Ground-Water Monitoring Plan for the Proposed State-Approved Land Disposal Site.* WHC-SD-C018H-PLN-004, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Reidel, S.P., K.A. Lindsey, K.R. Fecht. 1992. Field Trip Guide to the Hanford Site, WHC-MR-0391, Westinghouse Hanford Company, Richland, Washington.

Reidel, S.P. and E.C. Thornton. 1993. *Characterization Report, C-018H Disposal Siting Evaluation.* WHC-SD-C018H-RPT-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Runchal, A.K., B. Sagar, and N.W. Kine. 1992. *PORFLOW-3: A Mathematical Model for Fluid Flow, Heat, and Mass Transport in Variably Saturated Geologic Media.* WHC-EP-0385, Westinghouse Hanford Company, Richland, Washington.

Spane, F.A. and W.D. Webber. 1995. *Hydrochemistry and Hydrogeologic Conditions Within the Hanford Upper Basalt Confined Aquifer System.* PNL-10817, Pacific Northwest Laboratory, Richland, Washington.

Swanson. 1994. *1994 Characterization Report for the Proposed State-Approved Land.* WHC-SD-C018H-RPT-003, Rev. 0, Westinghouse Hanford Company, 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.

WHC (Westinghouse Hanford Company). 1995. *Waste Analysis Plan for the 200 Area Effluent Treatment Facility and Liquid Effluent Retention Facility.* WHC-SD-EN-WAP-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington

Wurstner, S.K., and J.L. Devary. 1993. *Hanford Site Ground-Water Model: Geographic Information System Linkages and Model Enhancements, FY 1993.* PNL-8991, Pacific Northwest Laboratory, Richland, Washington.

Wurstner, S.K., P.D. Thorne, M.A. Chamness, M.D. Freshley, and M.D. Williams. 1995. *Development of a Three-Dimensional Ground-Water Model of the Hanford Site Unconfined Aquifer System, FY 1995 Status Report.* PNL-10886, Pacific Northwest Laboratory, Richland, Washington.

Appendix A

Discharge Volumes to SALDS Through March 1997

Appendix A

Discharge Volumes to SALDS Through March 1997

This table lists actual effluent discharge volumes to the SALDS through March 1997.

Date	Discharge Volume (gallons)	Discharge Volume (liters)	Cumulative Discharge Volumes (liters)
12\12\95	591,385	2,238,392	2,238,392
01/18/96	311,460	1,178,876	3,417,268
01/31/96	607,347	2,298,808	5,716,076
02/09/96	393,529	1,489,507	7,205,584
03/05/96	498,336	1,886,202	9,091,786
03/15/96	506,122	1,915,672	11,007,457
04/07/96	630,707	2,387,226	13,394,683
04/18/96	615,134	2,328,282	15,722,965
05/01/96	599,561	2,269,338	17,992,304
05/12/96	568,414	2,151,447	20,143,751
05/17/96	638,495	2,416,704	22,560,454
05/25/96	638,493	2,416,696	24,977,150
06/04/96	622,920	2,357,752	27,334,903
06/12/96	576,201	2,180,921	29,515,823
08/27/96	23,359	88,414	29,604,237
11/24/96	358,179	1,355,708	30,959,945
03/20/97	583,988	2,210,395	33,170,339

Appendix B

Analytical Results for Tritium from the SALDS Tritium-Tracking Network

Appendix B

Analytical Results for Tritium from the SALDS Tritium-Tracking Network

The following table lists tritium results for all wells in the current tritium-tracking network for the SALDS. The table includes all results through April 1997. Flags and qualifiers are as follows:

Flags

D - Result is associated with an unresolved lab incident
G - Reviewed data that are considered valid
P - Result is associated with a potential problem
Q - Result is associated with suspect QC data
Y - Reviewed data that continue to be suspect

Qualifiers

U - Undetected - concentration is below the indicated value
J - Concentration is estimated

Specific circumstances concerning "D" and "P" flags may be determined by inspection of the associated laboratory reports. These are referenced in the Hanford Environmental Information System (HEIS) by well number, constituent (tritium), and date.

Appendix B - Tritium Results for ETF Tritium-Tracking Network Wells

Well	Result	Total Error	Units	Qualifier	Flag	Collect Date	Constituent Name
299-W6-11	7280	709.20	pCi/L			11-Dec-92	Tritium
299-W6-11	7080	678.20	pCi/L			15-Mar-93	Tritium
299-W6-11	7920	734.50	pCi/L			10-Jun-93	Tritium
299-W6-11	7830	731.20	pCi/L			09-Sep-93	Tritium
299-W6-11	7480	722.80	pCi/L			10-Feb-94	Tritium
299-W6-11	7390	717.00	pCi/L			10-Feb-94	Tritium
299-W6-11	8410	907.70	pCi/L			25-Aug-94	Tritium
299-W6-11	9450	860.60	pCi/L			08-Mar-95	Tritium
299-W6-11	8390	794.00	pCi/L			15-Sep-95	Tritium
299-W6-11	8200		pCi/L			18-Dec-96	Tritium
299-W6-12	550	258.80	pCi/L			08-Dec-92	Tritium
299-W6-12	478	236.80	pCi/L			15-Mar-93	Tritium
299-W6-12	348	225.80	pCi/L			15-Jun-93	Tritium
299-W6-12	502	241.50	pCi/L			09-Sep-93	Tritium
299-W6-12	239	233.90	pCi/L			08-Feb-94	Tritium
299-W6-12	303	392.80	pCi/L	U		23-Aug-94	Tritium
299-W6-12	563	221.70	pCi/L			09-Mar-95	Tritium
299-W6-12	394	228.00	pCi/L			15-Sep-95	Tritium
299-W6-12	360		pCi/L			18-Dec-96	Tritium
299-W6-5	34800	2714.00	pCi/L			19-Mar-92	Tritium
299-W6-5	34500	2692.00	pCi/L			15-Dec-92	Tritium
299-W6-5	33100	2560.00	pCi/L			15-Mar-93	Tritium
299-W6-5	32600	2524.00	pCi/L			11-Jun-93	Tritium
299-W6-5	31400	2447.00	pCi/L			10-Feb-94	Tritium
299-W6-5	35600	2856.00	pCi/L			24-Aug-94	Tritium
299-W6-5	37200	2876.00	pCi/L			08-Mar-95	Tritium
299-W6-5	39200	3030.00	pCi/L			15-Sep-95	Tritium
299-W6-5	39000		pCi/L			18-Dec-96	Tritium
299-W6-6	68	265.70	pCi/L			19-Mar-92	Tritium
299-W6-6	98.9	230.10	pCi/L			11-Jun-92	Tritium
299-W6-6	-72.9	218.20	pCi/L			04-Sep-92	Tritium
299-W6-6	2.78	212.90	pCi/L	U		17-Mar-93	Tritium
299-W6-6	173	212.10	pCi/L	U		10-Sep-93	Tritium
299-W6-6	30.7	235.40	pCi/L	U		09-Feb-94	Tritium
299-W6-6	-21.7	376.50	pCi/L	U		24-Aug-94	Tritium
299-W6-6	19	184.70	pCi/L	U		09-Mar-95	Tritium
299-W6-6	17.9	203.00	pCi/L	U		18-Sep-95	Tritium
299-W6-6	63		pCi/L	U		18-Dec-96	Tritium
299-W6-7	45300	3478.00	pCi/L			19-Mar-92	Tritium
299-W6-7	46700	3559.00	pCi/L			11-Jun-92	Tritium
299-W6-7	42600	3262.00	pCi/L			04-Sep-92	Tritium
299-W6-7	42400	3235.00	pCi/L			15-Mar-93	Tritium
299-W6-7	41000	3130.00	pCi/L			09-Sep-93	Tritium
299-W6-7	44400	3385.00	pCi/L			22-Mar-94	Tritium
299-W6-7	42700	3371.00	pCi/L			23-Aug-94	Tritium
299-W6-7	42900	3295.00	pCi/L			08-Mar-95	Tritium
299-W6-7	45000	3460.00	pCi/L			18-Sep-95	Tritium
299-W6-7	41000		pCi/L			18-Dec-96	Tritium
299-W6-8	931	311.50	pCi/L			19-Mar-92	Tritium
299-W6-8	761	302.30	pCi/L			19-Mar-92	Tritium
299-W6-8	1020	282.20	pCi/L			11-Jun-92	Tritium
299-W6-8	1040	279.90	pCi/L			04-Sep-92	Tritium
299-W6-8	991	266.00	pCi/L			15-Mar-93	Tritium
299-W6-8	947	266.90	pCi/L			09-Sep-93	Tritium

