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Pacific Northwest National Laboratory
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RCRA Assessment Plan for Single-Shell Tank Waste Management Area TX-TY at the Hanford Site

F. N. Hodges
C. J. Chou

February 2001

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

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Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

A groundwater quality assessment plan was prepared to investigate the rate and extent of aquifer contamination beneath Waste Management Area TX-TY. This area contains the 241-TX and 241-TY Tank Farms and is located in the northern portion of the 200 West Area of the Hanford Site in southeastern Washington State. The first determination failed to find an upgradient source for the groundwater contamination observed at Waste Management Area TX-TY; therefore, a continued assessment is required. The plan described here implements the *Resource Conservation and Recovery Act* requirement stated in 40 CFR 265.93(d)(7). This plan is an update of a draft plan issued in February 1999, which guided work performed in fiscal year 2000. Planned activities for fiscal year 2001 and beyond include additional groundwater sampling and analysis, hydraulic testing to further define flow rate and direction, and installation of additional wells to improve the detection monitoring network and to better define the areal and vertical extent of contamination. Five new downgradient wells to enhance spatial coverage will be completed during calendar year 2000. Nine new wells (subject to funding) are planned for calendar year 2001 to further define areal and vertical extent and to help distinguish tank leak sources from upgradient crib sources.

The groundwater quality assessment will provide input to a *Resource Conservation and Recovery Act* Facility Investigation Corrective Measures Study (RFI/CMS) conducted by the River Protection Program to investigate the vadose zone sources of observed groundwater contamination beneath Waste Management Area TX-TY. The groundwater quality assessment and the RFI/CMS work will be conducted under separate but coordinated plans. Results from the groundwater investigation together with the RFI/CMS results will provide information to support decisions on interim measures, corrective measures, waste retrieval, and eventual closure of the tank farms.

Acronyms and Abbreviations

CFR	Code of Federal Regulation
DOE	U.S. Department of Energy
DWS	drinking water standard
EPA	U.S. Environmental Protection Agency
GW-QAPP	Groundwater Monitoring Project Quality Assurance Project Plan
HEIS	Hanford Environmental Information System
MEMO	Monitoring Efficiency Model
NTU	nephelometric turbidity unit
PNNL	Pacific Northwest National Laboratory
RCRA	*Resource Conservation and Recovery Act*
RFI/CMS	RCRA Facility Investigation/Corrective Measures Study
WAC	Washington Administrative Code
WMA	Waste Management Area

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1.0 Introduction

Waste Management Area (WMA) TX-TY, containing the 241-TX and 241-TY Tank Farms, is located in the northern portion of the 200 West Area (Figure 1.1) and is used for the interim storage of radioactive waste from chemical processing of reactor fuel to recover plutonium. Over the years of plutonium recovery, tank waste supernate was cascaded from the tanks and disposed of in trenches or cribs. The WMA, regulated under *Resource Conservation and Recovery Act of 1976* (RCRA) interim status regulations was placed in assessment monitoring in 1993 because of elevated *specific conductance*, a RCRA indicator parameter, in two downgradient wells (299-W10-17 and 299-W14-12). This was done in accordance with Title 40, *Code of Federal Regulations* (CFR) Part 265, Subpart F (and by reference of Washington Administrative Code [WAC] 173-303-400[3]). A draft plan was issued in February 1999, which guided work performed in fiscal year 2000. This document supersedes the draft plan for continued RCRA groundwater quality assessment of WMA TX-TY as required by 40 CFR 265.93(d)(7). Pacific Northwest National Laboratory[a] conducted the assessment.

1.1 Background

A detection-level RCRA groundwater monitoring program for WMA TX-TY was initiated in 1989 (Jensen et al. 1989, Caggiano and Goodwin 1991). The locations of groundwater monitoring wells in the RCRA monitoring network for WMA T are shown in Figure 1.2. The WMA was placed into assessment monitoring in 1993 because specific conductance values in downgradient wells 299-W10-17 and 299-W14-12 exceeded the upgradient comparison value (critical mean) of 667 µS/cm (Caggiano and Chou 1993). A water-table map, based on June 1997 measurements, showing the location of wells in the RCRA detection monitoring network is presented in Figure 1.3. Since 1997, water- table elevations in the vicinity of WMA T and TX-TY have been strongly affected by reduction in wastewater discharge and more locally by the 200-ZP-1 pump-and-treat activity (DOE 2000). Figures 1.4 and 1.5 indicate the dramatic changes in the water-table elevation contours south of TX-TY after 1997.

Elevated specific conductance values in well 299-W10-17, principally due to sodium and nitrate, are most likely a result of a regional contaminant plume (upgradient source) centered to the north of the WMA. In the case of well 299-W14-12, the high specific conductance was accompanied by elevated technetium-99, iodine-129, tritium, nitrate, calcium, magnesium, sulfate, and chromium. Technetium-99, chromium, iodine-129, and tritium are the principal contaminants. In September 1993 technetium-99 reached a maximum activity of 12,200 pCi/L, 14 times the drinking water standard (DWS) of 900 pCi/L; iodine-129 reached an activity of 64.2 pCi/L, 64 times the DWS; and tritium reached an activity of 564,000 pCi/L, 28 times the DWS. The first determination (Hodges 1998) concluded that: 1) elevated technetium-99 and co-contaminants (e.g., chromium, tritium, nitrate, iodine-129, etc.) in well 299-W14-12 is consistent with a source within the WMA and contaminant chemistry is consistent with a

[a] Pacific Northwest National Laboratory is operated by Battelle for the U.S. Department of Energy under contract DE-AC06-76RL01830.

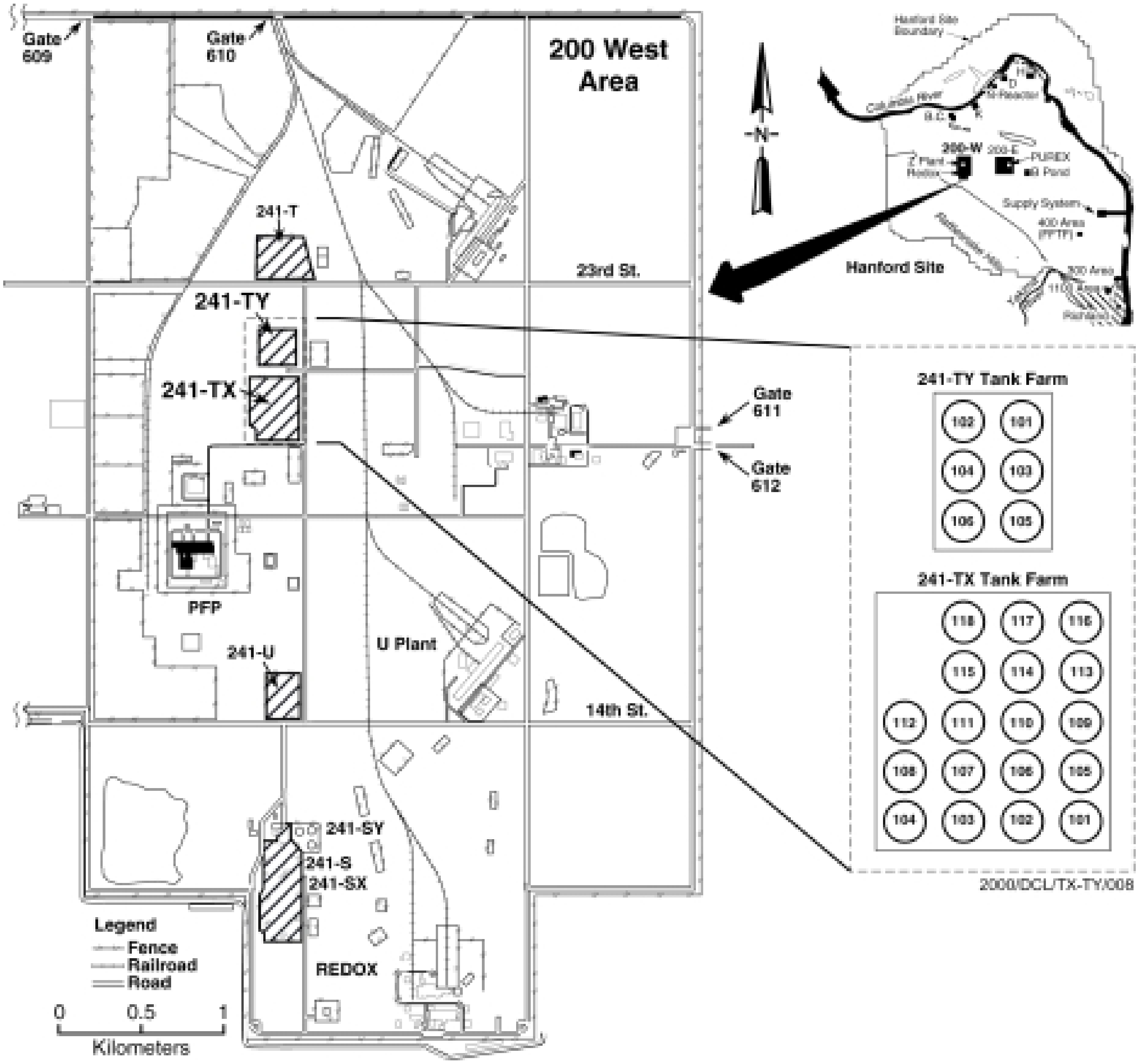

Figure 1.1. Location Map for Waste Management Area TX-TY

small volume tank waste source; and 2) an upgradient source (the 216-T-25 Trench) is possible. However, without direct evidence for an upgradient source, the default conclusion is that observed contamination from well 200-W14-12 is derived from within the WMA. Accordingly, continuation of the groundwater assessment is required (40 CFR 265.93[d][7]). The plan described here implements the continued groundwater assessment.

As a result of the first determination (Hodges 1998), a RCRA Facility Investigation/Corrective Measures Study (RFI/CMS) will be initiated at WMA T and WMA TX-TY. The primary focus of the RFI/CMS is on characterizing the nature and extent of vadose zone contamination and on assessing the data to identify initial activities to minimize intrusion and contaminant migration to groundwater. The

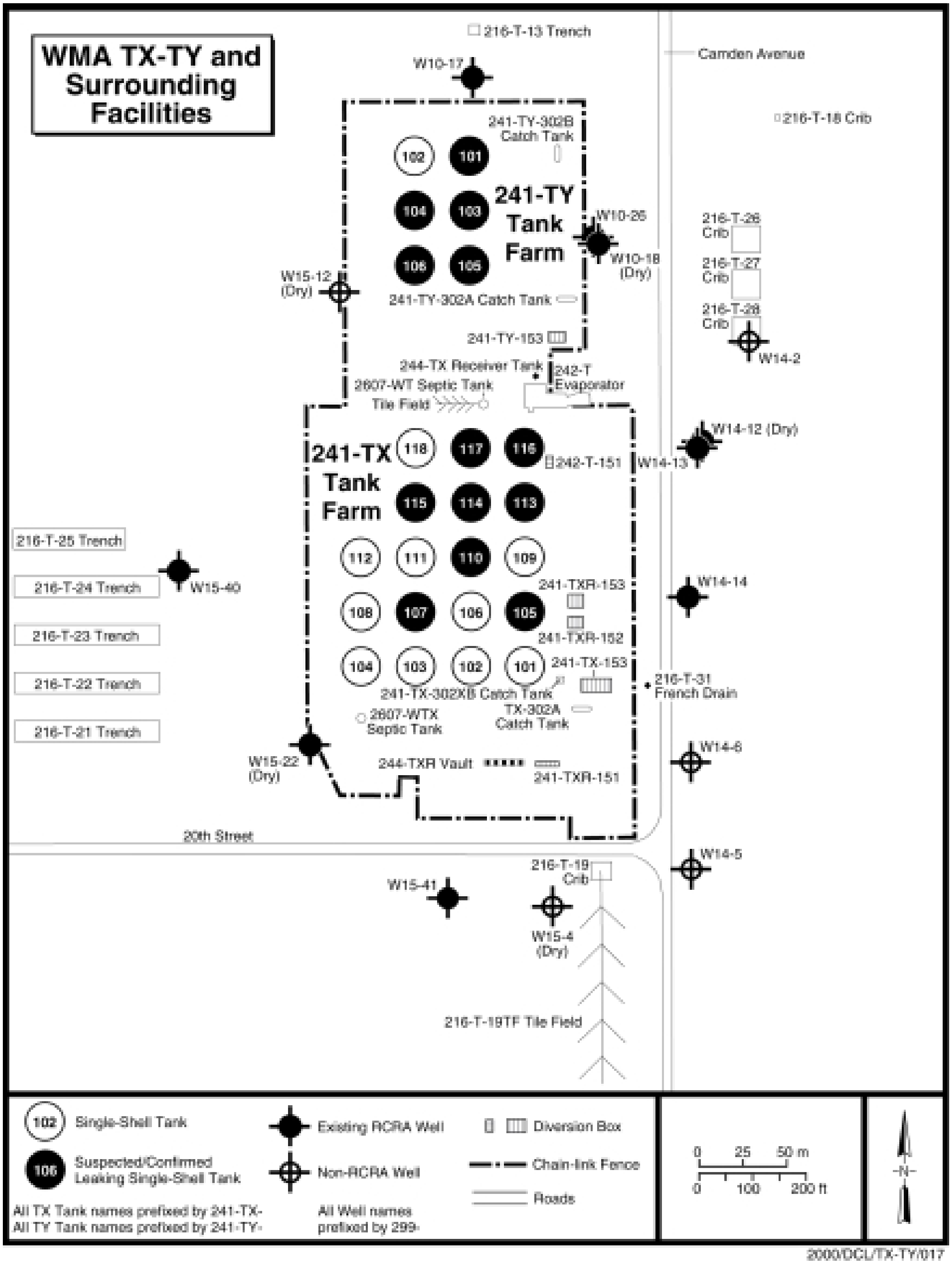

Figure 1.2. Monitoring Well Locations (well 299-W15-40 is the upgradient well)

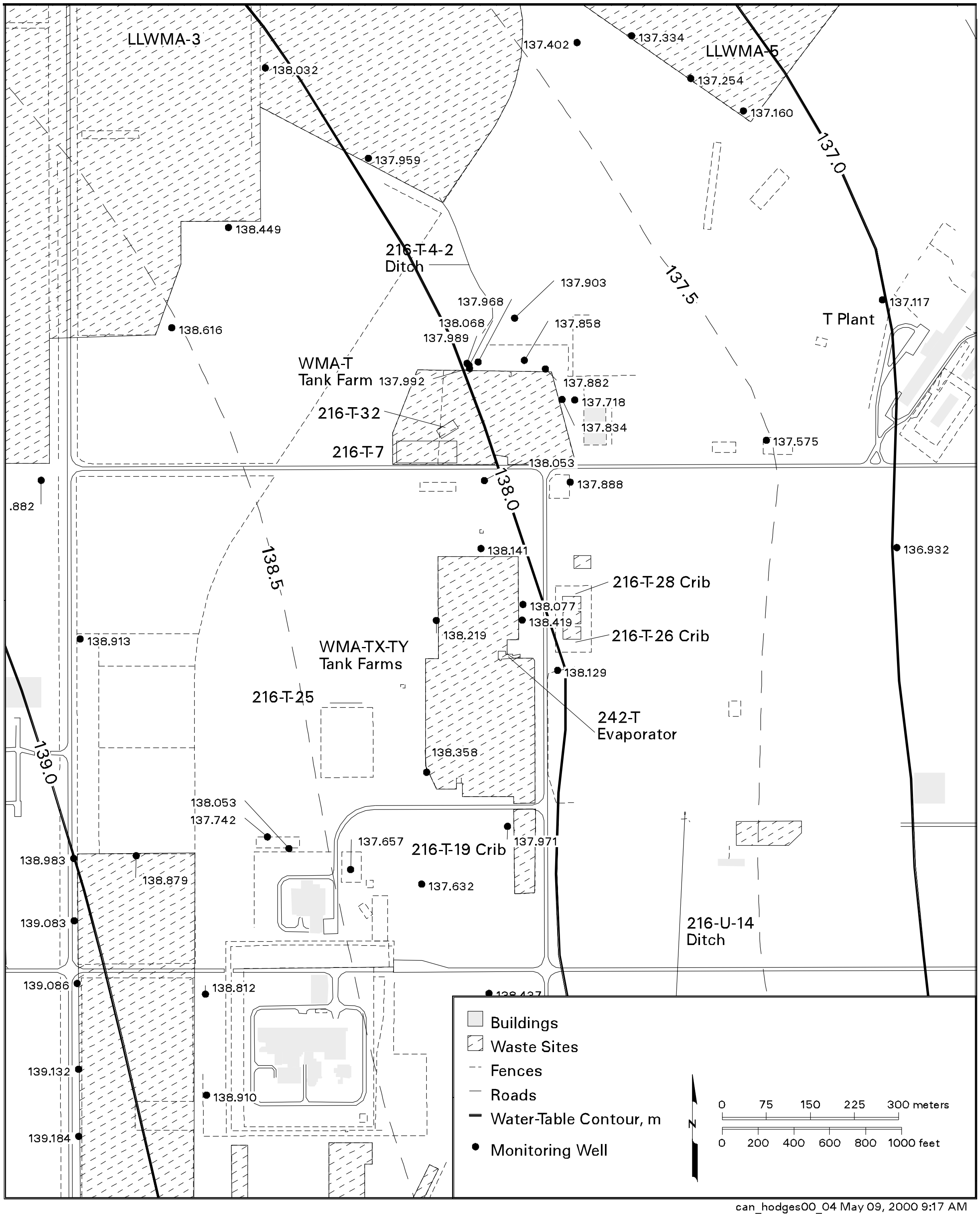

Figure 1.3. Water-Table Map of Waste Management Area TX-TY, 1997

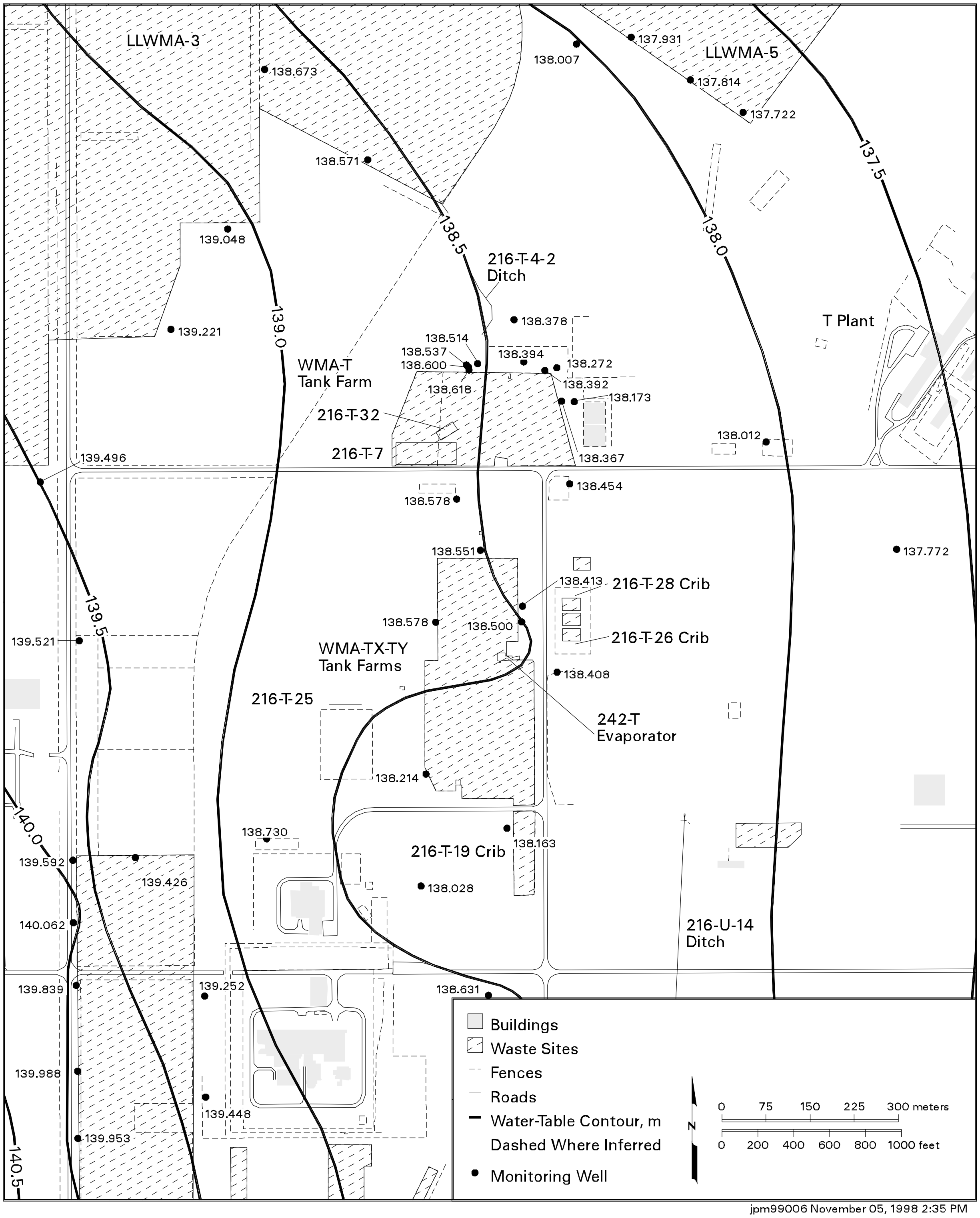

Figure 1.4. Water-Table Map of Waste Management Area TX-TY, June 1998

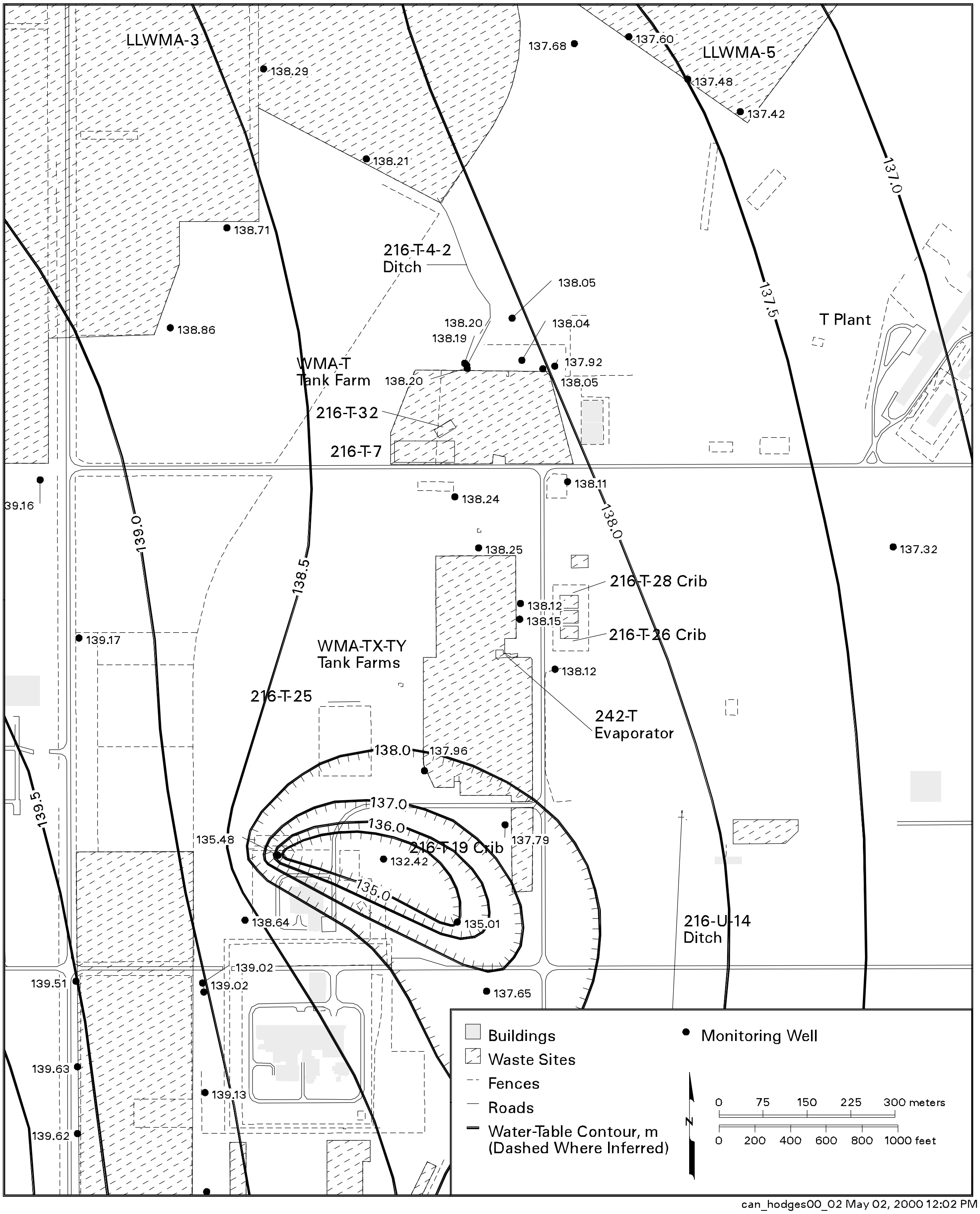

Figure 1.5. Water-Table Map of Waste Management Area TX-TY, June 1999

schedule and activities for the RFI/CMS are described in *the Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement, Ecology et al. 1989), Change Request M-45-98-03. In accordance with the agreement among the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology concerning this change request, the continuing RCRA groundwater quality assessment and the RFI/CMS work will be conducted under separate but coordinated plans. Integration of the groundwater quality assessment with the RFI/CMS will be accomplished through the Data Quality Objectives process for the Phase 1 RFI/CMS Work Plan addenda for WMA T and WMA TX-TY, due in December 2000 (milestone M-45-54). Data from the RCRA groundwater quality assessment will be used in RFI/CMS planning and will be included either by reference or directly with the vadose zone data from the RFI/CMS efforts in a field investigation report due June 2003 (milestone M-45-55-T03).

1.2 Objectives

The objectives for the continued assessment of groundwater quality at WMA TX-TY, as required by 40 CFR 265.93(d)(7)(i), are to determine:

(i) the rate and extent of migration of the hazardous waste or hazardous waste constituents in the groundwater

(ii) the concentration of hazardous waste or hazardous waste constituents in the groundwater.

These objectives are related to the remedial investigation of the vadose zone for the RFI/CMS at WMA TX-TY. For example, results from both the groundwater and vadose zone are needed to assess the potential near-term risk (*risk assessment*) associated with hypothetical exposure pathways (DOE/RL-99-36). The RFI/CMS process will be used to determine the potential need for interim or corrective measures. The process will proceed incrementally. If there is a determination of substantial risk based on both the groundwater and vadose zone results, a decision to acquire additional data may be made and or more immediate near-term mitigating actions may be taken (DOE/RL-99-36). Evaluation of risks associated with existing soil and groundwater contamination will serve the following purposes:

- establish the need for additional interim or corrective measures
- provide input to Hanford site-wide cumulative risk assessments
- serve as a basis to begin identifying cleanup standards (DOE/RL-99-36).

The endpoint for both soil and groundwater investigations will be decided by Ecology using the risk assessment results.

Key questions related to the above objectives are as follows:

1. What are the vertical and horizontal concentration profile for the hazardous waste constituents in the plume(s) released from WMA TX-TY?

2. What is the rate and extent of contaminant migration in the groundwater?

3. What are the likely sources or source areas for observed groundwater contamination?

4. What are the likely driving forces for observed groundwater contamination?

5. What is the groundwater flow direction?

The groundwater quality assessments for the single-shell tank WMAs are conducted by PNNL for DOE. The groundwater investigations will be planned and implemented to support decisions on interim measures, corrective measures, waste retrieval, and eventual closure of the tank farms, in accordance with the cleanup objective for Hanford Site tank farms.

1.3 Scope

The scope of this plan is limited to acquiring the necessary groundwater data to determine the vertical and areal extent of groundwater contamination, contaminant concentrations, and the rate of migration of contaminants originating from WMA TX-TY. Work conducted under the plan described here will also provide information for the RFI/CMS to be conducted at WMA TX-TY. Accordingly, the study boundary for this plan is the same study boundary as described for the RFI/CMS at WMA TX-TY (Change Request M-45-98-03, Attachment One). This consists of the fenced area within the 241-TX and 241-TY Tank Farms. The vertical extent is defined by the bottom of the aquifer (~56 m [184 ft] thick) contained within the semi-cemented sands and gravels of the Ringold Formation (i.e., above the lower mud unit).

1.4 General Approach

The general approach to meet the specific or immediate objectives for the continued assessment (i.e., to determine the concentration, rate of movement, and extent of contamination) includes the following major components:

- Determine optimum locations for new monitoring wells to improve the probability of detecting contaminant plumes from the WMA. A combination of well network design modeling and observational inferences will be used for this purpose. A reliable detection network is also important to demonstrate the effectiveness of any interim corrective measures undertaken as a result of the RFI/CMS process.

- Determine depth distribution of contaminants within the aquifer by discrete depth sampling during drilling of new wells and multi-depth completions.

- Conduct hydrologic testing on selected wells to obtain estimates of hydraulic conductivity, effective porosity, and preferential flow zones within the screened interval of monitoring wells. This information will be used in concert with new water-level data to determine groundwater flow velocities and to determine optimal locations of sampling intervals within the well screen intervals.

- Use spatial and temporal mapping of the contaminant plumes to delineate the extent and concentration of contaminants and their relationship to potential sources within the study boundary. In concert with hydrogeologic data, estimate the approximate rate and direction of contaminant migration.

- Use chemical constituent and isotopic ratios (fingerprinting) to aid in the identification of contaminant sources (e.g., cribs versus tanks) affecting groundwater quality. This, in turn, may help narrow the areas of concern for the vadose zone studies to be conducted for the RFI/CMS. This activity will be closely coordinated with the Tank Farm Vadose Zone Project activities, which include reconstruction of tank waste inventories over time based on tank transfer and disposal history.

The above efforts will lead to

- improved knowledge of the direction and velocity of groundwater flow

- a better understanding of the location and areal and vertical extent of contaminant plume(s) in the vicinity of WMA TX-TY

- enhanced understanding about the sources and characteristics of the groundwater contamination

- recommendations for effective placement of new monitoring wells.

1.5 Plan Organization

In addition to this introduction, a review of existing data including stratigraphy, water-level data, groundwater chemistry, and conceptual model development is presented in Chapter 2.0. A description of the groundwater monitoring program including evaluation of the assessment network, constituent lists and sample frequency, hydraulic testing, groundwater flow direction, and plume extent are presented in Chapter 3.0. The references cited in the text are given in Chapter 4.0. The sampling and analysis plan is included as Appendix A. Geologic cross-sections and as-built drawings of the existing RCRA and non-RCRA monitoring wells that will be used in the investigation are included in Appendix B. Results from the spatial modeling effort (e.g., Monitoring Efficiency Model as documented by Wilson et al. [1992]) are included in Appendix C. Preliminary results obtained from detailed hydrologic characterization tests within the WMA are presented in Appendix D.

2.0 Existing Data

This section summarizes existing stratigraphic, hydrologic, and groundwater chemistry data within and in the vicinity of WMA TX-TY. Most of this information is derived from RCRA and/or earlier non-RCRA groundwater monitoring wells. An extensive data set exists for the four RCRA-compliant wells (299-W10-17, 299-W10-18, 299-W14-12, and 299-W15-22) that were part of the original detection-level monitoring network. In calendar year 1998, four RCRA-compliant wells were drilled; these wells were drilled, in part, because wells 299-W15-22 (upgradient), 299-W10-18, and 299-W14-12 had gone dry. These wells were 299-10-26 (299-W10-18 replacement), 299-W14-13 (299-W14-12 replacement), 299-W14-14 (downgradient), and 299-W15-40 (upgradient). Five non-RCRA wells (299-W15-12, 299-W14-2, 299-W14-6, 299-W14-5, and 299-W15-4) were added to the extended assessment network. (Note: Well 299-W15-4 and well 299-W15-12 went dry in calendar year 2000 and well 299-W15-4 was replaced by 299-W15-41.) However, data for other wells in the area is less complete (see Chapter 3 for more information on well locations).

2.1 Stratigraphy

WMA TX-TY is underlain by approximately 152 m (500 ft) of suprabasalt sediments, based on the stratigraphy in well 299-W11-26 (DH-6) (Lindsey 1995). Well 299-W14-14, located on the east side of the WMA, was drilled through the Ringold Formation lower mud unit and bottomed in Ringold Unit A. In well 299-W14-14 the suprabasalt sediments consist of 30.4 m (92 ft) of Hanford formation glacial flood deposits, 9.1 m (30 ft) of Plio-Pleistocene unit, 85.3 m (280 ft) of Ringold Formation Unit E. The lower mud unit of the Ringold Formation occurs at a depth of 122.5 m (402 ft) and has a thickness of 11.0 m (36 ft). The water table in well 299-W14-14 occurs at a depth of 66.4 m (218 ft). Thus, assuming that the Ringold lower mud unit is confining, the unconfined aquifer beneath the WMA has a thickness of 56 m (184 ft).

The Hanford formation consists of gravels, sands, and silts deposited by catastrophic glacial floods at the end of the Pleistocene. The Hanford formation sediments are clast supported, uncemented, and highly permeable to both liquid and gases. At WMA TX-TY, they are contained entirely within the vadose zone. The Plio-Pleistocene unit is a sandy, silty carbonate cemented (caliche) paleosol that occurs at the top of the Ringold Formation. It is present throughout the 200 West Area and forms an extensive, but imperfect, barrier to vertical migration within the vadose zone. The Ringold Formation, in the vicinity of WMA T, consists of fluvial sediments deposited by the ancestral Columbia River. It is dominated by two gravel packages, unit E above a fine-grained unit called the lower mud unit, and unit A, which is between the lower mud unit and the top of basalt. Gravels within unit E, which contains the unconfined aquifer beneath the WMA, are characterized by highly variable cementation. As a result of this irregular cementation, highly variable hydraulic conductivities and preferred flow zones likely occur within the aquifer. A generalized stratigraphic column for the Hanford Site is presented in Figure 2.1. A north-south cross-section through WMA T and TX-TY, based on geologic and geophysical logs from existing RCRA monitoring wells, is presented in Figure 2.2.

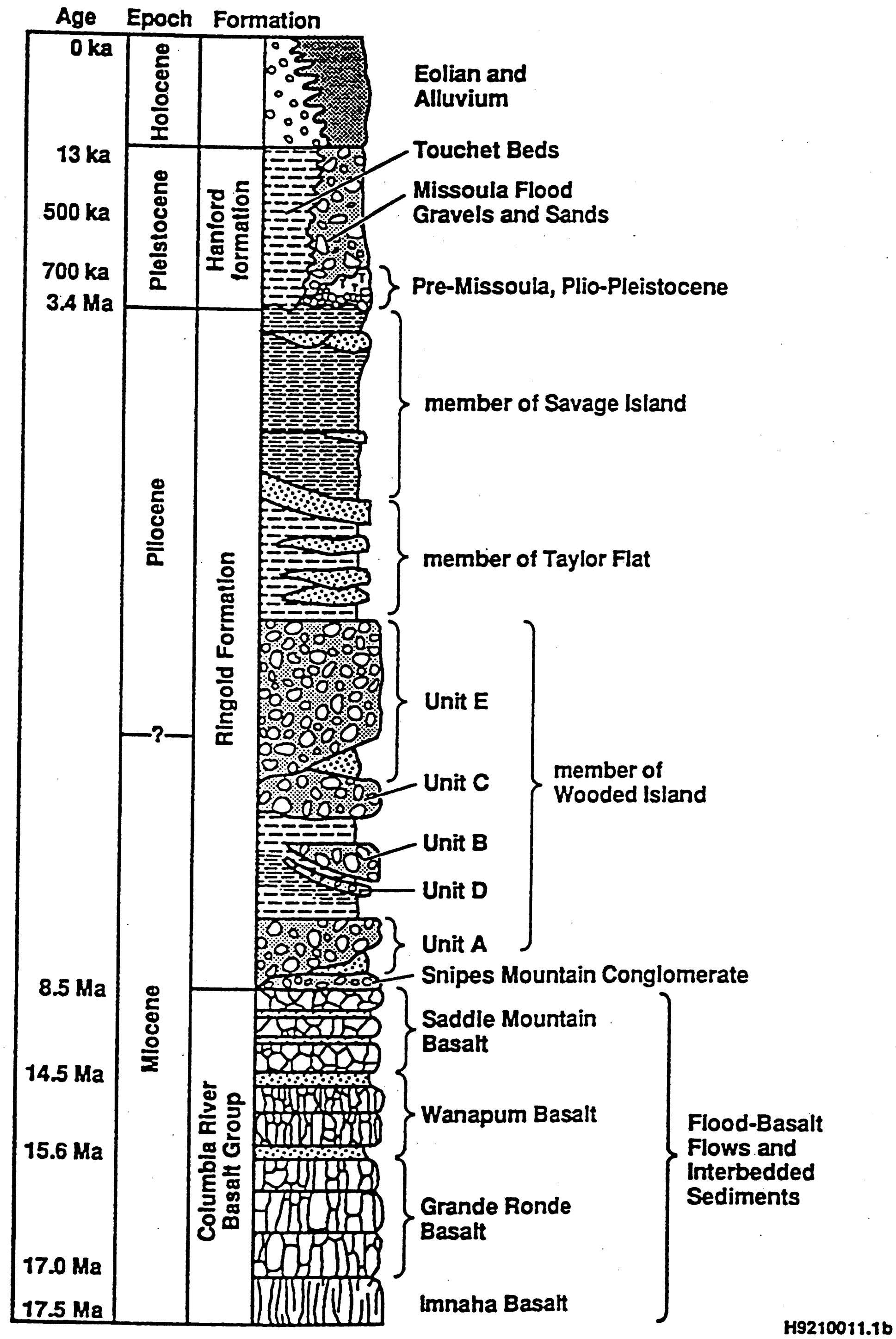

Figure 2.1. Generalized Stratigraphic Column for the Hanford Site (Lindsey 1995). Column emphasizes Ringold Formation and is not to scale.

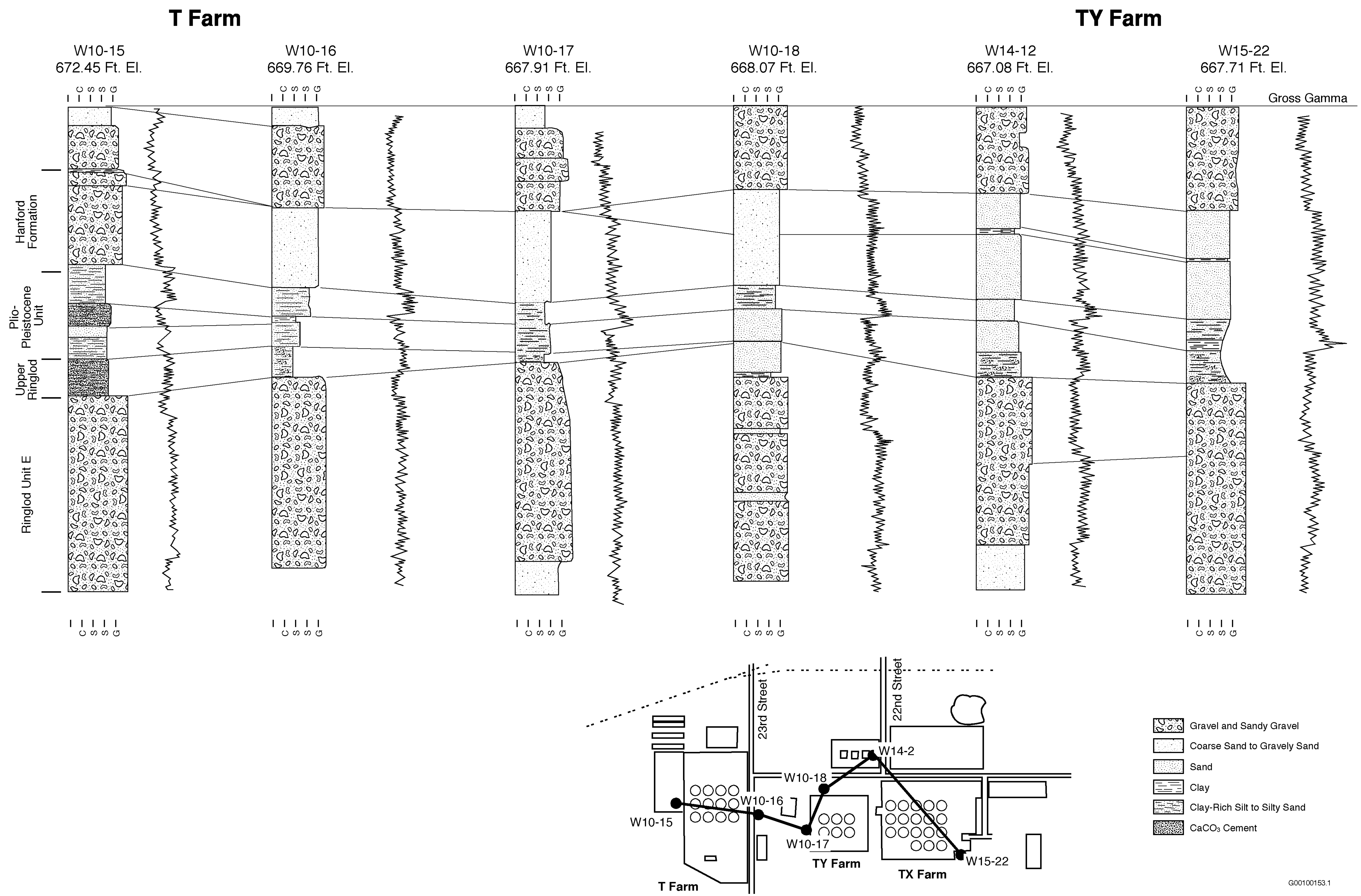

Figure 2.2. Cross-Section Through *Resource Conservation and Recovery Act* Monitoring Wells at Waste Management Areas T and TX-TY Showing Geologic and Gross Gamma Logs

2.2 Water-Level Data

Water levels have been declining beneath the WMA since the inception of RCRA monitoring in 1990 (Figure 2.3). This decline, resulting from decreasing effluent discharge in the 200 West Area, became much steeper in 1995 with the effective cessation of discharge to ground in this area. The rapid decrease in water levels after 1995 resulted in monitoring wells going dry more quickly than previously predicted and necessitated the drilling of four new monitoring wells in 1998. Also, water-table elevations in the vicinity of WMA T and TX-TY have been strongly affected by the 200-ZP-1 pump-and-treat activity (DOE 2000), as indicated by the dramatic changes in the water-table elevation contours after 1997.