299-W6-8	1030	269.60	pCi/L			14-Feb-94	Tritium
299-W6-8	567	406.20	pCi/L			23-Aug-94	Tritium
299-W6-8	886	244.70	pCi/L			08-Mar-95	Tritium
299-W6-8	723	241.00	pCi/L			21-Sep-95	Tritium
299-W6-8	810		pCi/L			18-Dec-96	Tritium
299-W7-1	175	455.00	pCi/L	U		04-Oct-88	Tritium
299-W7-1	62.6	309.00	pCi/L	U		29-Dec-88	Tritium
299-W7-1	82.4	177.00	pCi/L	U		10-May-89	Tritium
299-W7-1	167	202.00	pCi/L	U		10-Jul-89	Tritium
299-W7-1	-39.3	233.00	pCi/L	U		07-Sep-89	Tritium
299-W7-1	71.8	213.00	pCi/L	U		09-Jan-90	Tritium
299-W7-1	25.1	207.90	pCi/L			07-Aug-91	Tritium
299-W7-1	-26.8	268.00	pCi/L			08-Nov-91	Tritium
299-W7-1	-51.9	225.90	pCi/L			04-Feb-92	Tritium
299-W7-1	130	296.30	pCi/L			13-May-92	Tritium
299-W7-1	110	222.00	pCi/L			07-Aug-92	Tritium
299-W7-1	-303	242.30	pCi/L	U		12-Nov-92	Tritium
299-W7-1	-0.961	217.00	pCi/L	U		05-Feb-93	Tritium
299-W7-1	-12.5	216.60	pCi/L	U		05-Feb-93	Tritium
299-W7-1	487	251.20	pCi/L		Q	18-May-93	Tritium
299-W7-1	-47.1	203.70	pCi/L	U		11-Aug-93	Tritium
299-W7-1	81.2	205.50	pCi/L	U		06-Dec-93	Tritium
299-W7-1	9.27	192.70	pCi/L	U		22-Feb-94	Tritium
299-W7-1	214	304.10	pCi/L	U		17-Aug-94	Tritium
299-W7-1	176	205.70	pCi/L	U		13-Mar-95	Tritium
299-W7-1	-160	223.00	pCi/L	U		11-Sep-95	Tritium
299-W7-1	66.04	187.20	pCi/L	U		07-Mar-96	Tritium
299-W7-1	-51.2	202.00	pCi/L	UJ		10-Sep-96	Tritium
299-W7-11	13.8	197.10	pCi/L			09-Mar-92	Tritium
299-W7-11	36.1	223.80	pCi/L			27-May-92	Tritium
299-W7-11	97.9	222.10	pCi/L			06-Aug-92	Tritium
299-W7-11	41.3	243.30	pCi/L	U		16-Nov-92	Tritium
299-W7-11	-31.4	210.90	pCi/L	U	D	09-Feb-93	Tritium
299-W7-11	194	241.90	pCi/L	U		17-May-93	Tritium
299-W7-11	100	197.60	pCi/L	U		12-Aug-93	Tritium
299-W7-11	198	211.50	pCi/L	U		06-Dec-93	Tritium
299-W7-11	138	208.30	pCi/L	U		06-Dec-93	Tritium
299-W7-11	-15.8	191.60	pCi/L	U		23-Feb-94	Tritium
299-W7-11	33.3	206.50	pCi/L	U		18-Aug-94	Tritium
299-W7-11	90.2	200.00	pCi/L	U		13-Mar-95	Tritium
299-W7-11	-144	224.00	pCi/L	U		11-Sep-95	Tritium
299-W7-11	-41.442	179.80	pCi/L	U		11-Mar-96	Tritium
299-W7-11	79.3	210.00	pCi/L	UJ		10-Sep-96	Tritium
299-W7-12	60	199.30	pCi/L			10-Mar-92	Tritium
299-W7-12	39.7	226.10	pCi/L			01-Jun-92	Tritium
299-W7-12	84.1	221.00	pCi/L			06-Aug-92	Tritium
299-W7-12	816	285.50	pCi/L			16-Nov-92	Tritium
299-W7-12	78.8	221.00	pCi/L	U		05-Feb-93	Tritium
299-W7-12	452	249.00	pCi/L		Q	18-May-93	Tritium
299-W7-12	115	198.30	pCi/L	U		12-Aug-93	Tritium
299-W7-12	-32.3	199.90	pCi/L	U		03-Dec-93	Tritium
299-W7-12	-6.49	192.20	pCi/L	U		23-Feb-94	Tritium
299-W7-12	-85	200.60	pCi/L	U		18-Aug-94	Tritium
299-W7-12	183	206.00	pCi/L	U		13-Mar-95	Tritium
299-W7-12	120	201.80	pCi/L	U		13-Mar-95	Tritium
299-W7-12	-21	198.00	pCi/L	U		12-Sep-95	Tritium

299-W7-12	-104.37	175.50	pCi/L	U		11-Mar-96	Tritium
299-W7-12	69.1	211.00	pCi/L	U		18-Sep-96	Tritium
299-W7-2	397	466.00	pCi/L	U		04-Oct-88	Tritium
299-W7-2	110	311.00	pCi/L	U		29-Dec-88	Tritium
299-W7-2	40.9	208.00	pCi/L	U		20-Mar-89	Tritium
299-W7-2	56.8	282.00	pCi/L	U		20-Jul-89	Tritium
299-W7-2	-60.9	232.00	pCi/L	U		07-Sep-89	Tritium
299-W7-2	0.957	210.00	pCi/L	U		11-Jan-90	Tritium
299-W7-2	-11.1	206.20	pCi/L			07-Aug-91	Tritium
299-W7-2	78.4	273.20	pCi/L			08-Nov-91	Tritium
299-W7-2	-118	222.20	pCi/L			05-Feb-92	Tritium
299-W7-2	-55.7	225.10	pCi/L			21-May-92	Tritium
299-W7-2	-29.8	226.70	pCi/L			21-May-92	Tritium
299-W7-2	122	222.70	pCi/L			07-Aug-92	Tritium
299-W7-2	252	246.60	pCi/L			12-Nov-92	Tritium
299-W7-2	39.8	214.20	pCi/L	U	G	09-Feb-93	Tritium
299-W7-2	432	254.50	pCi/L			17-May-93	Tritium
299-W7-2	77.9	195.00	pCi/L	U		12-Aug-93	Tritium
299-W7-2	235	213.40	pCi/L			06-Dec-93	Tritium
299-W7-2	0.927	192.30	pCi/L	U		22-Feb-94	Tritium
299-W7-2	34	295.40	pCi/L	U		17-Aug-94	Tritium
299-W7-2	136	202.80	pCi/L	U		13-Mar-95	Tritium
299-W7-2	-163	223.00	pCi/L	U		11-Sep-95	Tritium
299-W7-2	45.05	185.30	pCi/L	U		07-Mar-96	Tritium
299-W7-3	40.5	448.00	pCi/L	U		03-Oct-88	Tritium
299-W7-3	61.7	307.00	pCi/L	U		29-Dec-88	Tritium
299-W7-3	65.2	210.00	pCi/L	U		20-Mar-89	Tritium
299-W7-3	-61.2	185.00	pCi/L	U		28-Jul-89	Tritium
299-W7-3	135	236.00	pCi/L	U		15-Sep-89	Tritium
299-W7-3	-75.6	213.00	pCi/L	U		17-Jan-90	Tritium
299-W7-3	29.7	188.70	pCi/L			08-Aug-91	Tritium
299-W7-3	-145	262.10	pCi/L			08-Nov-91	Tritium
299-W7-3	50.8	203.00	pCi/L			12-Feb-92	Tritium
299-W7-3	-21.2	217.60	pCi/L			22-May-92	Tritium
299-W7-3	-102	230.80	pCi/L			28-Aug-92	Tritium
299-W7-3	37.9	231.40	pCi/L	U		03-Dec-92	Tritium
299-W7-3	14.4	217.40	pCi/L	U		10-Feb-93	Tritium
299-W7-3	-29.8	230.50	pCi/L	U		17-May-93	Tritium
299-W7-3	145	209.80	pCi/L	U		25-Aug-93	Tritium
299-W7-3	-29.7	196.90	pCi/L	U		07-Dec-93	Tritium
299-W7-3	26.8	222.60	pCi/L	U		25-Feb-94	Tritium
299-W7-3	173	299.60	pCi/L	U		15-Aug-94	Tritium
299-W7-3	226	208.70	pCi/L			13-Mar-95	Tritium
299-W7-3	-35.8	197.00	pCi/L	U		12-Sep-95	Tritium
299-W7-3	103.92	188.90	pCi/L	U		07-Mar-96	Tritium
299-W7-3	-182	233.00	pCi/L	U		17-Sep-96	Tritium
299-W7-5	886	493.00	pCi/L			03-Oct-88	Tritium
299-W7-5	278	319.00	pCi/L	U		29-Dec-88	Tritium
299-W7-5	113	211.00	pCi/L	U		17-Mar-89	Tritium
299-W7-5	371	298.00	pCi/L			25-Jul-89	Tritium
299-W7-5	277	245.00	pCi/L			08-Sep-89	Tritium
299-W7-5	178	219.00	pCi/L	U		11-Jan-90	Tritium
299-W7-5	238	258.60	pCi/L			27-Mar-91	Tritium
299-W7-5	297	202.80	pCi/L			09-Aug-91	Tritium
299-W7-5	75.3	275.60	pCi/L			11-Nov-91	Tritium
299-W7-5	155	290.20	pCi/L			03-Feb-92	Tritium