Historically groundwater flow directions in the vicinity of WMA TX-TY have undergone major fluctuations as a result of changing effluent discharge sites within the 200 West Area. Since the 1940's groundwater directions have changed from easterly (pre-Hanford), to southerly as a result of T Pond, then to northerly as a result of U Pond (located to at the southwest end of 200 West), and then to a more northeasterly direction as a result of wastewater discharges from the Plutonium Finishing Plant (Hodges 1998). At the present time, flow directions are more complex as a result of the 200-ZP-1 pump-and-treat activity. The water-table elevations (Figure 1.4) suggest the flow direction is more easterly in the northern part of the WMA and then shifts to a more southerly direction at the south end of the WMA.

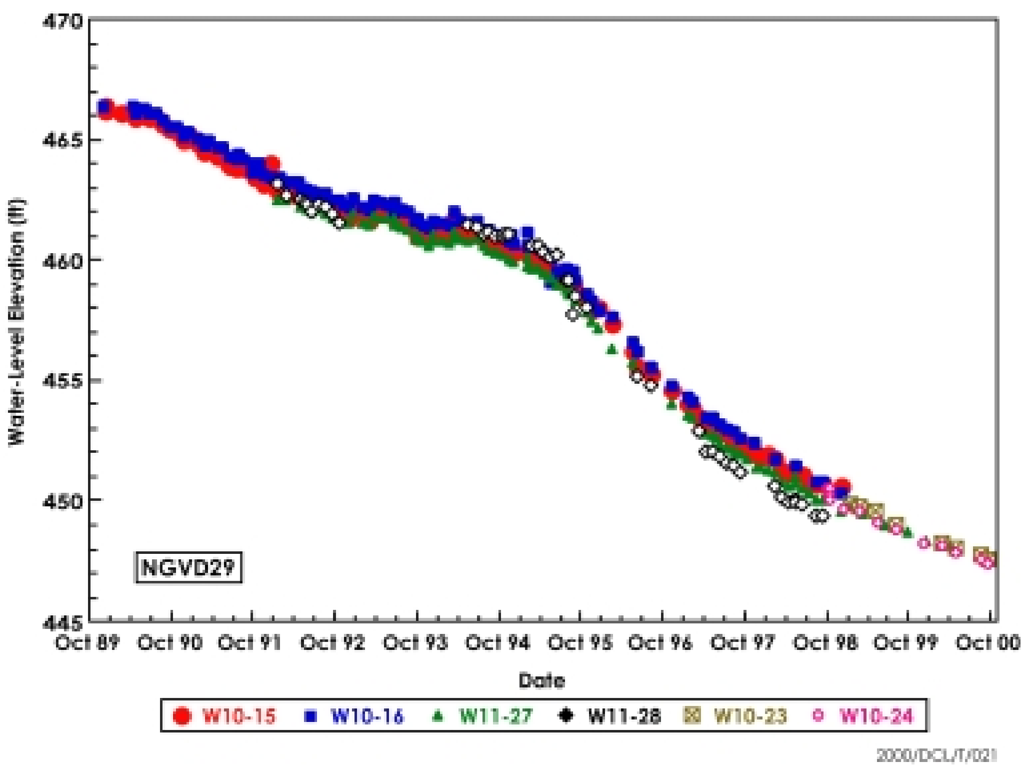

Figure 2.3. Hydrographs for RCRA Compliant Monitoring Wells at Waste Management Area TX-TY

2.3 Groundwater Chemistry

Groundwater contaminant chemistry in the vicinity of WMA TX-TY is dominated by high concentrations of sodium and nitrate, apparently a mixture of tank supernate disposed to ground during tank cascading, and carbon tetrachloride and nitrate rich water from waste disposal in the Plutonium Finishing Plant trenches. Another significant, tritium- rich component, is apparently from the disposal of evaporator condensate in the T-19 Crib and Tile Field south of the WMA. The center of the high-sodium, high-nitrate plume is located north of the WMA, and there is a general southward decrease in sodium and nitrate, and thus of specific conductance, across the WMA. The critical mean of specific conductance for the site was determined using data from well 299-W15-22, at the south end of the WMA. This southward decrease explains the exceedance of the specific conductance critical mean in downgradient well 299-W10-17, located at the north end of the WMA. Elevated specific conductance values in well 299-W10-17, principally due to sodium and nitrate, are most likely a result of upgradient sources from a regional contaminant plume centered to the north of the WMA. Well 299-W10-17 is one of the wells that placed the WMA in assessment.

The chemistry of groundwater sampled by well 299-W14-12, the second well that placed the WMA in assessment, is quite different from that found in well 299-W10-17. The high specific conductance in well 299-W14-12 was accompanied by elevated technetium-99, iodine-129, tritium, nitrate, calcium, magnesium, sulfate, and chromium. Technetium-99, chromium, iodine-129, and tritium are the principal contaminants. In September 1993, technetium-99 reached a maximum activity of 12,200 pCi/L, iodine-129 reached an activity of 64.2 pCi/L, tritium reached an activity of 564,000 pCi/L, and chromium reached 510 μg/L. Contaminant concentrations in well 299-W14-12 declined sharply between 1995 and 1996 and then seemed to stabilize. In 1998, concentrations of tritium, technetium-99, iodine-129, and chromium started to increase. This increase in contaminant concentrations in well 299-W14-12 is probably related to changes in groundwater flow direction resulting from the 200-ZP-1 pump-and-treat located south of the WMA.

In well 299-W14-2, located approximately 60 m northeast of well 299-W14-12, tritium and iodine-129 increased dramatically in 1998. In 299-W14-2 tritium reached 3,210,000 pCi/L in June 1998 and iodine-129 reached 81 pCi/L. The high tritium and iodine-129 were accompanied by relatively low technetium-99 and nitrate and slightly elevated total organic carbon. The most likely source of the contaminants observed in well 299-W14-2 is the 242-T evaporator located between the 241-TX and 241-TY tank farms.

Well 299-W14-12 was last sampled in January 1999 and can no longer be sampled. Well 299-W14-13, drilled as a replacement for 299-W14-12, has shown an increasing contaminant trend since the initiation of sampling in December 1998. In March 2000, tritium reached 2,940,000 pCi/L, iodine-129 reached 47 pCi/L, technetium-99 reached 7,400 pCi/L, and nitrate reached 433 mg/L. Contamination in 299-W14-13 appears to be a mixture of a tank farm plume, similar to that observed in 299-W14-12 prior to 1998, and the tritium/iodine-129 plume observed in well 299-W14-2 (see Section 2.3.2). If groundwater flow in this area is toward the southeast, as indicated by groundwater maps (see Figure 1.4), the most likely source of the technetium-99 contamination is the TY Tank Farm. Given the present southeasterly groundwater flow, the most likely source of the high tritium and iodine-129 is an undetected plume that was previously moving northeast from the 242-T evaporator and is presently drifting southeastward across well 299-W14-2.

Sampling during drilling at well 299-W10-24 (WMA T) and 299-W14-14 (WMA TX-TY), which were drilled through the Ringold lower mud unit, indicates contamination with carbon tetrachloride, tritium, and technetium-99 throughout the thickness of the aquifer, and below the lower mud unit. Except for technetium-99, contaminant concentrations tend to peak at depths of 30 to 45 m (~100 to 150 ft) beneath the water table; however, they are present in significant concentrations at all depths that were sampled.

As previously noted, the direction of groundwater flow at WMA TX-TY is complex, and there are multiple potential sources of groundwater contamination in the area. Therefore, a means is needed to distinguish one source type from another. One approach is to use elemental and isotopic ratios of mobile groundwater constituents as indicators to differentiate tank from crib sources. These ratios also may be used to define mixing lines for varying groundwater compositions (Hodges 1998). Contaminant concentrations can vary widely from the centerline of a plume to the outer edges. However, the ratio of two mobile constituents associated with the plume will not change (assuming the plume in question is the only source of the two constituents). Variation in the ratios (systematic deviation from a single or narrow range of values) of selected contaminant concentrations could be attributed to different source types. For example, the sodium/calcium ratio could provide useful information to discern between different sources. Other useful ratios include tritium/technetium-99, and nitrate/technetium-99.

2.4 Conceptual Model

Conceptual models are essentially collections of working hypotheses that provide a framework for ongoing work. This framework should be continually modified as new data become available and new knowledge is developed.

Figure 2.4, taken from Johnson and Chou (1998), is a reasonable representation of pathways to groundwater in the 200 West Area. Sources of contamination include tank leaks, tank overflows, diversion box or transfer line leaks, and in the case of WMA TX-TY, adjacent cribs, trenches, tile fields, and the 242-T evaporator. Thirteen tanks within WMA TX-TY are known or suspected to have leaked waste to the surrounding soil.

Driving forces, in addition to the volume and density of released waste, for moving waste through the vadose zone consist principally of gravel-enhanced infiltration of normal precipitation (Gee et al. 1992), the potential effects of flooding during rapid snow melt events (Hodges 1998, Figure 3.23), and leaking water lines within or adjacent to the WMA.

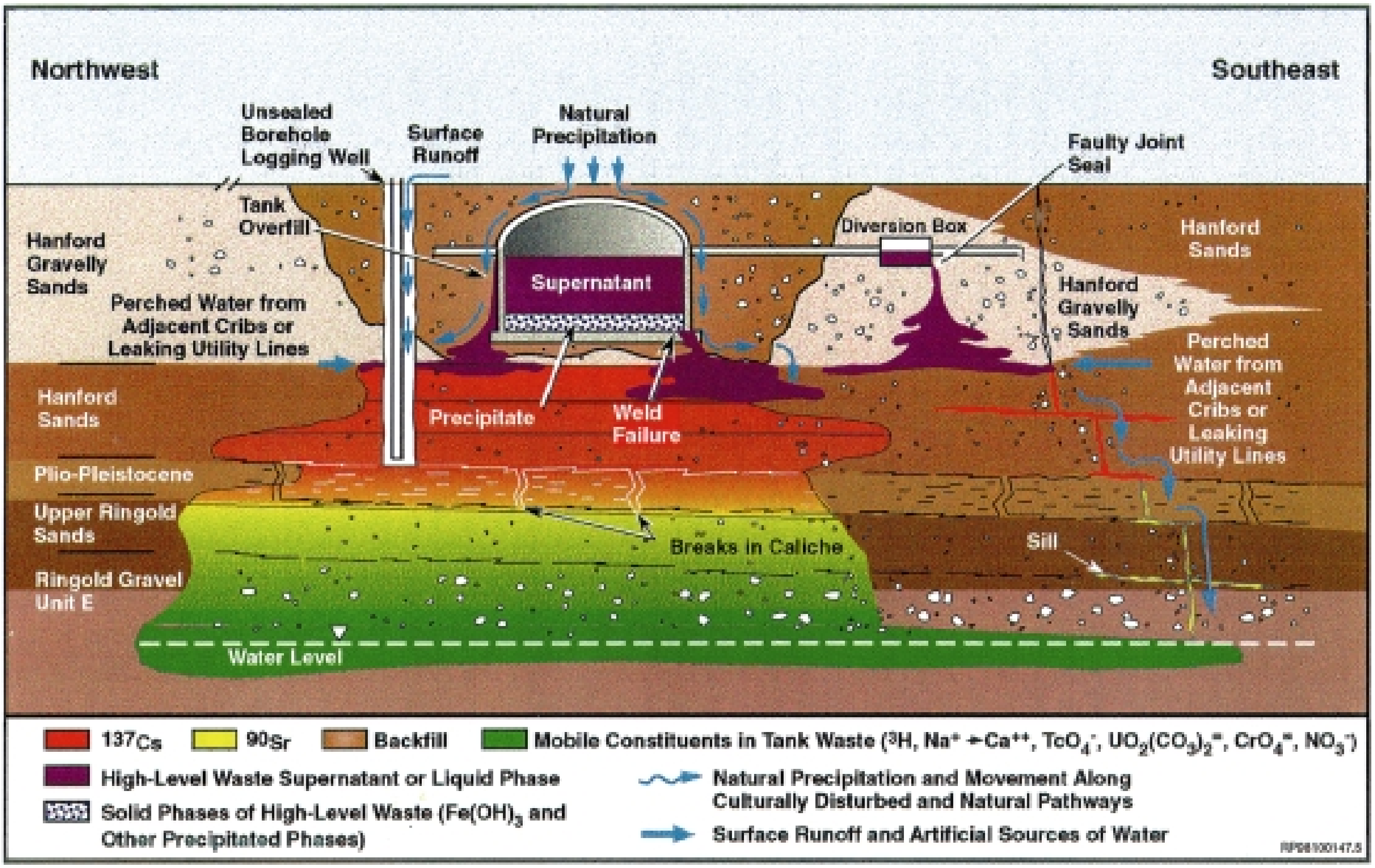

Figure 2.4. Soil Pathway Conceptual Model. Purple depicts tank waste and leakage during early operations in the 1960's. Subsequent hypothetical movement of contaminants through the vadose zone, shown in red, yellow, and green, covers a time period from early operations to the present. As a result of volume reduction measures, a much smaller volume of free liquid remains in the tanks today. Depth to groundwater is about 66 m (~217 ft). The tank base elevation is about 15 m (50 ft) below ground surface. The geologic strata shown are simplified for illustration purposes. Source: Johnson and Chou (1998).

Previous investigations of tank leaks at the 241-SX and 241-T Tank Farms (Freeman-Pollard et al. 1994, Serne et al. 1998) suggested that most of the contaminants remained high in the soil column.[a] One hypothesis proposed to account for this observation involves both sorption and plugging of the pore spaces in the soil with silica and alumina gel or precipitates released through reaction of highly alkaline waste and silicate minerals in the soil column (Serne et al. 1998). Thus, on the basis of the studies cited, there was not a general downward migration of contaminants, particularly cesium-137, strontium-90 or transuranics. However, these conclusions do not necessarily apply to the more mobile constituents.

Regardless of the pathway through the vadose zone, when tank waste reaches the water table it may sink or it may form a layer near the top of the aquifer, depending on the density of the waste and its arrival rate at the water table relative to the rate of groundwater flow and the hydraulic gradient. Hanford tank waste is essentially a saturated sodium nitrate brine, and its density is sufficient to allow it to sink through the aquifer, if the flow rate is too low to facilitate mixing. Waste mobilized by influx of meteoric or other surface water will be diluted and the density will depend on the degree of mixing. An additional complication is relatively clean water that may infiltrate to the water table upgradient and/or downgradient of the point where the contaminants entered the groundwater, an effect enhanced by wide gravel aprons around the tanks. If infiltration over the gravel covered areas equals 10 cm/y, and the effective porosity is 0.1, this mechanism may add as much as 1 m/y to the top of the aquifer. Thus, there may be vertical layering in the aquifer resulting from multiple infiltration effects. Determination of the vertical variation of contaminants within the aquifer may aid in determining vadose zone transport mechanisms within the tank farms.

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[a] Routson, R. C. 1981. *Volume of Sediments Contaminated with* ^{90}*Sr and* ^{137}*Cs in the T-Tank Farm,* letter from R. C. Routson to W. F. Heine, No. 72710-81-120, dated May 25, 1981.

3.0 Groundwater Quality Assessment Program

The initial investigation of groundwater quality conditions at WMA TX-TY (Hodges 1998) addressed the basic question of whether or not the WMA was responsible for contributing to groundwater contamination. Because it was concluded that the WMA has impacted groundwater (Hodges 1998), the general focus of the continued investigation is to determine the rate and extent of migration of the hazardous constituents or waste constituents in the groundwater and their concentrations (40 CFR 265 [d][4] and by reference of WAC 173-303-400[3]). The requirements under continued assessment program are more intensive than what is required for RCRA indicator evaluation monitoring. This section presents the groundwater monitoring network (including proposed locations for new wells), sampling frequency, and analytical constituent lists to be used to meet the requirements of assessment monitoring.

3.1 Assessment Network

RCRA groundwater monitoring at WMA TX-TY was initiated in 1989. Four RCRA-compliant wells (299-W10-17, 299-W10-18, 299-W14-12, and 299-W15-22) were constructed for the original detection level groundwater-monitoring network (Jensen et al. 1989, Caggiano and Goodwin 1991). The wells were all constructed with 4.6 m (15 ft) screened intervals. Because of the general water table decline in the 200 West Area, all have gone dry except for 299-W10-17. A number of older non-RCRA wells have been used as part of the assessment network since 1993. These older non-RCRA wells, drilled before 1990, normally have carbon-steel casings that are perforated to allow access to the aquifer. Because of the materials used to construct these wells and the potential effects of corrosion on groundwater chemistry, special care must be taken to maintain these wells and to purge the wells before sampling. However, with proper precautions, they should yield water samples adequately representative of the aquifer.

The current assessment network consists of six RCRA-compliant wells (four were drilled in 1998 either replacing original RCRA monitoring wells that went dry or filling gaps in the monitoring network created by changing groundwater flow directions) and three older, non-RCRA wells located around the margins of the WMA. As a result of the shifts in groundwater flow direction, MEMO model predictions of well coverage efficiency (Appendix C), combined with judgment and contaminant observations, four new wells as well as one replacement well were proposed to be drilled in calendar year 2000 (see Appendix C for a more detailed discussion). These new wells will provide more complete areal coverage to identify potential sources of contamination within the WMA and will help fulfill the requirement to assess the extent of groundwater contamination from this WMA. Existing monitoring wells and the proposed new wells for calendar year 2000 are listed in Table 3.1a. The approximate locations of the wells are shown in Figure 3.1. In addition, nine wells are planned for calendar year 2001 pending funding availability (see Table 3.1b). The proposed well locations are shown in Figure 3.2. One well is an upgradient well, which will replace a non-RCRA well (299-W15-12). Two wells are near field downgradient wells (near wells 299-W14-13 and 299-W15-41), which will monitor at depth to evaluate contaminant depth distribution near the WMA. Two wells (north of well 299-W14-6 and west of well 299-W15-41) will enhance downgradient coverage and contaminant detection. In addition, two new pairs of well clusters will be installed. One cluster located adjacent to well 299-W14-2 will consist of a shallow and deep well.

Table 3.1a. Assessment Monitoring Network, Constituent List, and Sampling Frequency for Waste Management Area TX-TY

Well	RCRA Standard	Sampling Frequency[a]	Constituent List[b]	Co-Sample	Comment
Existing Network					
299-W15-40[c,d]	Y	Q	A		New upgradient well
299-W10-17	Y	Q	A		
299-W10-26[c]	Y	Q	A, B		299-W10-18 replacement
299-W14-2[e]	N	Q	A, B, C	*Atomic Energy Act*	
299-W14-13[c]	Y	Q	A, B, C		299-W14-12 replacement
299-W14-14[f]	Y	Q	A, B		New downgradient well
299-W14-6	N	Q	A, B		
299-W14-5	N	Q	A, B		
299-W15-41	Y	Q	A, B		
New Wells to be Drilled in Calendar Year 2000					
Well 1	Y	Q	A, B		Mid-field
Well 2	Y	Q	A, B, C		Plume definition
Well 3	Y	Q	A, B		Mid-field
Well 4	Y	Q	A, B		299-W15-4 replacement
Well 5	Y	Q	A, B		East of 241-TY Tank Farm

(a) SA = Semiannually; Q = Quarterly.
(b) Letters refer to lists in Table 3.2.
(c) Completed September 1998.
(d) Upgradient well.
(e) Integrated with Atomic Energy Act monitoring activity.
(f) Completed November 1998.