299-W7-5	276	304.20	pCi/L			13-May-92	Tritium
299-W7-5	229	228.80	pCi/L			06-Aug-92	Tritium
299-W7-5	405	278.30	pCi/L			12-Nov-92	Tritium
299-W7-5	98	217.10	pCi/L	U	D	09-Feb-93	Tritium
299-W7-5	538	254.10	pCi/L		Q	18-May-93	Tritium
299-W7-5	195	216.00	pCi/L	U		11-Aug-93	Tritium
299-W7-5	255	214.40	pCi/L			06-Dec-93	Tritium
299-W7-5	90.5	225.90	pCi/L	U		24-Feb-94	Tritium
299-W7-5	182	300.00	pCi/L	U		16-Aug-94	Tritium
299-W7-5	260	203.60	pCi/L			14-Mar-95	Tritium
299-W7-5	331	221.00	pCi/L			12-Sep-95	Tritium
299-W7-5	99.315	196.30	pCi/L	U		08-Mar-96	Tritium
299-W7-5	174	255.00	pCi/L	U		17-Sep-96	Tritium
299-W7-6	1050	501.00	pCi/L			03-Oct-88	Tritium
299-W7-6	590	336.00	pCi/L			30-Dec-88	Tritium
299-W7-6	842	255.00	pCi/L			17-Mar-89	Tritium
299-W7-6	918	328.00	pCi/L			26-Jul-89	Tritium
299-W7-6	914	281.00	pCi/L			08-Sep-89	Tritium
299-W7-6	719	251.00	pCi/L			11-Jan-90	Tritium
299-W7-6	807	302.50	pCi/L			12-Aug-91	Tritium
299-W7-6	478	294.60	pCi/L			08-Nov-91	Tritium
299-W7-6	639	316.20	pCi/L			03-Feb-92	Tritium
299-W7-6	599	321.60	pCi/L			13-May-92	Tritium
299-W7-6	651	252.10	pCi/L			06-Aug-92	Tritium
299-W7-6	662	269.50	pCi/L			12-Nov-92	Tritium
299-W7-6	605	244.40	pCi/L		D	09-Feb-93	Tritium
299-W7-6	168	240.50	pCi/L	U		17-May-93	Tritium
299-W7-6	613	225.90	pCi/L			12-Aug-93	Tritium
299-W7-6	456	225.20	pCi/L			03-Dec-93	Tritium
299-W7-6	436	215.80	pCi/L			23-Feb-94	Tritium
299-W7-6	443	313.50	pCi/L			16-Aug-94	Tritium
299-W7-6	487	230.60	pCi/L			20-Apr-95	Tritium
299-W7-6	376	223.00	pCi/L			13-Sep-95	Tritium
299-W7-6	271.12	204.70	pCi/L			29-Mar-96	Tritium
299-W7-6	319	227.00	pCi/L	J		16-Sep-96	Tritium
299-W7-7	365	260.00	pCi/L			27-Feb-90	Tritium
299-W7-7	411	251.00	pCi/L			03-May-90	Tritium
299-W7-7	279	201.80	pCi/L			09-Aug-91	Tritium
299-W7-7	350	287.40	pCi/L			08-Nov-91	Tritium
299-W7-7	243	241.30	pCi/L			05-Feb-92	Tritium
299-W7-7	585	320.60	pCi/L			13-May-92	Tritium
299-W7-7	696	255.40	pCi/L			06-Aug-92	Tritium
299-W7-7	1570	346.10	pCi/L		Q	12-Nov-92	Tritium
299-W7-7	274	271.30	pCi/L		Q	12-Nov-92	Tritium
299-W7-7	371	236.30	pCi/L			08-Feb-93	Tritium
299-W7-7	54.9	235.10	pCi/L	U		17-May-93	Tritium
299-W7-7	325	209.80	pCi/L			12-Aug-93	Tritium
299-W7-7	211	212.50	pCi/L	U		03-Dec-93	Tritium
299-W7-7	156	200.50	pCi/L	U		22-Feb-94	Tritium
299-W7-7	138	300.20	pCi/L	U		17-Aug-94	Tritium
299-W7-7	350	210.10	pCi/L			14-Mar-95	Tritium
299-W7-7	216	213.00	pCi/L			12-Sep-95	Tritium
299-W7-7	384.46	215.50	pCi/L			08-Mar-96	Tritium
299-W7-7	435	234.00	pCi/L			10-Sep-96	Tritium
299-W7-7	293	225.00	pCi/L	J		10-Sep-96	Tritium
299-W7-8	489	265.00	pCi/L			27-Feb-90	Tritium

299-W7-8	517	258.00	pCi/L			03-May-90	Tritium
299-W7-8	513	214.30	pCi/L			09-Aug-91	Tritium
299-W7-8	473	296.50	pCi/L			11-Nov-91	Tritium
299-W7-8	366	300.90	pCi/L			03-Feb-92	Tritium
299-W7-8	269	304.00	pCi/L			13-May-92	Tritium
299-W7-8	553	246.70	pCi/L			06-Aug-92	Tritium
299-W7-8	778	276.10	pCi/L			13-Nov-92	Tritium
299-W7-8	535	245.30	pCi/L			08-Feb-93	Tritium
299-W7-8	-45.2	230.10	pCi/L	U		17-May-93	Tritium
299-W7-8	456	217.20	pCi/L			12-Aug-93	Tritium
299-W7-8	358	220.00	pCi/L			03-Dec-93	Tritium
299-W7-8	381	240.30	pCi/L			28-Feb-94	Tritium
299-W7-8	545	319.00	pCi/L			16-Aug-94	Tritium
299-W7-8	451	217.20	pCi/L			14-Mar-95	Tritium
299-W7-8	354	222.00	pCi/L			14-Sep-95	Tritium
299-W7-8	409.29	209.70	pCi/L			11-Mar-96	Tritium
299-W7-8	331	228.00	pCi/L	J		10-Sep-96	Tritium
299-W7-9	29.8	214.00	pCi/L	U		19-Apr-90	Tritium
299-W7-9	-119	223.00	pCi/L	U		03-May-90	Tritium
299-W7-9	70.6	191.10	pCi/L			09-Aug-91	Tritium
299-W7-9	127	275.70	pCi/L			08-Nov-91	Tritium
299-W7-9	35.5	230.60	pCi/L			04-Feb-92	Tritium
299-W7-9	166	298.50	pCi/L			13-May-92	Tritium
299-W7-9	113	222.50	pCi/L			06-Aug-92	Tritium
299-W7-9	172	242.30	pCi/L	U		13-Nov-92	Tritium
299-W7-9	178	221.30	pCi/L	U	D	09-Feb-93	Tritium
299-W7-9	100	237.00	pCi/L	U		17-May-93	Tritium
299-W7-9	4.62	224.00	pCi/L	U		26-Aug-93	Tritium
299-W7-9	-93.4	219.30	pCi/L	U		26-Aug-93	Tritium
299-W7-9	159	209.70	pCi/L	U		03-Dec-93	Tritium
299-W7-9	-27.7	219.70	pCi/L	U		28-Feb-94	Tritium
299-W7-9	12	205.40	pCi/L	U		18-Aug-94	Tritium
299-W7-9	69.2	191.00	pCi/L	U		14-Mar-95	Tritium
299-W7-9	90	205.00	pCi/L	U		13-Sep-95	Tritium
299-W7-9	115.63	190.60	pCi/L	U		11-Mar-96	Tritium
299-W7-9	-51.7	202.00	pCi/L	UJ		10-Sep-96	Tritium
299-W8-1	364	464.00	pCi/L	U		04-Oct-88	Tritium
299-W8-1	137	311.00	pCi/L	U		29-Dec-88	Tritium
299-W8-1	64	176.00	pCi/L	U		12-May-89	Tritium
299-W8-1	57.1	197.00	pCi/L	U		10-Jul-89	Tritium
299-W8-1	112	234.00	pCi/L	U		12-Sep-89	Tritium
299-W8-1	54.6	212.00	pCi/L	U		11-Jan-90	Tritium
299-W8-1	151	195.10	pCi/L			09-Aug-91	Tritium
299-W8-1	47.5	273.90	pCi/L			13-Nov-91	Tritium
299-W8-1	104	234.10	pCi/L			04-Feb-92	Tritium
299-W8-1	103	222.10	pCi/L		PQ	14-May-92	Tritium
299-W8-1	101	228.00	pCi/L			19-Aug-92	Tritium
299-W8-1	231	234.80	pCi/L			19-Aug-92	Tritium
299-W8-1	-46.1	238.40	pCi/L	U		16-Nov-92	Tritium
299-W8-1	104	224.20	pCi/L	U	D	09-Feb-93	Tritium
299-W8-1	-64.5	222.50	pCi/L	U	Q	18-May-93	Tritium
299-W8-1	165	200.80	pCi/L	U		12-Aug-93	Tritium
299-W8-1	-37.9	199.60	pCi/L	U		03-Dec-93	Tritium
299-W8-1	45.4	195.40	pCi/L	U		23-Feb-94	Tritium
299-W8-1	154	212.80	pCi/L	U		18-Aug-94	Tritium
299-W8-1	45.1	189.40	pCi/L	U		14-Mar-95	Tritium

299-W8-1	3.07	200.00	pCi/L	U	13-Sep-95	Tritium
299-W8-1	176	193.50	pCi/L	U	11-Mar-96	Tritium
299-W8-1	156	216.00	pCi/L	UJ	10-Sep-96	Tritium
299-W8-1	215		pCi/L	U	23-Jan-97	Tritium
299-W8-1	212		pCi/L	U	02-Apr-97	Tritium
699-48-71	1000		pCi/L		09-Jan-62	Tritium
699-48-71	1000		pCi/L		06-Feb-62	Tritium
699-48-71	1000		pCi/L		07-Mar-62	Tritium
699-48-71	70000		pCi/L		03-Apr-62	Tritium
699-48-71	1000		pCi/L		26-Jun-62	Tritium
699-48-71	1000		pCi/L		24-Jul-62	Tritium
699-48-71	1000		pCi/L		21-Aug-62	Tritium
699-48-71	1000		pCi/L		13-Nov-62	Tritium
699-48-71	1000		pCi/L		04-Dec-62	Tritium
699-48-71	60000		pCi/L		15-Jan-63	Tritium
699-48-71	1000		pCi/L		16-Feb-63	Tritium
699-48-71	1000		pCi/L		12-Mar-63	Tritium
699-48-71	1000		pCi/L		09-Apr-63	Tritium
699-48-71	1000		pCi/L		16-Oct-63	Tritium
699-48-71	930		pCi/L		20-Dec-68	Tritium
699-48-71	670		pCi/L		17-Mar-69	Tritium
699-48-71	920		pCi/L		19-Jun-69	Tritium
699-48-71	470		pCi/L		15-Jan-71	Tritium
699-48-71	640		pCi/L		12-Jul-71	Tritium
699-48-71	660		pCi/L		08-Oct-71	Tritium
699-48-71	1200		pCi/L		03-Feb-72	Tritium
699-48-71	610		pCi/L		09-Jun-72	Tritium
699-48-71	530		pCi/L		11-Aug-72	Tritium
699-48-71	510		pCi/L		16-Oct-72	Tritium
699-48-71	480		pCi/L		06-Jun-73	Tritium
699-48-71	570		pCi/L		09-Jul-73	Tritium
699-48-71	1000		pCi/L		31-Oct-73	Tritium
699-48-71	680		pCi/L		16-Jan-74	Tritium
699-48-71	1200		pCi/L		01-May-74	Tritium
699-48-71	500		pCi/L		09-Jul-74	Tritium
699-48-71	920		pCi/L		30-Oct-74	Tritium
699-48-71	1200		pCi/L		15-Jan-75	Tritium
699-48-71	480		pCi/L		30-Apr-75	Tritium
699-48-71	480		pCi/L		02-Jul-75	Tritium
699-48-71	840		pCi/L		03-Nov-75	Tritium
699-48-71	1000		pCi/L		02-Jan-76	Tritium
699-48-71	870		pCi/L		03-May-76	Tritium
699-48-71	1300		pCi/L		29-Jun-76	Tritium
699-48-71	1100		pCi/L		13-Jan-77	Tritium
699-48-71	850		pCi/L		11-Mar-77	Tritium
699-48-71	1600		pCi/L		01-Apr-77	Tritium
699-48-71	590		pCi/L		29-Jun-77	Tritium
699-48-71	760		pCi/L		03-Oct-77	Tritium
699-48-71	670		pCi/L		31-Jan-78	Tritium
699-48-71	1300		pCi/L		25-Apr-78	Tritium
699-48-71	900		pCi/L		24-Jul-78	Tritium
699-48-71	830		pCi/L		12-Oct-78	Tritium
699-48-71	1800		pCi/L		30-Apr-79	Tritium
699-48-71	14000		pCi/L		18-Jul-79	Tritium
699-48-71	1200		pCi/L		03-Oct-79	Tritium
699-48-71	630		pCi/L		24-Jan-80	Tritium