The other new cluster located adjacent to calendar year 2000 well 2, will consist of an intermediate and deep well, drilled to enhance downgradient coverage and to evaluate contamination and to monitor at depth. If contamination is detected at depth in downgradient wells, the results from monitoring wells installed at these locations will be evaluated to determine whether deep upgradient wells will be needed to differentiate possible upgradient sources of the deep contamination. As-built diagrams for the existing assessment network wells are presented in Appendix B.

In 1998, well 299-W14-14 was drilled through the lower mud unit of the Ringold Formation, with groundwater sampling at discrete intervals within the aquifer, to determine the depth distribution of contaminants. Samples were taken at depths of approximately 15, 30, 40, 57, and 69 m (48, 99, 131, 187, and 225 ft) below the water table. The lower two depths provided samples immediately above and below

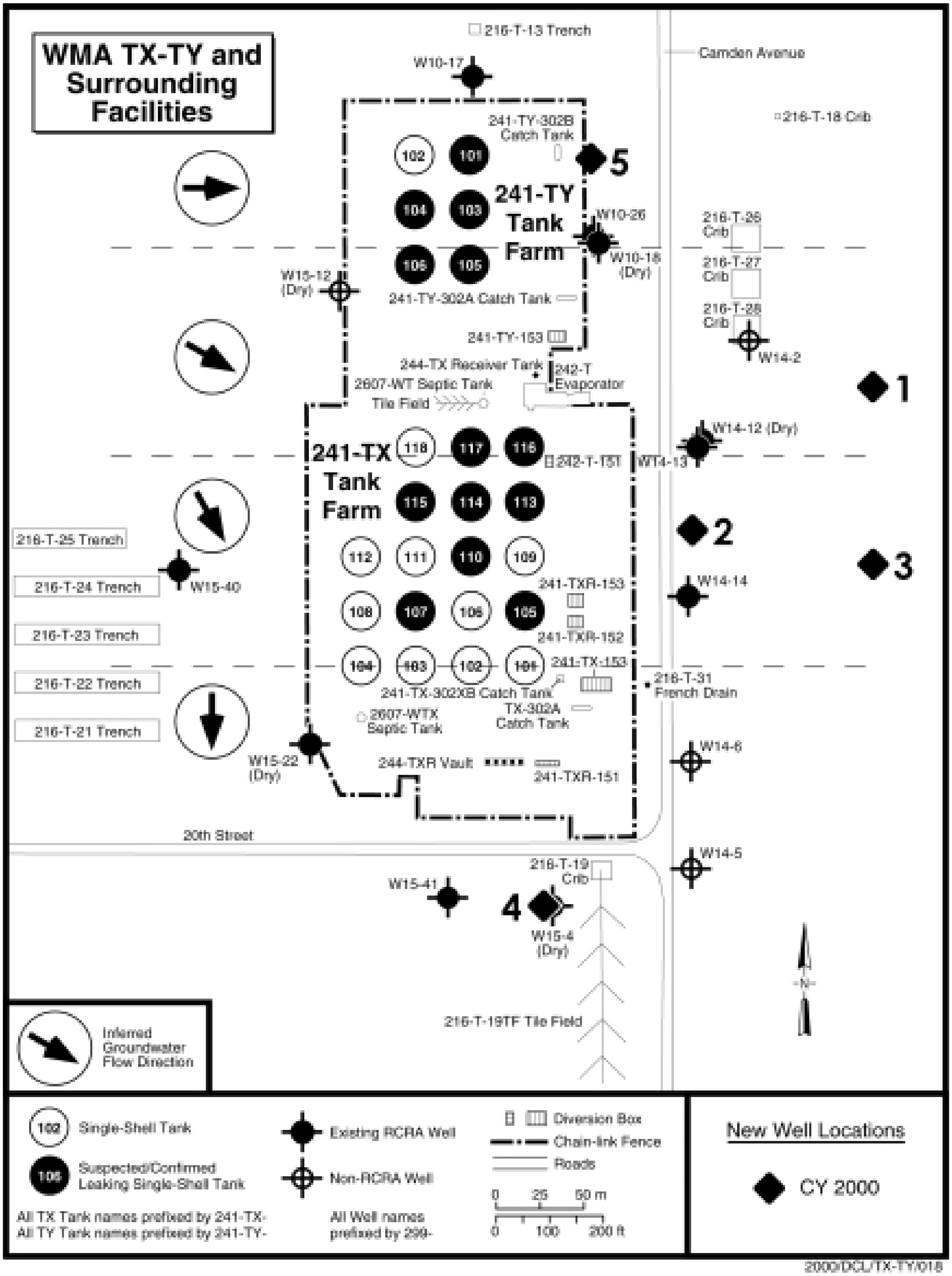

Figure 3.1. Calendar Year 2000 Well Locations

Table 3.1b. Additional Assessment Wells, Constituent List and Sample Frequency Planned for WMA TX-TY in Calendar Year 2001 (not numbered in order of priority)

Well	RCRA Standard	Sampling Frequency[a]	Constituent List[b]	Co-Sample	Comment
New Wells to be Drilled in Calendar Year 2001[c]					
Wells 6 and 10	Y	Q	A,B,C		A shallow and a deep well to enhance downgradient coverage and to evaluate contamination and monitor at depth
Well 7	Y	Q	A,B		Replace non-RCRA upgradient well 299-W15-12
Well 8	Y	Q	A,B		Contaminant detection and enhancement of downgradient coverage
Well 9	Y	Q	A,B		A shallow well to enhance downgradient coverage
Well 11	Y	Q	A,B,C		Monitor at depth to evaluate contaminant depth distribution
Well 12	Y	Q	A,B		A deep well adjacent to well 299-W15-41
Wells 13 and 14	Y	Q	A,B		Two wells adjacent to Calendar Year 2000 Well 2, these wells will evaluate contamination and monitor at selected depths

(a) Q = Quarterly.
(b) Letters refer to list in Table 3.2.
(c) Pending funding availability.

the Ringold lower mud unit. After completion of sampling, the well was backfilled and completed at the top of the water table with a 10.7 m (35 ft) screened interval.

In addition, some wells may become unusable in the future because of the declining water table, changing direction of groundwater flow, or being decommissioned. The need for additional new RCRA wells beyond those discussed above will be evaluated at least on an annual basis to determine the effects of declining water tables, changing flow directions, and contaminant distribution patterns.

3.2 Constituents and Sampling Frequency

Sampling frequency (Tables 3.1a and b) will depend on both proximity to the WMA and the presence or absence of contaminants in the well. Initially, wells immediately adjacent to the WMA will be sampled on a quarterly basis and more distant wells (mid-field) on a semiannual basis. If a mid-field well shows a rapid increase in technetium-99 or tritium activity or if technetium-99 exceeds the drinking water standard, sampling frequency in that well will be increased to quarterly. As the assessment study proceeds, the sampling frequencies may be increased or decreased on the basis of flow rates, flow directions, or contaminant patterns.

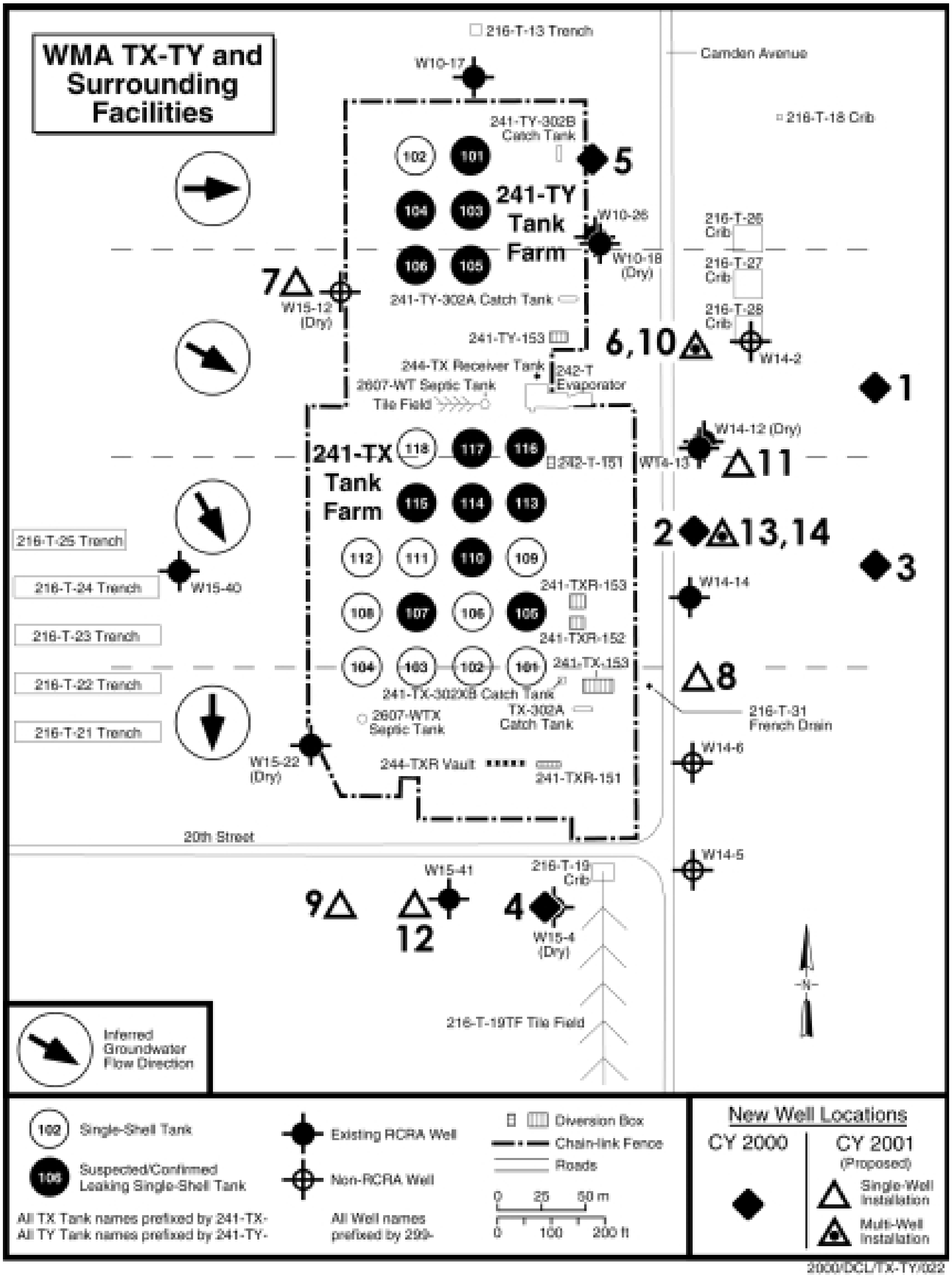

Figure 3.2. Calendar Year 2001 Well Locations

The analytical constituent lists (Table 3.2) are designed to meet monitoring needs of the assessment program. List A is the basic list for monitoring in near-field wells. Inductively coupled plasma metals and anions coupled with radionuclide analysis provide information on the major contaminants associated with the WMA and for calculating the ratios necessary for plume fingerprinting.

Total organic carbon (List B), a RCRA indicator parameter, will be analyzed from selected near- and mid-field downgradient well samples because many of the tanks contain organics (complexants) and because they should be concentrated in evaporator condensate. Total organic halogen is not on the list because halogenated hydrocarbons are not believed to be significant tank waste components. Carbon tetrachloride and trichloroethene are present in groundwater throughout the area; however, they are principally a result of waste disposal activities at the Plutonium Finishing Plant and are tracked by monitoring activities required by the *Atomic Energy Act*.

Ruthenium-101 (stable), selenium-79 ($t_{½}$ = 65 x 10^4 years), neptunium-237 ($t_{½}$ = 2.14 x 10^6 years), and americium-241 ($t_{½}$ = 244 years) (List C) are known to be present in tank waste and may be detectable in groundwater in low concentrations. Because of low expected concentrations, these constituents may be analyzed only in selected samples that have high concentrations of technetium-99, another mobile tank waste constituent. If results are positive for the high technetium-99 samples, the analysis may be extended to other samples.

3.3 Hydrologic Testing

The tests described below are designed to provide hydrologic data that will allow assessment and prediction of groundwater-flow rates and contaminant migration rates in the vicinity of WMA TX-TY. These predictions are important because they will form the basis for evaluating the rate and extent of contaminant migration, and because they may be used in risk analysis.

Table 3.2. Analytical Constituents for Waste Management Area TX-TY

List A	List B	List C
Temperature	Total organic carbon[(a)]	Strontium-90[(b)]
Specific conductance		Gamma scan
pH		Special analyses[(c)]
Inductively coupled plasma metals		
Anions		
Alkalinity		
Total dissolved solids		
Gross alpha		
Gross beta		
Technetium-99		
Tritium		
Iodine-129		

(a) Individual analysis.
(b) Non-routine analysis. If analytical tests show strontium as a nondetect, it will be dropped.
(c) Non-routine analyses include ruthenium-101, selenium-79, americium-241, and neptunium-237.

Hydrologic testing is planned for selected monitoring wells to provide specific characterization information. The hydrologic testing will provide aquifer information pertaining to flow velocity, hydraulic properties, and effective porosity in the vicinity of the well site, as well as well performance/efficiency. This information will serve as input to numerical models used to simulate groundwater flow rate and to predict contaminant transport within the Hanford Site. The hydrologic test plan involves four tests:

- Slug testing will evaluate well-development conditions and provide preliminary hydraulic property information (e.g., hydraulic conductivity) for design of subsequent hydrologic tests.

- Tracer-dilution testing will determine the vertical distribution of hydraulic conductivity and/or groundwater flow velocity within the well screen section.

- Tracer-pumpback testing will determine tracer removal and effective porosity, an important hydraulic transport parameter. This test will be conducted in conjunction with tracer-dilution tests.

- Pumping/recovery testing will be conducted in concert with tracer-pumpback phase. Analysis of drawdown and recovery data provides quantitative hydraulic characterization property information (e.g., hydraulic conductivity, storativity, specific yield).

As noted previously, slug testing is designed primarily to provide initial estimates of hydraulic properties to design more quantitative hydrologic tests. Several slug tests will be conducted at different stress levels during this characterization phase to provide information pertaining to well development and to the possible presence of near-well heterogeneities.

For the tracer-dilution test, a solution of potassium or lithium bromide (or other suitable tracer) of known concentration will be circulated/mixed within the well screen section. The decline (i.e., dilution) of tracer with time within the well screen will be monitored directly using bromide-specific ion electrodes located at known depth intervals. Based on the dilution characteristics observed, the vertical distribution (i.e., heterogeneity) of hydraulic properties and/or flow velocity can be estimated for the formation/well screen section.

After the tracer-dilution test is completed, and the tracer has sufficient time to clear the borehole, a pump will be placed in the well and water will be discharged at a constant rate to recover most of the tracer. The tracer-pumpback phase will be complete when the centroid of tracer concentration has been recovered. Analysis of the tracer recovery pattern will provide information on hydraulic conductivity and effective porosity. To quantitatively characterize the hydraulic properties of the surrounding formation, the constant-rate pumping test might be extended for duration longer than required for “capturing” the centroid of tracer concentration. The time required to obtain representative hydrologic property results will be determined using diagnostic derivative analysis results of the drawdown data obtained from the pumped and nearby observation well locations. A detailed description of the use of derivative analysis techniques is provided in Spane (1993) and Spane and Wurstner (1993).

After the constant-rate pumping test is complete, the recovery of water levels within the pumped and nearby observation wells will be monitored. The time required for recovery monitoring will be assessed through the use of diagnostic derivative analysis, similar to drawdown data during the pumping phase. For general planning purposes, however, recovery monitoring should be maintained for a period equal to the pumping period and preferably longer.

As of September 30, 2000, all of the above identified hydrologic tests were completed for wells 299-W10-26, 299-W14-13, and 299-W15-41. Slug tests were completed for wells 299-W14-14 and 299-W15-40. Preliminary results obtained from detailed hydrologic characterization tests within the WMA are presented in Appendix D. Final results will be documented in PNNL technical reports and in the groundwater annual report.

3.4 Groundwater Flow Direction

Determining both the direction and velocity of groundwater flow is important to assess and predict contaminant transport. The tests discussed in Section 3.3 provide estimates of groundwater flow velocities; however, they do not provide estimates of groundwater flow direction.

A number of techniques, including downhole flow measurements, and accurate determination of water-table elevations can be used to determine the direction of groundwater flow. It should be noted, however, that each of the identified techniques has strengths and weaknesses. For example, there is a high degree of uncertainty about the accuracy and reliability of downhole flow measurements, and the fact that they represent only a point in space. For initial evaluation of groundwater flow directions at WMA TX-TY, trend-surface analysis will be applied to refined water-table elevation measurements. As of September 30, 2000, trend-surface analysis was completed for wells 299-W10-26, 299-W14-13, and 299-W15-41. If, at a later date, the uncertainties about downhole flow meter measurements are positively resolved, flow meter measurements may be used to supplement or corroborate trend-surface analysis results.

3.5 Plume Extent

Regulations concerning RCRA assessment require both the horizontal and vertical extent of contaminant plumes be determined. Because the contaminant plume extends in both upgradient and downgradient directions from monitoring wells, it is important to determine the source as well as the downgradient extent of the plume. Groundwater monitoring wells, either existing or newly installed, are necessary to provide sampling data to establish the concentration of contaminants released from the WMA and the rate and extent of their migration. Five new wells were planned for calendar year 2000 to enhance the near field and mid field downgradient coverage (see Figure 3.1). As of October 2000, three of the planned calendar year 2000 wells were drilled. Additionally, nine wells are planned for calendar year 2001 to enhance the delineation of horizontal as well as vertical contaminant distribution (see Figure 3.2).

If contamination is detected at depth in downgradient wells, the results from monitoring wells installed at these locations will be evaluated to determine whether deep upgradient wells will be needed to differentiate possible upgradient sources of the deep contamination. The determination of sources within the WMA can be done only through the integration of groundwater sampling data with vadose characterization results within the WMA. Information on the depth distribution of contamination within the aquifer can be obtained through drilling new wells into the deeper portions of the aquifer or by discrete level sampling of older wells with long perforated intervals within the aquifer. In this study, both approaches will be used. In all of these determinations, it is important to use the overall pattern ("fingerprint") of contaminant concentrations, not simply the presence or absence of a particular contaminant to determine the impact of the contaminant plume in a particular well.

3.5.1 Plume Fingerprinting

Given the complexity of groundwater contamination patterns and the multiple potential sources for most contaminants observed in groundwater, individual contaminants are not reliable indicators of source. However, Johnson (1997), Johnson and Chou (1998), and Hodges (1998) have shown that ratios of chemical constituents and isotopes, coupled with process knowledge, may allow distinction of different groundwater contaminant source chemistries (see Section 2.3). In this context, "fingerprint" is defined as a set of chemical and isotopic parameters that are considered unique to a particular contaminant source. Given different reactor fuel burnup parameters, different processes used to extract plutonium from the fuel, and the treatment and mixing of the waste after reaching the tank farms, it is highly unlikely that any two contaminant sources would share exactly the same fingerprint (see Agnew 1997). Ratios to be used include sodium/calcium, tritium/technetium-99, and nitrate/technetium-99 (see Hodges 1998).

3.5.2 Horizontal Extent

Additional wells are proposed for calendar year 2001 to enhance the detection network and to assess areal extent of contamination at this WMA (see Figure 3.1).

To support the RCRA groundwater assessment objectives as well as the RFI/CMS and longer-term tank waste remediation objectives, compliance wells must be capable of

- detecting any new contamination from the WMA (either now or in the future during retrieval)
- documenting changes that occur as a result of any potential interim corrective measures that may result from the RFI/CMS process.

A monitoring well network design model (MEMO, Appendix C) was used as one tool for this purpose. A complicating factor is the uncertainty in flow direction due to changes that have occurred since 1997. Both water-table contour maps and judgment were used to assign flow directions for the MEMO model runs as documented in Appendix C. Based on the MEMO results and professional judgment, locations for new monitoring wells were selected that form the basis for the additional drilling as outlined in the sampling and analysis plan (see Appendix A, Figure A.2). Also, as new information is acquired (e.g., dispersivities), it might be necessary to re-evaluate the adequacy of the well spacing.

In addition, evaluation of the areal extent of the contamination requires some starting point information. For this purpose, judgment was used to identify locations for two new wells approximately 150 m (492 ft) east of the WMA eastern fenceline (Figure 3.1, wells 1 and 3). If field screening indicator results and routine sampling indicate that these wells intercept the same contaminant plume previously observed in the detection network wells, then a decision concerning the need for additional wells to further assess the areal extent of contamination will be made. This decision is tied to the risk assessment that will be performed for the Phase 1 RFI report due in 2004, as described in DOE/RL-99-36. The Phase 1 RFI report will integrate the results of specific WMA characterization activities and field investigation reports and establish the basis for a CMS. A Phase 1 CMS report, if necessary, will be prepared to assess and recommend appropriate corrective measures. The endpoint of the RCRA groundwater quality assessment is, therefore, linked to the RFI/CMS process currently underway.