699-48-71	520		pCi/L			15-Apr-80	Tritium
699-48-71	620		pCi/L			10-Jul-80	Tritium
699-48-71	510		pCi/L			07-Oct-80	Tritium
699-48-71	530		pCi/L			20-Jan-81	Tritium
699-48-71	420		pCi/L			21-Apr-81	Tritium
699-48-71	440		pCi/L			29-Sep-81	Tritium
699-48-71	530		pCi/L			21-Jan-82	Tritium
699-48-71	440		pCi/L			16-Apr-82	Tritium
699-48-71	340		pCi/L			04-Oct-82	Tritium
699-48-71	400		pCi/L			20-Jan-83	Tritium
699-48-71	-28		pCi/L			15-Apr-83	Tritium
699-48-71	-450		pCi/L			08-Jul-83	Tritium
699-48-71	250		pCi/L			08-Oct-83	Tritium
699-48-71	300		pCi/L			17-Jan-84	Tritium
699-48-71	-410		pCi/L			16-Apr-84	Tritium
699-48-71	-370		pCi/L			20-Aug-84	Tritium
699-48-71	780		pCi/L			02-Nov-84	Tritium
699-48-71	240		pCi/L			25-Feb-85	Tritium
699-48-71	-23		pCi/L			29-May-85	Tritium
699-48-71	340		pCi/L			05-Dec-85	Tritium
699-48-71	290		pCi/L	U		05-Feb-86	Tritium
699-48-71	150		pCi/L	U		10-Jun-86	Tritium
699-48-71	17		pCi/L			21-Aug-86	Tritium
699-48-71	11		pCi/L	U		02-Dec-86	Tritium
699-48-71	204	265.00	pCi/L	U		26-Feb-87	Tritium
699-48-71	81.7	252.00	pCi/L	U		11-Jun-87	Tritium
699-48-71	-45.2	315.00	pCi/L	U		25-Aug-87	Tritium
699-48-71	-95.8	300.00	pCi/L	U		10-Dec-87	Tritium
699-48-71	-38.8	388.00	pCi/L	U		12-Feb-88	Tritium
699-48-71	150	367.00	pCi/L	U		25-May-88	Tritium
699-48-71	-49.4	256.00	pCi/L	U		26-Aug-88	Tritium
699-48-71	94.2	455.00	pCi/L	U		14-Nov-88	Tritium
699-48-71	-102	203.00	pCi/L	U		25-Apr-89	Tritium
699-48-71	-89.9	225.00	pCi/L	U		08-Dec-89	Tritium
699-48-71	184	214.80	pCi/L			03-Dec-90	Tritium
699-48-71	23.7	287.40	pCi/L			02-Jan-92	Tritium
699-48-71	252	228.60	pCi/L			02-Jul-92	Tritium
699-48-71	-74.1	221.10	pCi/L			29-Jan-93	Tritium
699-48-71	10.2	206.80	pCi/L			12-Aug-93	Tritium
699-48-71	-2.77	211.80	pCi/L	U		13-Nov-93	Tritium
699-48-71	82.5	185.20	pCi/L			04-Mar-94	Tritium
699-48-71	-189	315.40	pCi/L			28-Sep-94	Tritium
699-48-71	128	203.00	pCi/L	U		18-Apr-95	Tritium
699-48-71	27.8	197.00	pCi/L	U		18-Apr-95	Tritium
699-48-71	45.6	215.00	pCi/L			23-Sep-95	Tritium
699-48-71	2.559	200.10	pCi/L	U		18-Mar-96	Tritium
699-48-71	-123.83	192.50	pCi/L			18-Mar-96	Tritium
699-48-77A	64.3	240.40	pCi/L		Q	19-Jun-92	Tritium
699-48-77A	139	229.00	pCi/L			02-Sep-92	Tritium
699-48-77A	94.1	226.80	pCi/L	U		22-Feb-93	Tritium
699-48-77A	88.6	236.90	pCi/L	U		17-May-93	Tritium
699-48-77A	64	201.60	pCi/L	U		02-Sep-93	Tritium
699-48-77A	8.35	208.60	pCi/L	U		15-Oct-93	Tritium
699-48-77A	131	223.80	pCi/L	U		17-Jan-94	Tritium
699-48-77A	212	221.90	pCi/L	U		15-Apr-94	Tritium
699-48-77A	29.7	185.00	pCi/L	U		10-Aug-94	Tritium

699-48-77A	86.9	232.00	pCi/L	U	12-Jul-95	Tritium
699-48-77A	142	224.00	pCi/L		27-Jul-95	Tritium
699-48-77A	149	200.00	pCi/L	U	24-Oct-95	Tritium
699-48-77A	64.5	194.00	pCi/L	U	24-Oct-95	Tritium
699-48-77A	260		pCi/L	U	15-Jan-96	Tritium
699-48-77A	300		pCi/L	U	03-Apr-96	Tritium
699-48-77A	135.05	207.70	pCi/L		03-Apr-96	Tritium
699-48-77A	74000		pCi/L		15-Jul-96	Tritium
699-48-77A	210000		pCi/L		06-Aug-96	Tritium
699-48-77A	270000		pCi/L		22-Aug-96	Tritium
699-48-77A	450000		pCi/L		23-Oct-96	Tritium
699-48-77A	500000		pCi/L		23-Jan-97	Tritium
699-48-77A	490000		pCi/L		23-Jan-97	Tritium
699-48-77A	530000		pCi/L		02-Apr-97	Tritium
699-48-77C	700	320.50	pCi/L		23-May-94	Tritium
699-48-77C	379	203.80	pCi/L		10-Aug-94	Tritium
699-48-77C	231	240.00	pCi/L	U	12-Jul-95	Tritium
699-48-77C	336	212.00	pCi/L	J	24-Oct-95	Tritium
699-48-77C	390		pCi/L		15-Jan-96	Tritium
699-48-77C	300		pCi/L	U	03-Apr-96	Tritium
699-48-77C	410		pCi/L		15-Jul-96	Tritium
699-48-77C	390		pCi/L		06-Aug-96	Tritium
699-48-77C	3000		pCi/L		22-Aug-96	Tritium
699-48-77C	180		pCi/L	U	22-Aug-96	Tritium
699-48-77C	580		pCi/L		23-Oct-96	Tritium
699-48-77C	2100		pCi/L		23-Jan-97	Tritium
699-48-77C	420		pCi/L		02-Apr-97	Tritium
699-48-77C	580		pCi/L		02-Apr-97	Tritium
699-48-77D	265	297.20	pCi/L	U	23-May-94	Tritium
699-48-77D	282	198.30	pCi/L		10-Aug-94	Tritium
699-48-77D	39.1	229.00	pCi/L	U	12-Jul-95	Tritium
699-48-77D	102	233.00	pCi/L	U	12-Jul-95	Tritium
699-48-77D	57.9	194.00	pCi/L	U	24-Oct-95	Tritium
699-48-77D	240		pCi/L	U	15-Jan-96	Tritium
699-48-77D	300		pCi/L	U	03-Apr-96	Tritium
699-48-77D	400		pCi/L		15-Jul-96	Tritium
699-48-77D	380		pCi/L		06-Aug-96	Tritium
699-48-77D	410		pCi/L		22-Aug-96	Tritium
699-48-77D	180		pCi/L		23-Oct-96	Tritium
699-48-77D	410		pCi/L		23-Jan-97	Tritium
699-48-77D	390		pCi/L		02-Apr-97	Tritium
699-49-79	1000		pCi/L		09-Jan-62	Tritium
699-49-79	1000		pCi/L		06-Feb-62	Tritium
699-49-79	1000		pCi/L		07-Mar-62	Tritium
699-49-79	80000		pCi/L		03-Apr-62	Tritium
699-49-79	1000		pCi/L		26-Jun-62	Tritium
699-49-79	20000		pCi/L		24-Jul-62	Tritium
699-49-79	1000		pCi/L		21-Aug-62	Tritium
699-49-79	1000		pCi/L		13-Nov-62	Tritium
699-49-79	1000		pCi/L		12-Mar-63	Tritium
699-49-79	1000		pCi/L		09-Apr-63	Tritium
699-49-79	1000		pCi/L		21-May-63	Tritium
699-49-79	12000		pCi/L		16-Oct-63	Tritium
699-49-79	650		pCi/L		20-Dec-68	Tritium
699-49-79	870		pCi/L		17-Mar-69	Tritium
699-49-79	590		pCi/L		19-Jun-69	Tritium

699-49-79	590		pCi/L		25-Jul-69	Tritium
699-49-79	4500		pCi/L		13-Jan-71	Tritium
699-49-79	560		pCi/L		13-Jul-71	Tritium
699-49-79	950		pCi/L		09-Dec-71	Tritium
699-49-79	860		pCi/L		09-Jun-72	Tritium
699-49-79	540		pCi/L		03-Apr-73	Tritium
699-49-79	1000		pCi/L		27-Nov-73	Tritium
699-49-79	660		pCi/L		05-Jun-74	Tritium
699-49-79	660		pCi/L		05-Jul-74	Tritium
699-49-79	800		pCi/L		26-Nov-74	Tritium
699-49-79	1400		pCi/L		02-Dec-75	Tritium
699-49-79	690		pCi/L		02-Jun-76	Tritium
699-49-79	720		pCi/L		28-Sep-76	Tritium
699-49-79	540		pCi/L		06-Jan-77	Tritium
699-49-79	890		pCi/L		01-Apr-77	Tritium
699-49-79	730		pCi/L		29-Jun-77	Tritium
699-49-79	650		pCi/L		03-Oct-77	Tritium
699-49-79	540		pCi/L		31-Jan-78	Tritium
699-49-79	2100		pCi/L		25-Apr-78	Tritium
699-49-79	1200		pCi/L		24-Jul-78	Tritium
699-49-79	840		pCi/L		12-Oct-78	Tritium
699-49-79	1600		pCi/L		30-Apr-79	Tritium
699-49-79	840		pCi/L		20-Jul-79	Tritium
699-49-79	460		pCi/L		01-Oct-79	Tritium
699-49-79	540		pCi/L		24-Jan-80	Tritium
699-49-79	520		pCi/L		15-Apr-80	Tritium
699-49-79	800		pCi/L		17-Jul-80	Tritium
699-49-79	650		pCi/L		26-Sep-80	Tritium
699-49-79	920		pCi/L		20-Jan-81	Tritium
699-49-79	620		pCi/L		16-Apr-81	Tritium
699-49-79	830		pCi/L		14-Jul-81	Tritium
699-49-79	380		pCi/L		29-Sep-81	Tritium
699-49-79	450		pCi/L		25-Jan-82	Tritium
699-49-79	370		pCi/L		16-Apr-82	Tritium
699-49-79	390		pCi/L		30-Sep-82	Tritium
699-49-79	400		pCi/L		19-Jan-83	Tritium
699-49-79	18		pCi/L		13-Apr-83	Tritium
699-49-79	-220		pCi/L		11-Jul-83	Tritium
699-49-79	-320		pCi/L		08-Oct-83	Tritium
699-49-79	-130		pCi/L		17-Jan-84	Tritium
699-49-79	-35		pCi/L		16-Apr-84	Tritium
699-49-79	-210		pCi/L		20-Aug-84	Tritium
699-49-79	540		pCi/L		01-Nov-84	Tritium
699-49-79	-470		pCi/L		27-Mar-85	Tritium
699-49-79	-150		pCi/L		05-Aug-85	Tritium
699-49-79	60		pCi/L		14-Aug-85	Tritium
699-49-79	53		pCi/L	U	23-Dec-85	Tritium
699-49-79	88		pCi/L	U	04-Mar-86	Tritium
699-49-79	510		pCi/L		10-Jun-86	Tritium
699-49-79	-7.5		pCi/L		21-Aug-86	Tritium
699-49-79	65		pCi/L	U	11-Dec-86	Tritium
699-49-79	5.39	261.00	pCi/L	U	25-Feb-87	Tritium
699-49-79					13-May-87	Tritium
699-49-79	385	334.00	pCi/L		18-May-87	Tritium
699-49-79	-221	309.00	pCi/L	U	25-Aug-87	Tritium
699-49-79	467	272.00	pCi/L		30-Nov-87	Tritium

699-49-79	-89.4	386.00	pCi/L	U		09-Feb-88	Tritium
699-49-79	52.7	365.00	pCi/L	U		07-Jun-88	Tritium
699-49-79	-36.8	257.00	pCi/L	U		26-Aug-88	Tritium
699-49-79	-923	465.00	pCi/L	U		11-Nov-88	Tritium
699-49-79	-97.2	203.00	pCi/L	U		21-Apr-89	Tritium
699-49-79	38.4	229.00	pCi/L	U		20-Oct-89	Tritium
699-49-79	88.8	254.60	pCi/L			04-Dec-90	Tritium
699-49-79	19000	1552.00	pCi/L		Y	29-Jan-91	Tritium
699-49-79	-74.3	274.80	pCi/L			07-Jan-92	Tritium
699-49-79	21.3	216.10	pCi/L			02-Jul-92	Tritium
699-49-79	-96.2	219.80	pCi/L			29-Jan-93	Tritium
699-49-79	-230	212.60	pCi/L			26-Aug-93	Tritium
699-49-79	-62.8	209.00	pCi/L	U		12-Nov-93	Tritium
699-49-79	-51.9	219.30	pCi/L			07-Nov-94	Tritium
699-49-79	154	205.00	pCi/L	U		18-Apr-95	Tritium
699-49-79	127	207.80	pCi/L			01-May-95	Tritium
699-49-79	24.6	201.10	pCi/L			01-May-95	Tritium
699-49-79	17.912	200.70	pCi/L	U		22-Apr-96	Tritium
699-51-75	1000		pCi/L			09-Jan-62	Tritium
699-51-75	1000		pCi/L			06-Feb-62	Tritium
699-51-75	1000		pCi/L			07-Mar-62	Tritium
699-51-75	70000		pCi/L			03-Apr-62	Tritium
699-51-75	1000		pCi/L			26-Jun-62	Tritium
699-51-75	1000		pCi/L			24-Jul-62	Tritium
699-51-75	1000		pCi/L			21-Aug-62	Tritium
699-51-75	1000		pCi/L			13-Nov-62	Tritium
699-51-75	1000		pCi/L			11-Dec-62	Tritium
699-51-75	1000		pCi/L			15-Jan-63	Tritium
699-51-75	1000		pCi/L			12-Feb-63	Tritium
699-51-75	1000		pCi/L			12-Mar-63	Tritium
699-51-75	1000		pCi/L			11-Apr-63	Tritium
699-51-75	1000		pCi/L			21-May-63	Tritium
699-51-75	1000		pCi/L			11-Jun-63	Tritium
699-51-75	1000		pCi/L			16-Oct-63	Tritium
699-51-75	930		pCi/L			20-Dec-68	Tritium
699-51-75	670		pCi/L			17-Mar-69	Tritium
699-51-75	510		pCi/L			19-Jun-69	Tritium
699-51-75	2000000		pCi/L			08-Jun-73	Tritium
699-51-75	2900		pCi/L			29-Aug-73	Tritium
699-51-75	980		pCi/L			10-Oct-73	Tritium
699-51-75	510		pCi/L			27-Nov-73	Tritium
699-51-75	1000		pCi/L			04-Jun-74	Tritium
699-51-75	760		pCi/L			17-Sep-74	Tritium
699-51-75	710		pCi/L			26-Nov-74	Tritium
699-51-75	700		pCi/L			27-Feb-75	Tritium
699-51-75	550		pCi/L			30-May-75	Tritium
699-51-75	700		pCi/L			28-Aug-75	Tritium
699-51-75	1300		pCi/L			02-Dec-75	Tritium
699-51-75	360		pCi/L			30-Jan-76	Tritium
699-51-75	1100		pCi/L			27-Feb-76	Tritium
699-51-75	700		pCi/L			02-Jun-76	Tritium
699-51-75	1000		pCi/L			08-Sep-76	Tritium
699-51-75	1100		pCi/L			28-Sep-76	Tritium
699-51-75	880		pCi/L			01-Dec-76	Tritium
699-51-75	860		pCi/L			07-Mar-77	Tritium
699-51-75	920		pCi/L			08-Jun-77	Tritium