3.5.3 Vertical Extent

Contaminant levels in well 299-W14-12 started a sharp decline in 1995, coincident with the rapid decline in the local water table resulting from the cessation of effluent discharge to ground in the 200 West Area. Hodges (1998) hypothesized that the decrease in contaminant levels is a result of a vertically stratified aquifer dropping past a fixed pump inlet as the water table declines.

With approximately 56 m (184 ft) of saturated, unconfined aquifer beneath WMA TX-TY, determination of the vertical distribution of contaminants is an important task, complicated by three-dimensional variation in degree of cementation and hydraulic properties within the aquifer. The distribution of contaminants with depth, in addition to indicating the volume of contaminated groundwater, may provide important constraints on the transport mechanisms that resulted in the observed contamination. The depth of penetration of contaminants into the aquifer depends on both the density of waste liquids reaching the water table and the rate at which they arrive (relative to groundwater flow rate). Denser liquids and rapid arrivals will tend to penetrate deeper into the aquifer, while low arrival rates may result in thin layers of contaminants at the top of the aquifer.

As previously indicated, one new monitoring well 299-W14-14 was drilled through the entire thickness of the unconfined aquifer with multiple groundwater samples taken during drilling. Samples were taken for chemical analysis at depths below the water table of approximately 15, 30, 40, 57, and 69 m (48, 99, 131, 187, and 225 ft). The last sample was below the Ringold lower mud unit that apparently forms the bottom of the unconfined aquifer in this portion of the Hanford Site.

Results from discrete depth sampling in well 299-W14-14, drilled as part of the ongoing assessment at this WMA, indicated that tank waste constituents (technetium-99 and nitrate) increased with depth to approximately 20 m (~65 ft) below the water table and then declined. Tritium was at a minimum at the ~20 m (~65 ft) depth and then increased to a maximum of about 40 m (~131 ft). This information indicates that deeper well completion depths are needed to quantify the higher concentrations that appear to occur in the 15 to 25 m (49 to 82 ft) depth range as compared to the existing shallow well completions (0 to 10 m [0 to 38 ft] below the water table) and at ~30 to 40 m (~98 to 131 ft) below the water table. Permanent multi-depth completions also allow for monitoring changes in contaminant concentrations at the selected depths over time.

Additional wells completed at greater depths are thus needed to characterize the maximum concentrations that may occur downgradient from this WMA. A deeper completion near well 299-W14-14 is needed to confirm the drill and test findings noted above. Well clusters (individual wells completed at different depths at the same location) are the most reliable installations for this purpose. Additionally, one cluster is needed at the south end to characterize possible contaminant movement in that direction (due to the shift in flow direction caused by the pump and treat). Another is needed along the east side of the TX farm fenceline to intercept suspected contaminant movement in that direction. If these initial well monitoring clusters show indications of concentrations at depth that are of concern based on the risk assessment results for the Phase I RFI/CMS report (DOE/RL-99-36), then upgradient well clusters may also be needed to determine if the higher concentrations at depth are coming from the WMA and not the upgradient trench sources that received SST overflow waste in the past. If the downgradient concentrations are judged to be of minimal exposure significance (by Ecology), then the upgradient cluster may not be necessary. On the other hand, if the new well installations indicate tank waste constituent concentrations (e.g., technetium-99, hexavalent chromium, and nitrate) that are of concern, then additional clusters and or locations may be required.

Vertical sampling within screened intervals to examine the depth variation in the upper aquifer will be carried out after a sufficient equilibration time has passed (2 to 3 months) to mitigate any hydraulic disturbance due to sampling or other testing. The vertical sampling, to be conducted using either a Kabis sampler or other suitable multilevel device, will include the collection of samples as near the top of the aquifer as possible as well as at selected depths. Special consideration will be given to sampling any zones of high hydraulic conductivity indicated by the tracer-dilution tests. Sampling at the top of the aquifer is given added importance by the detection of high tritium and iodine-129 in well 299-W14-2 and recent increases in these same contaminants in well 299-W14-12. If this represents leakage from the 242-T evaporator, it would be low-density waste that would tend to be limited in depth to near the water table.

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Appendix A

Sampling and Analysis Plan

Appendix A

Sampling and Analysis Plan

This appendix consists of a field sampling plan and a quality assurance project plan. The field sampling plan specifies the data collection activities and schedule. The quality assurance project plan includes procedures and project controls for the activities that implement acquisition of the information needs described in Chapter 3. Planned activities include the following tasks:

1. well drilling, hydraulic testing, and sampling
2. transport /spatial modeling and directional mapping
3. quarterly sampling and analysis
4. data evaluation and reporting
5. project planning and direction.

The tasks, schedules, and estimated cost to implement this continuing groundwater quality assessment are shown in Figure A.1. The data collection tasks shown in Figure A.1 are based on the rationale and discussion provided in Chapter 3. Additional background information can be found elsewhere in the main text. The dates shown in Figure A.1 are approximate times. Actual start and end dates may shift as detailed field work plans are prepared by the various subcontractors near the time the work is initiated. The need to coordinate with the Tank Farm Vadose Zone Project may also alter the schedule. This coordination will accommodate co-sampling opportunities and/or address other information needs that may be identified during the process to develop data quality objectives for the *Resource Conservation and Recovery Act* Facility Investigation/Corrective Measures Study (RFI/CMS) for Waste Management Area (WMA) TX-TY.

A.1 Field Sampling Plan

Locations of existing wells and the approximate locations of the wells to be drilled in calendar years 2000 are shown in Figure A.2. Locations of planned wells to be drilled in calendar year 2001 are shown in Figure A.3. The vadose zone portion of well 3 (see Figure A.2) will be cored for the Tank Farm Vadose Zone Project and will be drilled to 30.5 m (100 ft) below the water table, then back filled and completed with a 10.7 m (35 ft) screen. Details for the well drilling are included in a description of work that was submitted to Bechtel Hanford, Inc. by Pacific Northwest National Laboratory. All other groundwater sampling and analysis will be conducted in accordance with procedures described in the following section.

A.2 Quality Assurance Project Plan

The Hanford Groundwater Monitoring Project Quality Assurance Project Plan,[a] hereafter referred to as the GW-QAPP, and associated subcontractor procedures/manuals currently in place will cover the work activities required for conducting the WMA TX-TY groundwater quality investigation. Pacific Northwest National Laboratory administers the project for the Richland Operations Office of the U.S. Department of Energy, Environmental Restoration Branch.

A.2.1 Groundwater Sampling and Analysis Procedures

Sample Collection. Groundwater sampling procedures, sample collection documentation, sample preservation and shipment, and chain-of-custody requirements are described in subcontractor operating procedures/manuals and in the GW-QAPP. Quality requirements for sampling activities, including requirements for procedures, containers, transport, storage, chain of custody, and records requirements, are specified in a statement of work to the performing subcontractor (Waste Management Technical Services, Inc.). To ensure that samples of known quality are obtained, the subcontractor is required to use contractor-controlled procedures based on standard methods for groundwater sampling whenever possible. Pacific Northwest National Laboratory will review these procedures for technical quality and consistency. In addition, periodic assessments will be performed by Pacific Northwest National Laboratory to further ensure that procedures are followed to maintain sample quality and integrity. A brief description of the sampling requirements follows.

Samples are generally collected after three casing volumes are withdrawn or after field parameters (pH, temperature, specific conductance, and turbidity) have stabilized. Field parameters are measured in a flow-through chamber. Generally, turbidities should be equal to or below 5 NTU (nephelometric turbidity units, 1 NTU = 1 mg/L of solids) before sample collection. The project scientist, depending on site-specific conditions and sampling objectives, however, could override this general requirement. For example, collection of water during drilling necessarily involves turbid, unfiltered water, which will be processed further in the laboratory. Thus, the 5 NTU requirement will be waived for these special water samples.

For routine groundwater samples, preservatives are added to the collection bottles in the laboratory before their use in the field. Duplicates, trip blanks, and field equipment blanks are collected as part of the general quality control program. The sampling and analysis methods and procedures and associated quality control results are described in more detail by Hartman et al. (2000).

Analytical Procedures. Procedures for field measurements (pH, specific conductance, temperature, and turbidity) are specified in the manufacturer's manual for each instrument used. The laboratory approved for the groundwater monitoring program will operate under the requirements of current laboratory contracts and will use standard laboratory procedures as listed in *Test Methods for Evaluating Solid*

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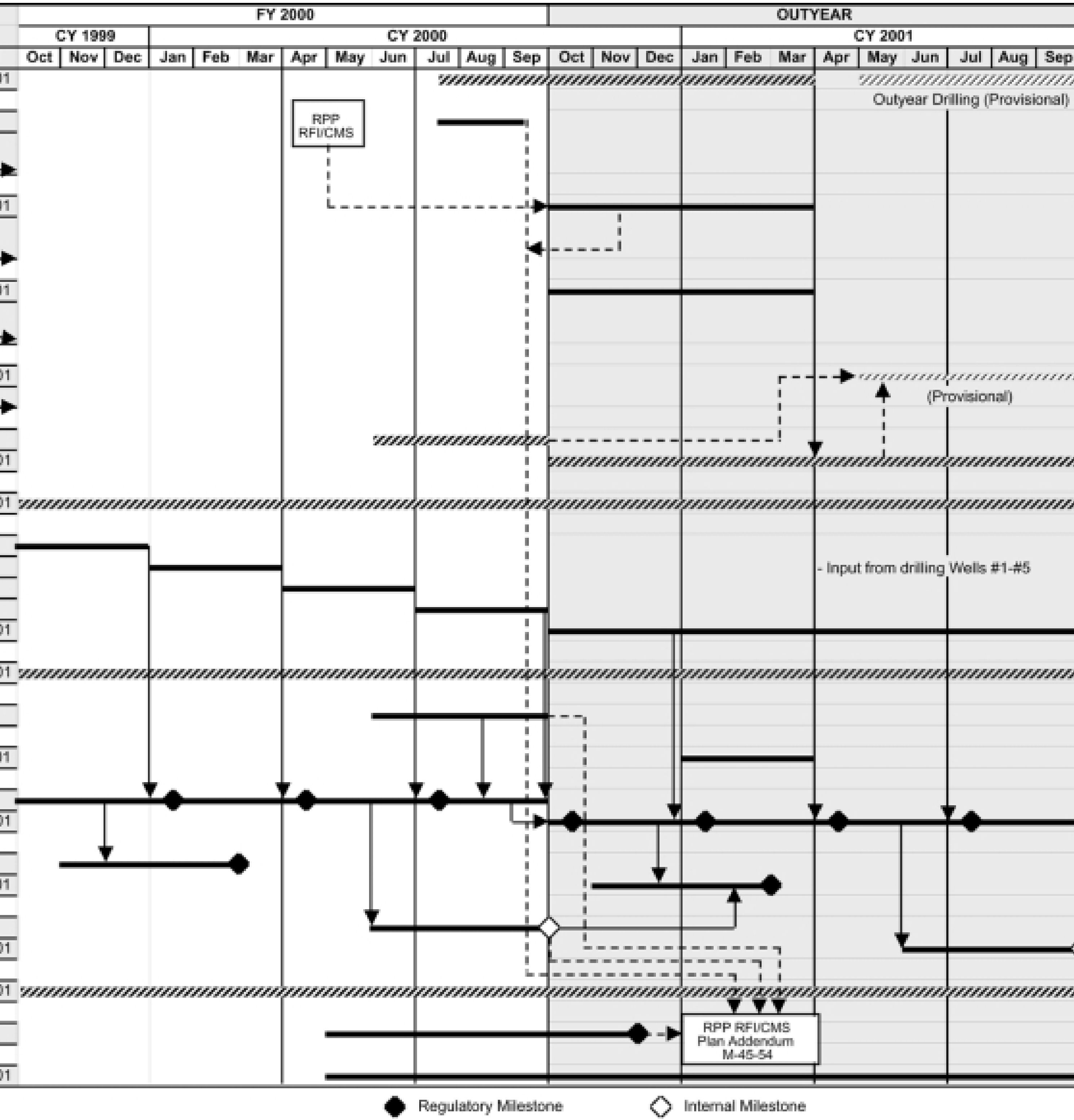
[a] The project quality assurance plan (ETD-012, Rev 0.) is available from Pacific Northwest National Laboratory, Richland, Washington.

Hanford Groundwater Monitoring Project #28203		FY 2000		OUTYEAR	
TASK NO.	WMA TX-TY TASK TITLE	START	FINISH	START	FINISH
T-1	**Well Drilling, Testing, and Sampling (see Figure A.2 for CY2000 wells)**	15-Jul-00	→	→	31-Mar-01
	Drill Downgradient Well #2	15-Jul-00	15-Sep-00		
	Sampling During Drilling				
	Hydraulic Tests (specific well(s) to be determined)				
	Drill Mid-Field Wells #3 and #1	01-Oct-00	→	→	31-Mar-01
	Sampling During Drilling				
	Hydraulic Tests (specific well(s) to be determined)				
	Drill Replacement Well #4 and Downgradient Well #5			01-Oct-00	31-Mar-01
	Sampling During Drilling				
	Hydraulic Tests (specific well(s) to be determined)				
	Drill Additional Outyear Wells (see Figure A.3 for CY2001 wells)			01-May-01	30-Sep-01
	Near-Field New and/or Replacement Wells (plume definition)				
T-2	**Transport/Spatial Modeling (e.g. MEMO) and Trend-Surface Analysis (FY00)**	01-Jun-00	30-Sep-00		
	Transport/Spatial Modeling (e.g. MEMO) and Trend-Surface Analysis (Outyear)			01-Oct-00	30-Sep-01
T-3	**Quarterly Groundwater Sampling and Analysis**	01-Oct-99	→	→	30-Sep-01
	1st Quarter Sampling and Analysis	01-Oct-99	31-Dec-99		
	2nd Quarter Sampling and Analysis	01-Jan-00	31-Mar-00		
	3rd Quarter Sampling and Analysis	01-Apr-00	30-Jun-00		
	4th Quarter Sampling and Analysis	01-Jul-00	30-Sep-00		
	Outyear Quarterly Sampling and Analysis			01-Oct-00	30-Sep-01
T-4	**Data Evaluation and Reporting**	01-Oct-99	→	→	30-Sep-01
	Plume Fingerprinting	01-Jun-00	30-Sep-00		
	Borehole Completion Data Package Report for Wells #1, #2, #3, #4, #5			01-Jan-01	31-Mar-01
	Quarterly Status Report to DOE/Ecology (FY00)	01-Oct-99	30-Sep-00		
	Quarterly Status Report to DOE/Ecology (Outyear)			01-Oct-00	30-Sep-01
	FY 1999 Annual Report	01-Nov-99	29-Feb-00		
	FY 2000 Annual Report			01-Nov-00	28-Feb-01
	Assessment Results Documentation (FY00)	01-Jun-00	30-Sep-00		
	Assessment Results Documentation (Outyear)			01-Jun-01	30-Sep-01
T-5	**Project Planning and Direction**	01-Oct-99	→	→	30-Sep-01
	Assessment Plan	01-May-00	30-Nov-00		
	Coordination of Groundwater/Vadose Zone Activities	01-May-00	→	→	30-Sep-01



2000/DCL/TX-TY/012

Figure A.1. Tasks and Schedule for Continuing Groundwater Assessment at Waste Management Area TX-TY

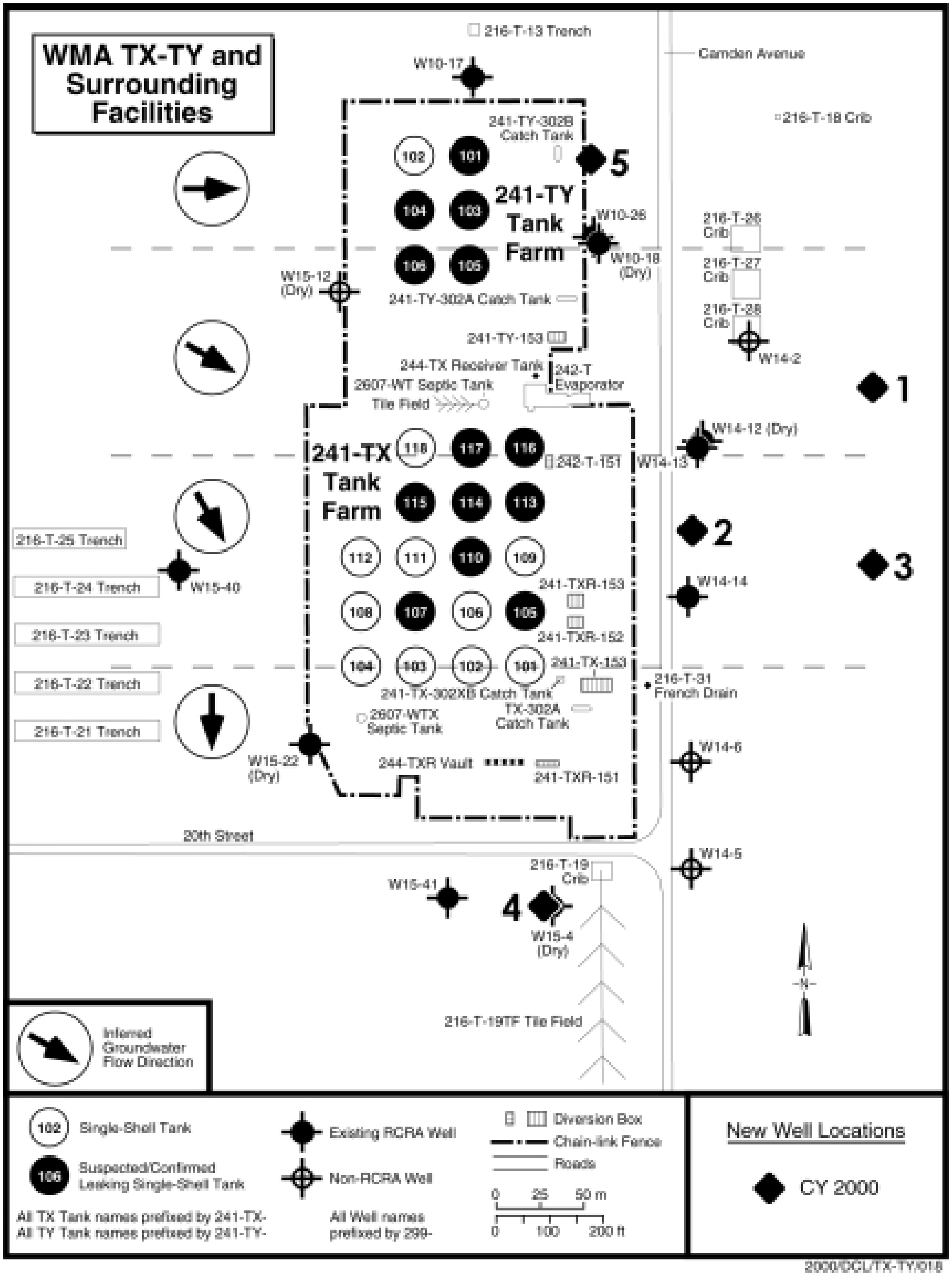


Figure A.2. Locations of Wells in Assessment Networks

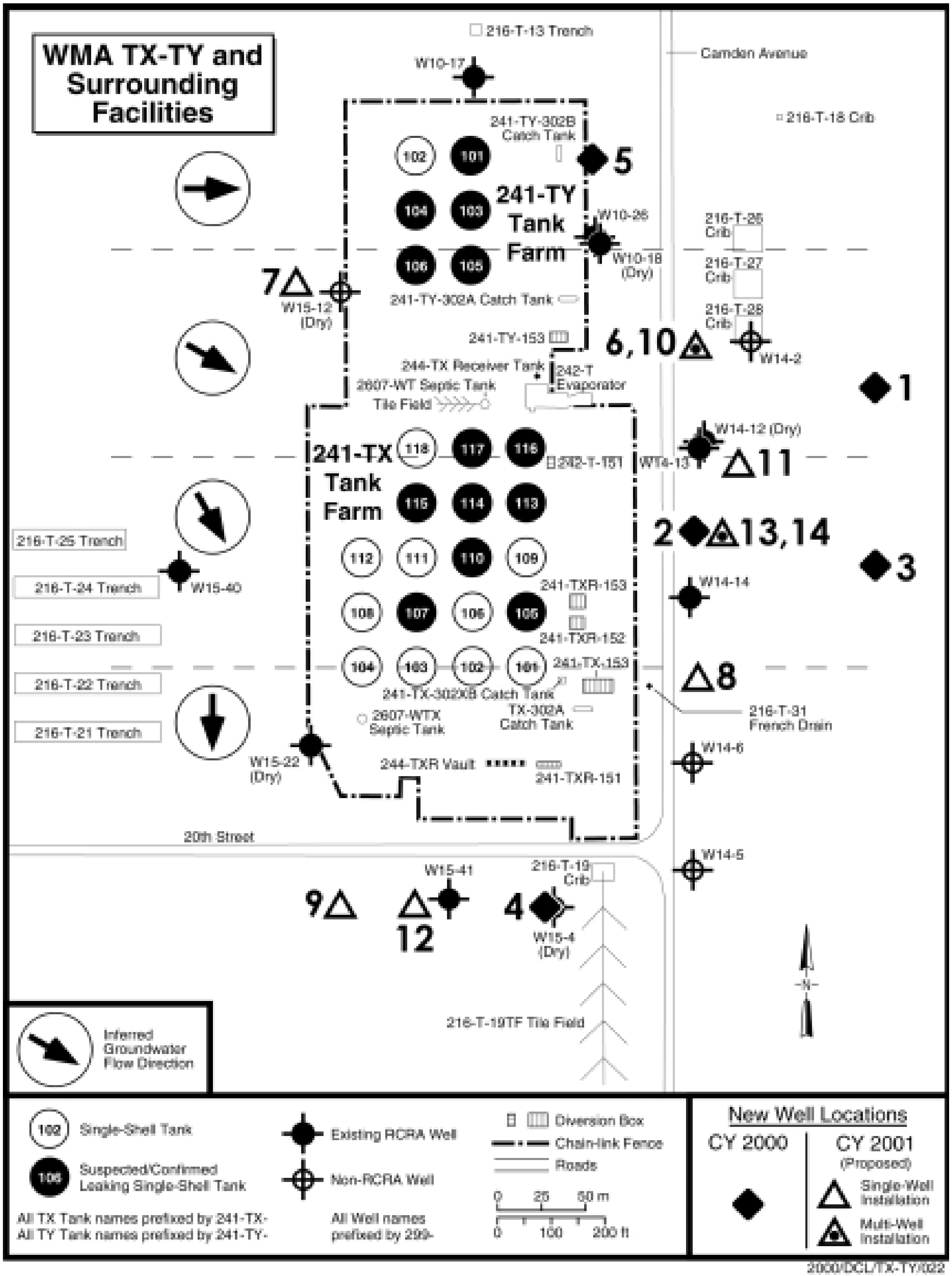


Figure A.3. Calendar Year 2001 Well Locations

Waste Physical/Chemical Methods, SW-846, (EPA 1986) or an alternate equivalent. Alternative procedures, when used, will meet the guidelines of SW-846, Chapter 10. Analytical methods and quality control for the RCRA groundwater monitoring activities are described in the GW-QAPP.

Data Storage and Retrieval. All contract analytical laboratory results are submitted by the laboratory in electronic form and loaded in the Hanford Environmental Information System (HEIS) database. Parameters measured in the field either are entered into HEIS manually or through electronic transfer. Data from the HEIS database may be downloaded to smaller databases, for data validation, data reduction, and trend analysis. All field and laboratory hydrochemical results for this assessment will be entered in the publicly accessible HEIS database. Hard copy data reports and field records are considered to be the record copy of the data and are stored at Pacific Northwest National Laboratory.

A.2.2 Hydrologic Testing

Hydraulic conductivity will be determined using slug test and tracer test procedures as specified in "Aquifer Testing" in PNL-MA-567 (PNNL 1989), or the most recent revision(s) or equivalent of this document. If procedures do not exist for particular tests, field instructions will be prepared before testing. Field data and other related information would be maintained in physical files at Pacific Northwest National Laboratory Groundwater Project Record files in the Sigma V Building. Hydraulic test results will be documented in a Pacific Northwest National Laboratory topical report and summarized in the assessment report for WMA TX-TY.

A.2.3 Borehole Drilling and Testing

Bechtel Hanford Inc. manages borehole drilling and well installation under their safety and related job control procedures. Data needs and objectives from this assessment plan are used as input to Bechtel Hanford Inc. to write the detailed specifications for the drilling contracts. The drilling and sampling activities and requirements associated with installation of a new monitoring well that is compliant with the *Resource Conservation and Recovery Act* (RCRA) to assess groundwater are specified in a Description of Work submitted to Bechtel Hanford Inc. by Pacific Northwest National Laboratory. This document specifies the drilling and sampling requirements to meet the *Resource Conservation and Recovery Act* groundwater assessment project needs for WMA TX-TY, as identified in this plan. Additional requirements for special co-sampling during drilling (e.g., coring) are submitted to Bechtel Hanford Inc. by the requesting sponsor or project.

A.3 References

Hartman, M. J., L. F. Morasch, and W. D. Webber (eds.). 2000. *Hanford Site Groundwater Monitoring for Fiscal Year 1999*. PNNL-13116, Pacific Northwest National Laboratory, Richland, Washington.

Pacific Northwest National Laboratory. 1989. *Procedures for Ground-Water Investigations*. PNL-MA-567, Pacific Northwest National Laboratory, Richland, Washington.

Resource Conservation and Recovery Act of 1976. 42 USC 6901 et seq., as amended.

U.S. Environmental Protection Agency. 1986. *Test Methods for Evaluating Solid Waste Physical/ Chemical Methods, 3rd ed.* EPA SW-846, U.S. Environmental Protection Agency, Washington, D.C.

Appendix B

Well Construction Data

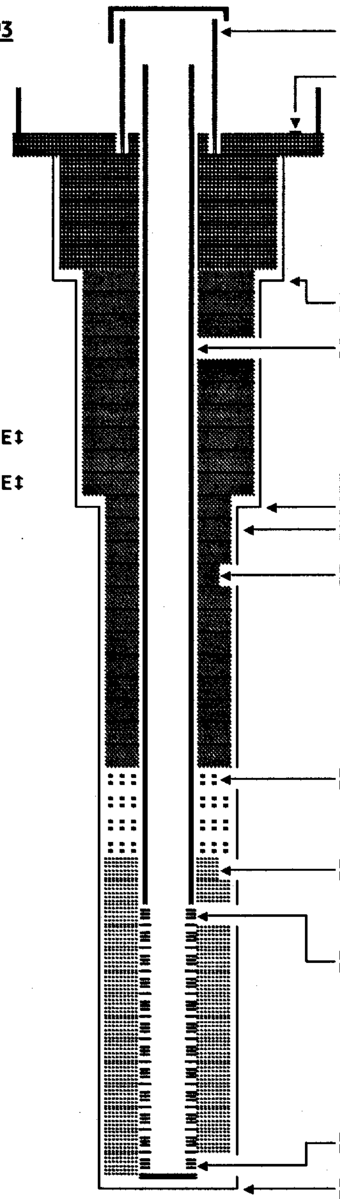
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Drive barrel Hard tool	WELL NUMBER: 299-W10-17 — TEMPORARY WELL NO: None
Drilling Fluid Used: 200 W Water Supply	Additives Used: None	Hanford Coordinates: N/S N 42,751 — E/W W 75,844
Driller's Name: D. Ludtke	WA State Lic Nr: Not documented	State NAD83 Coordinates: N 136,491.46m E 566,775.74m; N 447,858 E 2,219,371
Drilling Company: Kaiser Engineers	Company Location: Hanford	Start Card #: Not documented T___ R___ S___
Date Started: 28Nov90	Date Complete: 17Jan91	Elevation Ground surface (ft): 667.91 Brass cap

Depth to water: 202.6-ft Dec90
(Ground surface) 205.3-ft 26Mar93

GENERALIZED STRATIGRAPHY
Geologist's Log
Sl=slightly

0↔5: (Backfill) Gravelly SAND
5↔10: Silty SAND
10↔15: Sandy GRAVEL
15↔20: Silty sandy GRAVEL
20↔35: GRAVEL
35↔42.5: Sandy GRAVEL
42.5↔43: SILT lens
43↔64: SAND
64↔67: Gravelly SAND
67↔90: SAND
90↔95: Sl silty SAND
95↔105: Silty SAND
‡Some interbedded CALICHE‡
105↔110: Gravelly silty SAND
‡Some interbedded CALICHE‡
110↔115: Sl silty SAND
115↔120: Sandy SILT
120↔125: SAND
125↔128: Sandy SILT
128↔130: Gravelly SAND
130↔135: GRAVEL
135↔210: Silty sandy GRAVEL
210↔215: Sl silty gravelly SAND
215↔222.9: SAND



Elevation of reference point: (top of casing) [670.84-ft]
Height of reference point above ground surface [2.93-ft]
Depth of surface seal [0↔20-ft]
Type of surface seal: Pre-mix concrete
4x4-ft x 6-in surface pad to 2.9-ft
4 equidistant protective posts
Cement grout, 2.9↔20.0-ft
13-in nominal hole to 20.7-ft
I.D. of riser pipe: [4-in]
Type of riser pipe: Stainless steel
Diameter of borehole,
20.7↔129.7-ft, 11-in nominal
129.7↔222.9-ft, 9-in nominal
Type of filler, 20.0↔193.0-ft
8↔20 mesh bentonite crumbles
Depth top of seal: [193.0-ft]
Type of seal: Bentonite pellets
Depth top of sand pack: [197.4-ft]
8↔12-mesh silica sand
Depth top of screen: [201.4-ft]
4-in, #10-slot, stainless steel with channel pack
Depth bottom of screen [222.7-ft]
Depth to bottom of borehole: [222.9-ft]

Drawing By: RKL/2W10-17.ASB Date: 16Apr93

Reference: WHC-SD-EN-DP-041

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W10-17

WELL DESIGNATION	:	299-W10-17
CERCLA UNIT	:	200 Aggregate Area Management Study
RCRA FACILITY	:	Single Shell Tanks
HANFORD COORDINATES	:	N 42,751 W 75,844 [200W-01Apr91]
LAMBERT COORDINATES	:	N 447,858 E 2,219,371 [HANCONV] N 136,491.46m E 566,775.74m [NAD83-01Apr91]
DATE DRILLED	:	Jan91
DEPTH DRILLED (GS)	:	222.9-ft
MEASURED DEPTH (GS)	:	Not documented
DEPTH TO WATER (GS)	:	202.6-ft, 13Dec90; 205.3-ft, 26Mar93
CASING DIAMETER	:	4-in stainless steel, +1.0↔201.4-ft; 6-in stainless steel, +2.93↔~0.5-ft
ELEV TOP CASING	:	670.84-ft, [NGVD'29-01Apr91]
ELEV GROUND SURFACE	:	667.91-ft, Brass cap [NGVD'29-01Apr91]
PERFORATED INTERVAL	:	Not applicable
SCREENED INTERVAL	:	201.4↔222.7-ft, 4-in #10-slot stainless steel, with channel pack
COMMENTS	:	FIELD INSPECTION, 20Jan92 6-in stainless steel casing. 4-ft by 4-ft concrete pad, 4 posts, 1 removable capped and locked, brass cap in pad with well ID. Not in radiation zone. OTHER:
AVAILABLE LOGS	:	Geologist, driller
TV SCAN COMMENTS	:	Not applicable
DATE EVALUATED	:	Not applicable
EVAL RECOMMENDATION	:	Not applicable
LISTED USE	:	SST monthly water level measurements, 01Jul91↔26Mar93;
PUMP TYPE	:	Hydrostar
MAINTENANCE	:	

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: 200 W Water Supply
Driller's Name: G. Lydin/W. Peters
Drilling Company: Kaiser Engineers
Date Started: 01Nov90

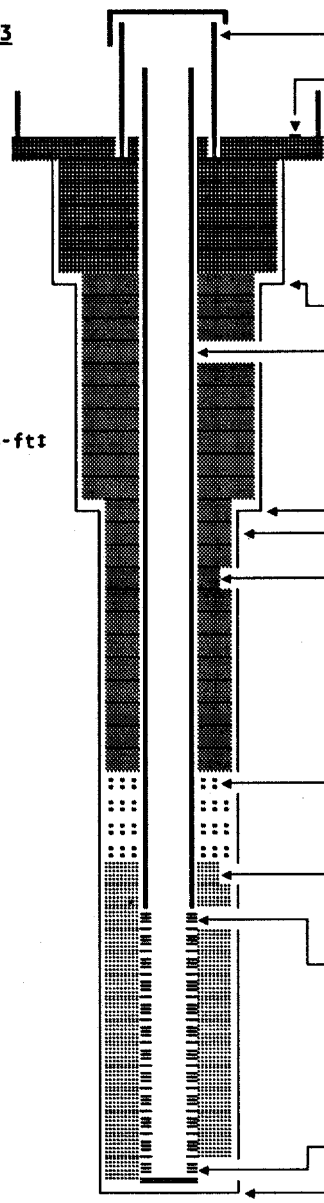
Sample Method: Drive barrel Hard tool
Additives Used: None
WA State Lic Nr: Not documented
Company Location: Hanford
Date Complete: 12Dec90

WELL NUMBER: 299-W10-18
TEMPORARY WELL NO: None
Hanford Coordinates: N/S N 42,439 E/W W 75,610
State NAD83 N 136,396.52m E 566,847.18m
Coordinates: N 447,547 E 2,219,606
Start Card #: Not documented T____ R____ S______
Elevation Ground surface (ft): 668.08 Brass cap

Depth to water: 202.2-ft Dec90
(Ground surface) 204.8-ft 26Mar93

GENERALIZED STRATIGRAPHY
Geologist's Log
Sl=slightly

0↔5: (Backfill)
5↔25: Silty sandy GRAVEL
25↔40: Sandy GRAVEL
40↔43: Silty sandy GRAVEL
(BOULDER @ 42-ft)
43↔55: Sl gravelly SAND
55↔65: SAND
65↔80: Gravelly SAND
80↔90: Sl gravelly SAND
90↔91: SAND
91↔97: Sl silty SAND
97↔105: Silty sandy GRAVEL
‡CALICHE, 97,101,111↔113-ft‡
105↔115: Gravelly silty SAND
115↔120: Gravelly SAND
120↔125: Gravelly silty SAND
125↔129: Silty SAND
129↔160: Silty sandy GRAVEL
160↔165: SAND
165↔175: Silty sandy GRAVEL
175↔190: Sandy GRAVEL
190↔200: Muddy sandy GRAVEL
200↔221.6: Silty sandy GRAVEL



Elevation of reference point: (top of casing) [670.93-ft]
Height of reference point above ground surface [2.85-ft]
Depth of surface seal [0↔18.6-ft]
Type of surface seal: Pre-mix concrete
4x4-ft x 6-in surface pad to 2.0-ft
4 equidistant protective posts
Cement grout, 2.0↔18.6-ft
13-in nominal hole to 20.2-ft
I.D. of riser pipe: [4-in]
Type of riser pipe: Stainless steel
Diameter of borehole,
20.2↔146.9-ft, 11-in nominal
146.9↔222.6-ft, 9-in nominal
Type of filler, 20.0↔193.5-ft
8↔20 mesh bentonite crumbles
Depth top of seal: [193.5-ft]
Type of seal: Bentonite pellets
Depth top of sand pack: [197.3-ft]
8↔12-mesh silica sand
Depth top of screen: [199.8-ft]
4-in, #10-slot, stainless steel with channel pack
Depth bottom of screen [221.1-ft]
Depth to bottom of borehole: [222.6-ft]

Drawing By: RKL/2W10-18.ASB Date: 16Apr93
Reference: WHC-SD-EN-DP-041

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W10-18

WELL DESIGNATION :	299-W10-18
CERCLA UNIT :	200 Aggregate Area Management Study
RCRA FACILITY :	Single Shell Tanks
HANFORD COORDINATES :	N 42,439 W 75,610 [200W-01Apr91]
LAMBERT COORDINATES :	N 447,547 E 2,219,606 [HANCONV]
:	N 136,396.52m E 566,847.18m [NAD83-01Apr91]
DATE DRILLED :	Dec90
DEPTH DRILLED (GS) :	222.6-ft
MEASURED DEPTH (GS) :	Not documented
DEPTH TO WATER (GS) :	202.2-ft, 12Dec90; 204.8-ft, 26Mar93
CASING DIAMETER :	4-in stainless steel, ˜+1.0↔199.8-ft; 6-in stainless steel, +2.9↔˜0.5-ft
ELEV TOP CASING :	670.93-ft, [NGVD'29-01Apr91]
ELEV GROUND SURFACE :	668.08-ft, Brass cap [NGVD'29-01Apr91]
PERFORATED INTERVAL :	Not applicable
SCREENED INTERVAL :	199.8↔221.1-ft, 4-in #10-slot stainless steel, with channel pack
COMMENTS :	FIELD INSPECTION, 20Jan92 6-in stainless steel casing. 4-ft by 4-ft concrete pad, 4 posts, 1 removable capped and locked, brass cap in pad with well ID. Not in radiation zone. OTHER:
AVAILABLE LOGS :	Geologist, driller
TV SCAN COMMENTS :	Not applicable
DATE EVALUATED :	Not applicable
EVAL RECOMMENDATION :	Not applicable
LISTED USE :	SST Monthly water level measurement, 01Jun91↔26Mar93,
PUMP TYPE :	Hydrostar
MAINTENANCE :	

0502371

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Air Rotary - TUBEX	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W10-28 B8548 TEMPORARY WELL NO: Not Allowed
Drilling Fluid Used:	Reverse Air	Additives Used:	None	Coordinates: N	Not documented
Driller's Name:	Willie Franklin	WA State Lic Nr:	Not Available	Coordinates: E	Not documented
Drilling Company:	Layne Christensen	Company Location:	Salt Lake City, Ut	Start Card #:	Not Available
Date Started:	20Aug98	Date Completed:	25Aug98	Elevation Ground Surface:	Brass Marker

Depth to Water: **216.8 ft 25Aug98**
(Ground surface)

GENERALIZED STRATIGRAPHY **Geologist's Log & Geophysical Logs**

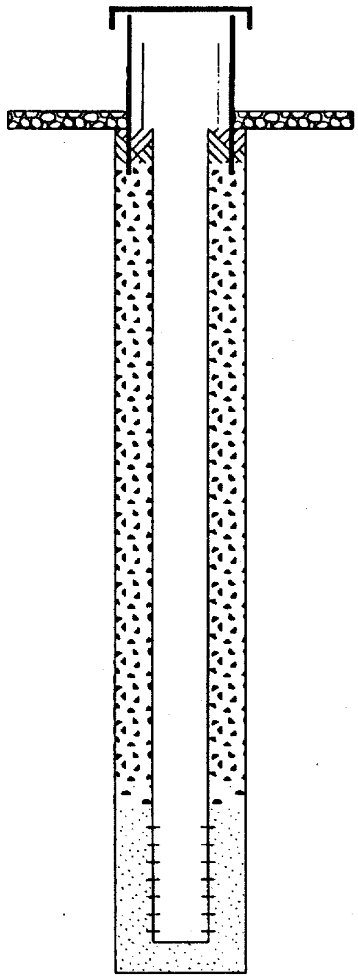
Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: **10.5 ft.**

Type of Surface Seal: **4x4 Concrete Pad**

0 - 4 ft : Backfill
4 - 9 ft : Sand
9 - 22 ft : Gravel
22 - 42.5 ft : Sandy gravel
42.5 - 64 ft : Sand
64 - 89 ft : Gravelly sand
89 - 102 ft : Silty sand - calcareous (97-100: Caliche)
102 - 108 ft : Sand (108-110: caliche)
108 - 114 ft : Silty sand
114 - 116 ft : Sand
116 - 124 ft : Silty sand
124 - 127 ft : Sand
127 - 159 ft : Silty sandy gravel (152-156: large cobbles)
159 - 161 ft : Gravelly sand
161 - 205 ft : Sandy gravel
205 - 262 ft : Silty sandy gravel



Fill	*Casing*	*Screen*
0 - 10.5 ft : 9.125-inch hole Cement Seal		
10.5 - 204.5 ft : 9.125-inch hole Bentonite Chips		
204.5 - 211 ft : 9.125-inch hole Bentonite Pellets 211 - 217.04 ft : 9.125-inch hole 20-40 Silica Sand 217.04 - 252.13 ft : 9.125-inch hole 20-40 Silica Sand 252.13 - 262 ft : 9.125-inch hole 20-40 Silica Sand	217.04 - 0 ft : 4 inch 4" SS Sch. 5 Csg. 252.13 - 252.45 ft : 4 inch 4" SS End Cap	217.04 - 252.13 ft : 4 inch 4" Wire Wrap SS .010 Slot Screen

262 ft : Borehole drilled depth

0 - 262 ft : 9.125-in. 8-5/8" Temp. carbon steel csg.