699-51-75	600		pCi/L		29-Jun-77	Tritium
699-51-75	1400		pCi/L		31-Aug-77	Tritium
699-51-75	1500		pCi/L		05-Dec-77	Tritium
699-51-75	630		pCi/L		31-Jan-78	Tritium
699-51-75	1500		pCi/L		25-Apr-78	Tritium
699-51-75	580		pCi/L		24-Jul-78	Tritium
699-51-75	1200		pCi/L		05-Oct-78	Tritium
699-51-75	650		pCi/L		22-Jan-79	Tritium
699-51-75	1200		pCi/L		23-Apr-79	Tritium
699-51-75	630		pCi/L		16-Jul-79	Tritium
699-51-75	580		pCi/L		01-Oct-79	Tritium
699-51-75	730		pCi/L		25-Jan-80	Tritium
699-51-75	590		pCi/L		15-Apr-80	Tritium
699-51-75	650		pCi/L		17-Jul-80	Tritium
699-51-75	440		pCi/L		27-Sep-80	Tritium
699-51-75	690		pCi/L		28-Jan-81	Tritium
699-51-75	390		pCi/L		16-Apr-81	Tritium
699-51-75	750		pCi/L		15-Jul-81	Tritium
699-51-75	490		pCi/L		29-Sep-81	Tritium
699-51-75	540		pCi/L		25-Jan-82	Tritium
699-51-75	370		pCi/L		22-Apr-82	Tritium
699-51-75	370		pCi/L		30-Sep-82	Tritium
699-51-75	400		pCi/L		19-Jan-83	Tritium
699-51-75	33		pCi/L		13-Apr-83	Tritium
699-51-75	-140		pCi/L		11-Jul-83	Tritium
699-51-75	46		pCi/L		08-Oct-83	Tritium
699-51-75	350		pCi/L		17-Jan-84	Tritium
699-51-75	-140		pCi/L		16-Apr-84	Tritium
699-51-75	-280		pCi/L		20-Aug-84	Tritium
699-51-75	1000		pCi/L		01-Nov-84	Tritium
699-51-75	-420		pCi/L		27-Mar-85	Tritium
699-51-75	-370		pCi/L		13-Jun-85	Tritium
699-51-75	2.7		pCi/L		14-Aug-85	Tritium
699-51-75	570		pCi/L		27-Nov-85	Tritium
699-51-75	57		pCi/L	U	20-Mar-86	Tritium
699-51-75	230		pCi/L	U	10-Jun-86	Tritium
699-51-75	-70		pCi/L	U	24-Sep-86	Tritium
699-51-75	63		pCi/L	U	11-Dec-86	Tritium
699-51-75	66.8	260.00	pCi/L	U	26-Feb-87	Tritium
699-51-75	170	255.00	pCi/L	U	11-Jun-87	Tritium
699-51-75					11-Jun-87	Tritium
699-51-75	144	321.00	pCi/L	U	25-Aug-87	Tritium
699-51-75	-26.8	250.00	pCi/L	U	08-Dec-87	Tritium
699-51-75	-174	382.00	pCi/L	U	12-Feb-88	Tritium
699-51-75	-119	370.00	pCi/L	U	19-Apr-88	Tritium
699-51-75	4.31	333.00	pCi/L	U	20-Jul-88	Tritium
699-51-75	-187	280.00	pCi/L	U	31-Oct-88	Tritium
699-51-75	-23.3	207.00	pCi/L	U	21-Apr-89	Tritium
699-51-75	26.2	233.00	pCi/L	U	08-Dec-89	Tritium
699-51-75	136	189.90	pCi/L		12-Dec-90	Tritium
699-51-75	207	284.80	pCi/L		09-Dec-91	Tritium
699-51-75	225	230.10	pCi/L		19-May-92	Tritium
699-51-75	-77.8	237.00	pCi/L		19-Nov-92	Tritium
699-51-75	-1.85	206.20	pCi/L		26-Mar-93	Tritium
699-51-75	-21.3	210.40	pCi/L		05-Apr-93	Tritium
699-51-75	733	341.60	pCi/L		17-Sep-94	Tritium

699-51-75	3.58	212.00 pCi/L	17-Aug-95 Tritium
699-51-75	-27.115	187.30 pCi/L	08-Jul-96 Tritium

Distribution

No. of Copies		
OFFSITE		
2	DOE/Office of Scientific and Technical Information	
ONSITE		
3	**Rust Federal Services of Hanford, Inc.**	
	D.L. Flyckt	S6-71
	P.C. Mohondro	S6-72
	D.W. Lindsey	S6-71

No. of Copies		
11	**Pacific Northwest National Laboratory**	
	D.B. Barnett (7)	K6-81
	M.P. Bergeron	K9-36
	C.R. Cole	K9-36
	M.D. Freshley	K9-36
	S.K. Wurstner	K9-36