Drawing By: **TGB**
Reference: **Hanford Wells**
Revision: **0**
Revision Date: **21Sep98**
Print Date: **28Dec98**

Report Form: WELLS Project File: WELLS.GPJ

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W10-26

WELL DESIGNATION	:	299-W10-26
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	262.0 ft
MEASURED DEPTH (GS)	:	
AVAILABLE LOGS	:	Data not available
DATE EVALUATED	:	Data not available
EVAL RECOMMENDATION	:	Data not available
LISTED USE	:	Data not available
CURRENT USER	:	RCRA & Operations
PUMP TYPE	:	Data not available
MAINTENANCE	:	Data not available
COMMENTS	:	8-5/8" TUBEX Sys. 4-1/2" Reverse Cir. Drl. Pipe with interchange
TV SCAN COMMENTS	:	

Report Form: WELLS Project File: WELLS.GPJ

Drawing By:	TGB
Reference:	Hanford Wells
Revision:	0
Revision Date:	21Sep98
Print Date:	28Dec98

BECHTEL

WELL CONSTRUCTION AND COMPLETION SUMMARY

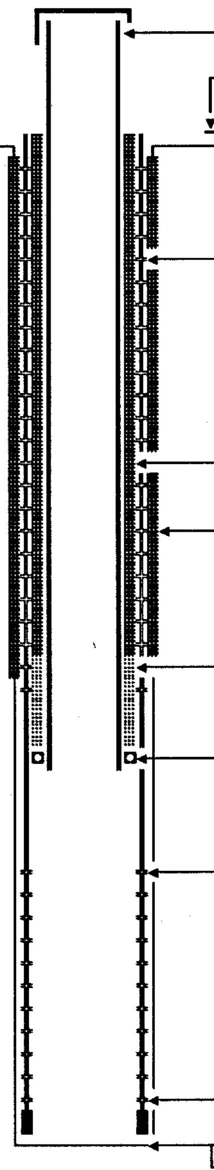
Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 299-W14-2 TEMPORARY WELL NO: 216-TY-3 241-TY-5
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford Coordinates: N/S N 42,255.3 E/W W 75,330.1
Driller's Name: Row/Richards	WA State Lic Nr: Not documented	State NAD83 N 136,340.70m E 566,932.61m Coordinates: N 447,364 E 2,219,887
Drilling Company: Not documented	Company Location: Not documented	Start Card #: Not documented T___ R___ S___
Date Started: 26Apr55	Date Complete: 11May55	Elevation Ground surface (ft): 666.4 Estimated

Depth to water: 195-ft May55
(Ground surface) ~200-ft Nov88

GENERALIZED STRATIGRAPHY   Driller's Log

0↔20: BACKFILL
20↔35: GRAVEL and SAND
35↔40: SAND, GRAVEL, SILT
40↔75: SAND, SILT
75↔80: SAND, very little SILT
80↔90: SAND-SILT
90↔105: Heavy SILT, CALICHE
105↔122: SILT, CALICHE, fine SAND fine GRAVEL
122↔145: GRAVEL and SAND
145↔155: Pure GRAVEL
155↔160: GRAVEL, BASALT, SAND
160↔175: GRAVEL, black SAND
175↔220: SAND, GRAVEL, SILT
220↔223: GRAVEL, SILT, SAND

REMEDIATION:
Jan↔Feb83, by Garcia and Evans
Perforated 8-in casing and
ran 6-in liner. Grouted annulus.



Elevation of reference point: (top of casing) [671.54-ft]

Height of reference point above ground surface [ND]

Depth of surface seal [20-ft]

Type of surface seal: Partial, grout between 6 and 8-in casing

8-in casing perforated 0↔150-ft, 2 cuts/rd/ft

Type of riser pipes: Carbon steel

Type of filler: 218-gals cement grout

Diameter of borehole: [9-in nom]

10-gals sand

6-in casing to 158.0-ft set on packer

Depth top of perforations: [181-ft]
Description of perforations: 181↔222-ft, 4 holes/ft

Depth bottom of perforations: [222-ft]

Depth bottom 8-in casing: [222.6-ft]

Depth bottom of borehole: [223-ft]

Drawing By: RKL/2W14-02.ASB   Date: 27Apr93

Reference: HANFORD WELLS

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W14-2

WELL DESIGNATION	:	299-W14-2
CERCLA UNIT	:	200 Aggregate Area Management Study
RCRA FACILITY	:	Not applicable
HANFORD COORDINATES	:	N 42,255.3 W 75,330.1 [200W-22Feb90]
LAMBERT COORDINATES	:	N 447,364 E 2,219,887 [HANCONV] N 136,340.70m E 566,932.61m [NAD83-22Feb90]
DATE DRILLED	:	May55
DEPTH DRILLED (GS)	:	223-ft
MEASURED DEPTH (GS)	:	Not documented
DEPTH TO WATER (GS)	:	195-ft, Jan56; ~200-ft, Nov88
CASING DIAMETER	:	8-in carbon steel, ~0↔222.6-ft; 6-in carbon steel, +5.1↔158.0-ft
ELEV TOP CASING	:	671.54-ft, [200W-22Feb90]
ELEV GROUND SURFACE	:	666.4-ft, Estimated
PERFORATED INTERVAL	:	8-in casing, 0↔150, and 181↔222-ft
SCREENED INTERVAL	:	Not applicable
COMMENTS	:	FIELD INSPECTION, 09Feb90, 6-in carbon steel casing. No pad, no posts, capped and locked. No permanent identification. In undergound radiation zone. OTHER:
AVAILABLE LOGS	:	Driller
TV SCAN COMMENTS	:	Not applicable
DATE EVALUATED	:	Not applicable
EVAL RECOMMENDATION	:	Not applicable
LISTED USE	:	Water levels measured, 18Aug55↔10Nov88; PNL Annual, Semiannual, WHC Semiannual water sample schedule
PUMP TYPE	:	Electric submersible
MAINTENANCE	:	Casing apparently extended. Not documented.

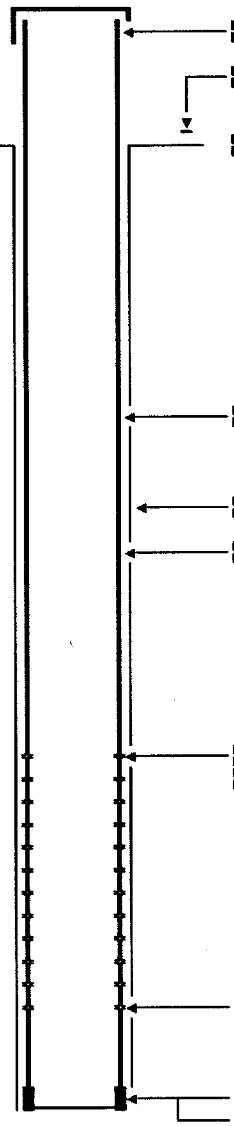
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 299-W14-5
Drilling Fluid Used: Water	Additives Used: Not documented	TEMPORARY WELL NO:
Driller's Name: Evans	WA State Lic Nr: Not documented	Hanford Coordinates: N/S N 41,269 E/W W 75,441
Drilling Company: Not documented	Company Location: Not documented	State NAD83 Coordinates: N 136,040.12m E 566,899.55m
Date Started: 18Sep74	Date Complete: 18Oct74	N 446,268 E 2,219,780
		Start Card #: Not documented T___ R___ S___
		Elevation Ground surface (ft): 663.9 Estimated

Depth to water: 205-ft Oct74
(Ground surface) 192.6-ft Mar90TV

GENERALIZED STRATIGRAPHY — Driller's Log

0↔10: SAND
10↔29: PEBBLES, COBBLES & SAND
29↔90: SAND & SILT
90↔99: SILT
99↔110: CALICHE
110↔120: CALICHE & SAND
120↔135: COBBLES, PEBBLES & SAND
135↔240: COBBLES, PEBBLES, SAND & SILT



Elevation of reference point: (top of casing) [666.56-ft]
Height of reference point above ground surface [2.7-ft]
Depth of surface seal [ND]
Type of surface seal: None documented
I.D. of surface casing (If present) [ND]
I.D. of riser pipe: [6-in]
Type of riser pipe: Carbon steel
Diameter of borehole: [7-in nom]
Type of filler: Not documented
Depth top of perforations: [190-ft]
Description of perforations: 4 cuts/rd/ft
Depth bottom of perforations: [225-ft]
Depth bottom of casing: [240-ft]
Depth bottom of borehole: [240-ft]

Drawing By: RKL/2W14-05.ASB Date: 16Apr93

Reference: HANFORD WELLS

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W14-5

WELL DESIGNATION	:	299-W14-5
CERCLA UNIT	:	200 Aggregate Area Management Study
RCRA FACILITY	:	Not applicable
HANFORD COORDINATES	:	N 41,269 W 75,441 [200W-06May91]
LAMBERT COORDINATES	:	N 446,377 E 2,219,778 [HANCONV] N 136,040.12m E 566,899.55m [NAD83-06May91]
DATE DRILLED	:	Oct74
DEPTH DRILLED (GS)	:	240-ft
MEASURED DEPTH (GS)	:	Not documented
DEPTH TO WATER (GS)	:	205-ft, Oct74; 192.6-ft, Mar90 TV
CASING DIAMETER	:	6-in carbon steel, +2.7↔240-ft;
ELEV TOP CASING	:	666.59-ft, [NGVD'29-06May91]
ELEV GROUND SURFACE	:	663.9-ft, Estimated
PERFORATED INTERVAL	:	6-in casing, 190↔225-ft
SCREENED INTERVAL	:	Not applicable
COMMENTS	:	FIELD INSPECTION, 12Feb90, 6-in carbon steel casing. No pad, no posts, capped, not locked. No permanent identification. Not in radiation zone. OTHER:
AVAILABLE LOGS	:	Driller
TV SCAN COMMENTS	:	Not applicable
DATE EVALUATED	:	Not applicable
EVAL RECOMMENDATION	:	Not applicable
LISTED USE	:	Two water level measurements, 23Aug88 & 10Nov88; PNL Annual, Semiannual, WHC Semiannual water sample schedule
PUMP TYPE	:	Electric submersible
MAINTENANCE	:	Casing may have been extended. Not documented.

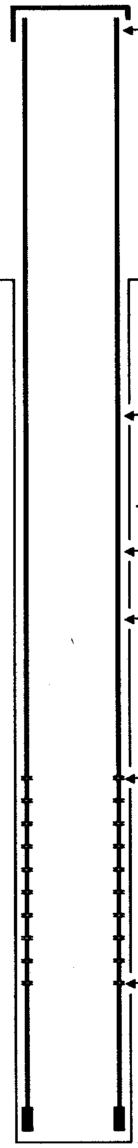
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Drive barrel Hard tool	WELL NUMBER: 299-W14-6 TEMPORARY WELL NO:
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford Coordinates: N/S N 41,469 E/W W 75,441
Driller's Name: Hatch/Evans	WA State Lic Nr: Not documented	State NAD83 Coordinates: N 136,101.04m E 566,899.44m; N 446,577 E 2,219,778
Drilling Company: Hatch Drilling Co	Company Location: Pasco, WA	Start Card #: Not documented T R S
Date Started: 13Dec73	Date Complete: 03Dec74	Elevation Ground surface (ft): 664.9 Estimated

Depth to water: 205-ft Nov74
(Ground surface) 196.0-ft Jan92

GENERALIZED STRATIGRAPHY   Driller's Log

5,10: Br SAND, moist
12: Br SAND GRAVELS
15,20,25: COBBLES, SAND & GRAVEL
 Drilling stopped, 29-ft 18Dec73
 Drilling restarted, 29-ft 21Oct74
29↔35: 30%c↔fSAND, 10%mPEB, 20%SILT
35↔40: 90%c↔fSAND, 10%SILT
40↔47: 80%c↔fSAND, 20%SILT
47↔49: 100% SILT
49↔88: 80%c↔fSAND, 20%SILT
88↔93: 70%c↔vfSAND, 30%SILT
93↔95: 93%SILT, 7%fSAND
95↔103: 100%SILT
103↔113: 98%CALICHE, 2%fSAND
113↔116: 85%CALICHE, 15%SAND
116↔121: 30%COB, 50%s↔mPEB, 10%SILT
121↔137: 60%COB↔mPEB, 20%mSAND, 20% SILT
137↔146: 80%COB↔sPEB, 10%SAND, 10%SILT
146↔152: 75%COB↔sPEB, 15%mSAND, 10%SILT
152↔158: 60%COB↔sPEB, 25%mSAND, 15%SILT
158↔210: 70%COB↔sPEB, 20%SAND, 10%SILT
210↔240: 60%COB↔sPEB, 20%SAND, 20%SILT



Elevation of reference point: (top of casing) [664.49-ft]
Height of reference point above ground surface [1.6-ft]
Depth of surface seal [ND]
Type of surface seal: None documented
I.D. of surface casing (Assumed pulled) [10-in]
I.D. of riser pipe: [6-in]
Type of riser pipe: Carbon steel
Diameter of borehole: [7-in nom]
Type of filler: Not documented
Elevation/depth top of seal
Type of seal: Not documented
Depth top of perforations: [195-ft]
Description of perforations: 195↔225-ft, 4 cuts/rd/ft
Depth bottom of perforations: [225-ft]
Depth bottom of casing: [240-ft]
Depth bottom of borehole:

Drawing By: RKL/2W14-06.ASB   Date: 16Apr93

Reference: HANFORD WELLS

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W14-6

WELL DESIGNATION	:	299-W14-6
CERCLA UNIT	:	200 Aggregate Area Management Study
RCRA FACILITY	:	Not applicable
HANFORD COORDINATES	:	N 41,469 W 75,441 [200W-06May91]
LAMBERT COORDINATES	:	N 446,577 E 2,219,778 [HANCONV] N 136,101.04m E 566,899.444m [NAD83-06May91]
DATE DRILLED	:	Dec74
DEPTH DRILLED (GS)	:	240-ft
MEASURED DEPTH (GS)	:	Not documented
DEPTH TO WATER (GS)	:	205-ft, Dec74; 196.0-ft, 21Jan92
CASING DIAMETER	:	6-in carbon steel, +1.6↔240-ft;
ELEV TOP CASING	:	666.49-ft, [NGVD'29-06May91]
ELEV GROUND SURFACE	:	664.9-ft, Estimated
PERFORATED INTERVAL	:	6-in casing, 195↔225-ft
SCREENED INTERVAL	:	Not applicable
COMMENTS	:	FIELD INSPECTION, 21Jan92, 6-in carbon steel casing. No pad, No posts, capped and locked. No permanent identification. Not in radiation zone. OTHER:
AVAILABLE LOGS	:	Driller
TV SCAN COMMENTS	:	Not applicable
DATE EVALUATED	:	Not applicable
EVAL RECOMMENDATION	:	Not applicable
LISTED USE	:	Water levels measured, 23Aug88↔10Nov88 PNL Annual & Semiannual water sample schedule WHC Quarterly
PUMP TYPE	:	Electric submersible
MAINTENANCE	:	Casing may have been extended. Not documented.

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: 200 W Water Supply
Driller's Name: K. Olson
Drilling Company: Kaiser Engineers
Date Started: 17Sep91

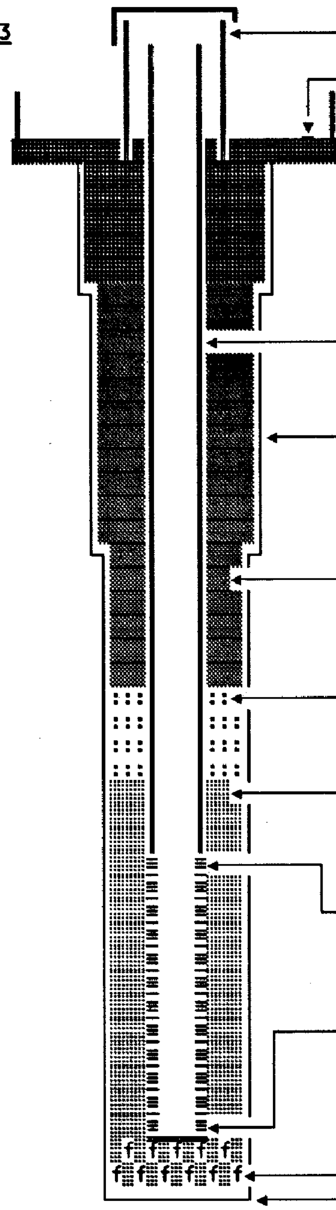
Sample Method: Drive barrel Hard tool
Additives Used: Not documented
WA State Lic Nr: Not documented
Company Location: Hanford
Date Complete: 04Nov91

WELL NUMBER: 299-W14-12
TEMPORARY WELL NO: ____
Hanford Coordinates: N/S N 42,070.0 E/W W 75,418.9
State NAD83 N 136,284.17m 566,905.69m
Coordinates: N 447,178 E 2,219,798
Start Card #: Not documented T____ R____ S____
Elevation Ground surface (ft): 667.08 (Brass cap)

Depth to water: 201.2-ft Nov91
(Ground surface) 203.0-ft 26Mar93

GENERALIZED STRATIGRAPHY
Geologist's Log
Sl=slightly

0↔10: FILL-sandy GRAVEL
10↔15: Sl gravelly SAND
15↔20: SAND
20↔34: Sandy GRAVEL
34↔94: SAND (Clayey sandy SILT lens @ 57-ft)
94↔102: Sandy SILT
102 : CALICHE layer
102↔110: Sl gravelly sandy SILT ($CaCO_3$ cemented)
110↔126: Gravelly sandy SILT ($CaCO_3$ cemented)
126↔205: Sandy GRAVEL (Venting CCl_4 @ 142-ft)
205↔215: Sl silty gravelly SAND
215↔222.5: Sl silty sandy GRAVEL



Elevation of reference point: [670.52-ft]
(top of casing)
Height of reference point above ground surface [3.44-ft]
Depth of surface seal [2↔19.5-ft]
Type of surface seal: Pre-mix concrete
4x4-ft x 6-in surface pad
4 equidistant protective posts
Cement grout 2↔19.5-ft

I.D. of riser pipe: [4-in]
Type of riser pipe:
Stainless steel

Diameter of borehole,
0↔19.5-ft, 13-in nominal
19.5↔160.0-ft, 11-in nominal
160.0↔222.5-ft, 9-in nominal

Type of filler, 19.5↔190.5-ft
8↔20-mesh bentonite crumbles

Depth top of seal: [190.5-ft]
Type of seal:
3/8-in bentonite pellets

Depth top of sand pack: [194.8-ft]
20↔40-mesh silica sand

Depth top of screen: [198.4-ft]
4-in, #10-slot, continous wrap
T304 stainless steel with
filter pack

Depth bottom of screen: [218.7-ft]

Fill, 218.7↔222.5-ft
Depth to bottom of borehole: [222.5-ft]

Drawing By: RKL/2W14-12.ASB Date: 16Apr93

Reference: ____

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W14-12

WELL DESIGNATION	:	299-W14-12
CERCLA UNIT	:	200 Aggregate Area Management Study
RCRA FACILITY	:	Single Shell tanks
HANFORD COORDINATES	:	N 42,070.0 W 75,418.9 [200W-13Dec91]
LAMBERT COORDINATES	:	N 447,178 E 2,219,798 [HANCONV] N 136,284.17m E 566,905.69m [NAD83-13Dec91]
DATE DRILLED	:	Nov91
DEPTH DRILLED (GS)	:	222.5-ft
MEASURED DEPTH (GS)	:	Not documented
DEPTH TO WATER (GS)	:	201.2-ft, Nov91; 203.0-ft, 26Mar93
CASING DIAMETER	:	4-in stainless steel, +1.0↔198.4-ft; 6-in stainless steel, +3.44↔~0.5-ft
ELEV TOP CASING	:	670.52-ft, [NGVD'29-13Dec91]
ELEV GROUND SURFACE	:	667.08-ft, Brass cap [NGVD'29-13Dec91]
PERFORATED INTERVAL	:	Not applicable
SCREENED INTERVAL	:	198.4↔218.7-ft, 4-in #10-slot stainless steel;
COMMENTS	:	FIELD INSPECTION, OTHER:
AVAILABLE LOGS	:	Geologist
TV SCAN COMMENTS	:	Not applicable
DATE EVALUATED	:	Not applicable
EVAL RECOMMENDATION	:	Not applicable
LISTED USE	:	SST Monthly water level measurement, 22Jan92↔26Mar93; Not on water sample schedule
PUMP TYPE	:	Hydrostar, intake at 207.3-ft (TOC)
MAINTENANCE	:	

0502372

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Air Rotary - TUBEX	Sample Method:	Grab/Split Spoon
Drilling Fluid Used:	Reverse Air	Additives Used:	None
Driller's Name:	Willie Franklin	WA State Lic Nr:	Not Available
Drilling Company:	Layne Christensen	Company Location:	Salt Lake City, Ut
Date Started:	26Aug98	Date Completed:	31Aug98

WELL NUMBER:	299-W14-13 B8549
TEMPORARY WELL NO:	Not Allowed
Coordinates: N	Not documented
Coordinates: E	Not documented
Start Card #:	Not Available
Elevation Ground Surface:	Brass Marker

Depth to Water: 215.8 ft 31Aug98
(Ground surface)

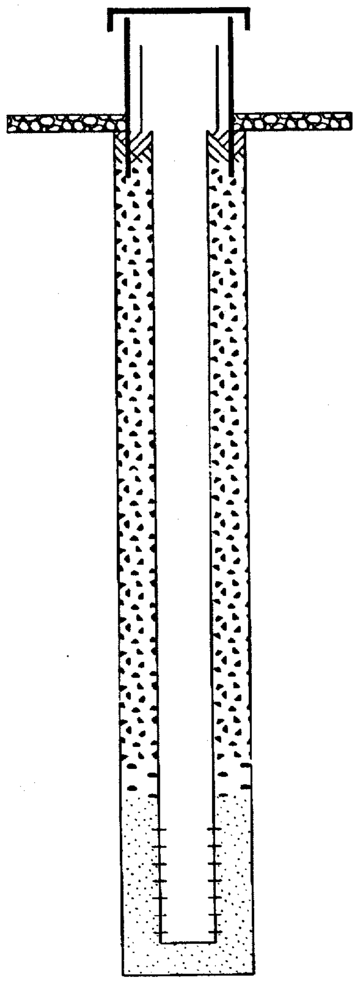
GENERALIZED STRATIGRAPHY — Geologist's Log & Geophysical Logs

Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 9.6 ft.

Type of Surface Seal: 4x4 Concrete Pad



0 - 4 ft : Construction fill
4 - 14 ft : Sand
14 - 33 ft : Sandy gravel
33 - 95 ft : Sand
95 - 98 ft : Sand, sl calcareous
98 - 101 ft : Caliche
101 - 112 ft : Sandy gravel sl calcareous
112 - 125 ft : Sand
125 - 163 ft : Silty sandy gravel
163 - 210 ft : Sandy gravel
210 - 262 ft : Sandy gravel

Fill	Casing	Screen
0 - 9.6 ft : 9.125-inch hole Cement Seal	0 - 216.62 ft : 4 inch 4" SS Sch. 5 Csg.	
9.6 - 195.1 ft : 9.125-inch hole Bentonite Chips		
195.1 - 206.4 ft : 9.125-inch hole Bentonite Pellets		216.62 - 251.73 ft : 4 inch 4" Wire Wrap SS .010 Slot Screen
206.4 - 252.05 ft : 9.125-inch hole 20-40 Silica Sand		
252.05 - 262 ft : 9.125-inch hole 20-40 Silica Sand	251.73 - 252.05 ft : 4 inch 4" SS End Cap	

262 ft : Borehole drilled depth

0 - 262 ft : 9.125-in. 8-5/8" CS Temp. Csg.

Drawing By: TGB
Reference: Hanford Wells
Revision: 0
Revision Date: 21Sep98
Print Date: 28Dec98

Report Form: WELLS Project File: WELLS.GPJ

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W14-13

WELL DESIGNATION	:	299-W14-13
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	262.0 ft
MEASURED DEPTH (GS)	:	
AVAILABLE LOGS	:	Data not available
DATE EVALUATED	:	Data not available
EVAL RECOMMENDATION	:	Data not available
LISTED USE	:	Data not available
CURRENT USER	:	RCRA & Operations
PUMP TYPE	:	Data not available
MAINTENANCE	:	Data not available
COMMENTS	:	8-5/8" TUBEX Sys. 4-1/2" Reverse Cir. Drl. Pipe with Interchange

TV SCAN COMMENTS :

Report Form: WELLS Project File: WELLS.GPJ

Drawing By: TGB
Reference: Hanford Wells
Revision: 0
Revision Date: 21Sep98
Print Date: 28Dec98

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	**Air Rotary - TUBEX**	Sample Method:	**Grab/Split Spoon**	WELL NUMBER:	**299-W14-14 B8547** TEMPORARY WELL NO: **Not Allowed**
Drilling Fluid Used:	**Reverse Air**	Additives Used:	**None**	Coordinates: N	**Not documented**
Driller's Name:	**Randy Smith**	WA State Lic Nr:	**Not Available**	Coordinates: E	**Not documented**
Drilling Company:	**Layne Christensen**	Company Location:	**Salt Lake City, Ut**	Start Card #:	**Not Available**
Date Started:	**08Oct98**	Date Completed:	**12Nov98**	Elevation Ground Surface:	**Brass Marker**

Depth to Water: **216 ft 24Oct98**
(Ground surface) **217.42 ft 14Nov98**

GENERALIZED STRATIGRAPHY **Geologist's Log & Geophysical Logs**

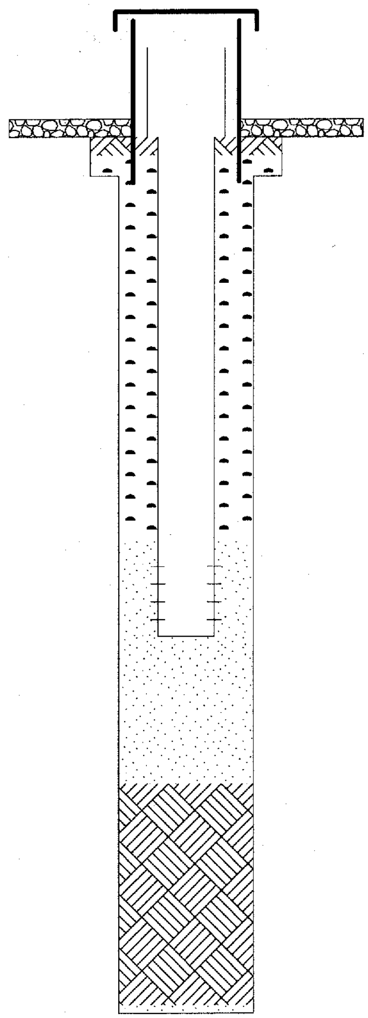
Elevation of Reference Point: **m**

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: **9.3 ft.**

Type of Surface Seal: **4x4 Concrete Pad**

0 - 4.5 ft : Backfill - Sand and gravel
4.5 - 7 ft : Silty Gravelly SAND
7 - 14.5 ft : Silty SAND
14.5 - 16.5 ft : Silty Sandy GRAVEL
16.5 - 33 ft : Sandy GRAVEL
33 - 86.5 ft : SAND
86.5 - 93.5 ft : SAND (trace of caliche @ 86')
93.5 - 123 ft : Silty SAND (Caliche 108 to 110')
123 - 145 ft : Sandy GRAVEL
145 - 209 ft : Sandy GRAVEL
209 - 217 ft : Gravelly SAND
217 - 360 ft : Silty Sandy GRAVEL
360 - 402 ft : Sandy GRAVEL
402 - 412 ft : Silty CLAY
412 - 415.5 ft : SILT
415.5 - 424 ft : SILT (trace of gravel)
424 - 428 ft : GRAVEL
428 - 438 ft : SILT
438 - 443 ft : Sandy GRAVEL



Fill	*Casing*	*Screen*
0 - 9.3 ft : 13-inch hole Cement Seal	0 - 216.98 ft : 9.125 inch 4" SS Sch. 5 Csg.	
9.3 - 20 ft : 13-inch hole Medium Bentonite Chunks		
20 - 202.3 ft : 9.125-inch hole Medium Bentonite Chunks		
202.3 - 203.8 ft : 9.125-inch hole 3/8 Bentonite Pellets		216.98 - 252 ft : 4 inch 4" SS Wire Wrap Screen - .010 Slot
203.8 - 252.3 ft : 9.125-inch hole 20-40 Silica Sand	252 - 252.3 ft : 9.125 inch 4" SS End Cap	
252.3 - 257.3 ft : 9.125-inch hole 20-40 Silica Sand		
257.3 - 326.6 ft : 9.125-inch hole 4-10, 6-9, 8-12, 8-16 & 10-20 Silica Sand		
326.6 - 438.8 ft : 9.125-inch hole Cement Grout		
438.8 - 443 ft : 9.125-inch hole 8-16 & 10-20 Silica Sand		

443 ft : Borehole drilled depth

0 - 20 ft : 13-in. 12-3/4" Temp. Csg. set w/Cable Tool
20 - 443 ft : 9.125-in. 8-5/8" Temp. Csg. Set w/Tubex air rotary-rev. air 4-1/2" Drl. Pipe

Drawing By: **JEA**
Reference: **Hanford Wells**
Revision: **0**
Revision Date: **16Oct98**
Print Date: **01Jun00**

Report Form: WELLS Project File: WELLS.GPJ

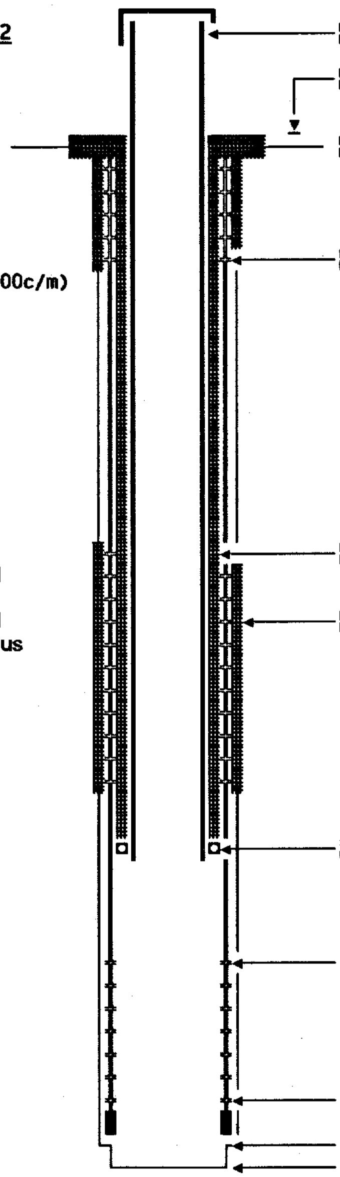
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 299-W15-4
Drilling Fluid Used: Water	Additives Used: Not documented	TEMPORARY WELL NO: 241-TX-#12
Driller's Name: Row/Richards	WA State Lic Nr: Not documented	Hanford Coordinates: N/S N 41,200 E/W W 75,700
Drilling Company: Not documented	Company Location: Not documented	State Coordinates: N 446,308 E 2,219,519
Date Started: 30Dec55	Date Complete: 30Jan56	Start Card #: Not documented T___ R___ S___
		Elevation Ground surface (ft): 659.9 Estimated

Depth to water: 185-ft Jan56
(Ground surface) 198.0-ft 04Dec92

GENERALIZED STRATIGRAPHY — Driller's Log

0↔15: GRAVEL & SAND
20↔25: GRAVEL, BOULDERS and SAND
25: GRAVEL, SAND
30↔40: GRAVEL, coarse black SAND
45: SAND
47: SILT (Radiation in well-40,000c/m)
50↔70: SAND-very little SILT
75↔80: SAND, more SILT
85↔90: SAND-SILT
95↔115: SAND, heavy SILT
120: SILT, 4-ft of GRAVEL
125: GRAVEL-SAND
130↔148: Pure GRAVEL, caves
150↔180: GRAVEL-SAND
185↔195: SAND-GRAVEL
197↔217: GRAVEL-SAND, caves
REMEDIATION:
May83, by Troy and Evans
Perforated 6-in casing 0↔20 and 80↔155-ft, 2 cut/rd/ft.
Set 6-in casing to 159.5-ft and grouted 6 and 8-in casing annulus with 198-gals grout.



Elevation of reference point: (top of casing) [662.00-ft]
Height of reference point above ground surface [2.1-ft]
Depth of surface seal [20-ft]
Type of surface seal: Partial, grout between 6 and 8-in casing
8-in casing perforated 0↔20-ft and 80↔155-ft
Type of riser pipes: Carbon steel
Type of filler: Cement grout 0↔159-ft
Diameter of borehole: [9-in nom]
6-in casing to 159.5-ft set on packer
Depth top of perforations: [170-ft]
Depth bottom of perforations: [216-ft]
Depth bottom 8-in casing: [216.5-ft]
Depth bottom of borehole: [217-ft]

Drawing By: RKL/2W15-04.ASB Date: 19Apr93

Reference: HANFORD WELLS

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W15-4

WELL DESIGNATION	:	299-W15-4
CERCLA UNIT	:	200 Aggregate Area Management Study
RCRA FACILITY	:	Not applicable
HANFORD COORDINATES	:	N 41,200 W 75,700
LAMBERT COORDINATES	:	N 446,308 E 2,219,519
DATE DRILLED	:	Jan56
DEPTH DRILLED (GS)	:	217-ft
MEASURED DEPTH (GS)	:	Not documented
DEPTH TO WATER (GS)	:	185-ft, Jan56;
	:	198.0-ft, 04Dec92
CASING DIAMETER	:	8-in carbon steel, ~0↔216.5-ft; 6-in carbon steel, +2.1↔159.5-ft
ELEV TOP CASING	:	662.00-ft
ELEV GROUND SURFACE	:	659.9-ft, Estimated
PERFORATED INTERVAL	:	8-in casing, 0↔20, 80↔155 & 170↔216-ft;
SCREENED INTERVAL	:	Not applicable
COMMENTS	:	FIELD INSPECTION, 27Jan92, 6-in carbon steel casing. 2-ft cement pad, No posts, capped and locked. No permanent identification. Not in radiation zone. OTHER: Contains grouted liner.
AVAILABLE LOGS	:	Driller
TV SCAN COMMENTS	:	Not applicable
DATE EVALUATED	:	Not applicable
EVAL RECOMMENDATION	:	Not applicable
LISTED USE	:	Separations area Semiannual water level measurement, 14Aug73↔04Dec92; PNL Annual and Semiannual water, WHC Seminannual Water sample schedule
PUMP TYPE	:	Electric submersible
MAINTENANCE	:	

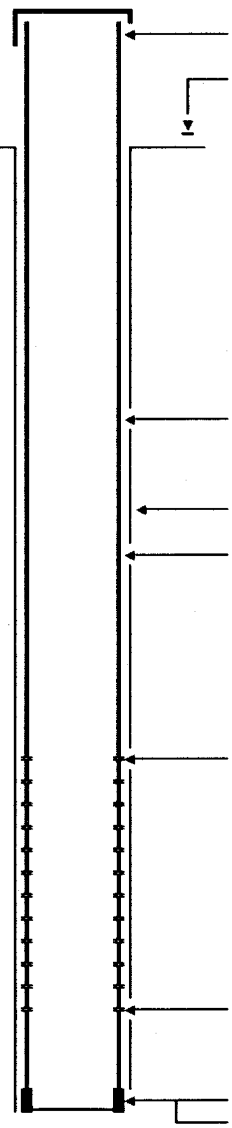
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 299-W15-12 TEMPORARY WELL NO:
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford Coordinates: N/S N 42,350 E/W W 76,095
Driller's Name: Evans	WA State Lic Nr: Not documented	State Coordinates: N 447,457 E 2,219,122
Drilling Company: Not documented	Company Location: Not documented	Start Card #: Not documented T ___ R ___ S ___
Date Started: 06Sep73	Date Complete: 04Oct73	Elevation Ground surface (ft): 667.4 Estimated

Depth to water: 200-ft Oct73
(Ground surface) 203.9-ft 26Mar93

GENERALIZED STRATIGRAPHY   Driller's Log

0↔45: SAND, SILT & GRAVEL to COBBLE
45↔92: SILT & SAND
92↔102: SILT
102↔130: CALICHE
130↔225: Ringold Fm.



Elevation of reference point: [670.07-ft]
(top of casing)
Height of reference point above ground surface [2.7-ft]

Depth of surface seal [ND]

Type of surface seal: None documented

I.D. of surface casing [ND]
(If present)

I.D. of riser pipe: [6-in]
Type of riser pipe:
Carbon steel

Diameter of borehole: [7-in nom]

Type of filler:
Not documented

Depth top of perforations: [195-ft]
Description of perforations:
4 cuts/rd/ft

Depth bottom of perforations: [215-ft]

Depth bottom of casing: [225-ft]
Depth bottom of borehole: [225-ft]

Drawing By: RKL/2W15-12.ASB   Date: 19Apr93

Reference: HANFORD WELLS

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W15-12

WELL DESIGNATION	:	299-W15-12
CERCLA UNIT	:	200 Aggregate Area Management Study
RCRA FACILITY	:	Single Shell Tanks
HANFORD COORDINATES	:	N 42,350 W 76,095 [200W-06May91]
LAMBERT COORDINATES	:	N 447,457 E 2,219,122 [HANCONV] N 136,369.02m E 566,699.52m [NAD83-06May91]
DATE DRILLED	:	Oct73
DEPTH DRILLED (GS)	:	225-ft
MEASURED DEPTH (GS)	:	Not documented
DEPTH TO WATER (GS)	:	200-ft, Oct73; ~204-ft, 22Oct92
CASING DIAMETER	:	6-in carbon steel, +2.7↔250-ft;
ELEV TOP CASING	:	670.07-ft, [NGVD'29-06May91]
ELEV GROUND SURFACE	:	667.4-ft, Estimated
PERFORATED INTERVAL	:	6-in casing, 195↔215-ft
SCREENED INTERVAL	:	Not applicable
COMMENTS	:	FIELD INSPECTION, 08Feb90, 6-in carbon steel casing. Capped, not locked No pad, posts or permanent identification. Not in radiation zone. OTHER:
AVAILABLE LOGS	:	Driller
TV SCAN COMMENTS	:	Not applicable
DATE EVALUATED	:	Not applicable
EVAL RECOMMENDATION	:	Not applicable
LISTED USE	:	SST Monthly water level measurement, 30Jun88↔26Mar93; PNL Semiannual water sample schedule
PUMP TYPE	:	None documented
MAINTENANCE	:	

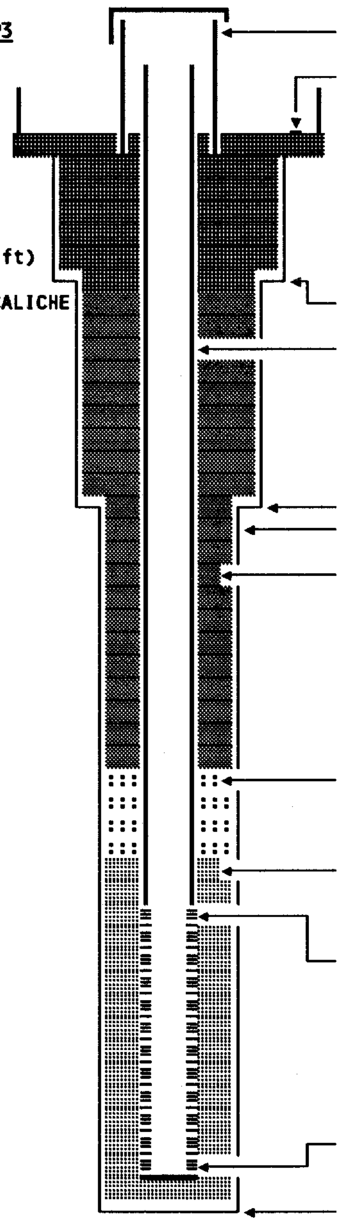
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Drive barrel Hard tool	WELL NUMBER: 299-W15-22
Drilling Fluid Used: 200 W Water Supply	Additives Used: None	TEMPORARY WELL NO: None
Driller's Name: G Thomas/C Wamsley B Strode/L Watkins	WA State Lic Nr: Not documented	Hanford Coordinates: N/S N 41,504 E/W W 76,150
Drilling Company: Kaiser Engineers	Company Location: Hanford	State NAD83 Coordinates: N 136,111.19m 446,610 E 566,683.32m 2,219,069
Date Started: 15Nov90	Date Complete: 16Jan91	Start Card #: Not documented T____ R____ S______
		Elevation Ground surface (ft): 667.71 Brass cap

Depth to water: 198.1-ft Dec90
(Ground surface) 202.4-ft 26Mar93

GENERALIZED STRATIGRAPHY
Geologist's Log
Sl=slightly

0↔5: (Backfill)
5↔30: Silty sandy GRAVEL
30↔47: Sandy GRAVEL
47↔102.5: SAND
(4-in SILT lens, 69.7↔70-ft)
102.5↔110: SILT
110↔123: Gravelly silty SAND w/CALICHE
123↔124.5: Silty SAND w/CALICHE
124.5↔126: Silty SAND
126↔221.9: Silty sandy GRAVEL
(Cemented @ 137-ft)



Elevation of reference point: (top of casing) [670.77-ft]

Height of reference point above ground surface [3.06-ft]

Depth of surface seal [0↔19.0-ft]

Type of surface seal: Pre-mix concrete 4x4-ft x 6-in surface pad to 2.7-ft 4 equidistant protective posts Cement grout, 2.7↔19.0-ft

13-in nominal hole to 17.9-ft

I.D. of riser pipe: [4-in]
Type of riser pipe: Stainless steel

Diameter of borehole,
17.9↔150.6-ft, 11-in nominal
150.6↔221.9-ft, 9-in nominal

Type of filler, 19.0↔186.1-ft
8↔20 mesh bentonite crumbles

Depth top of seal: [186.1-ft]
Type of seal: Bentonite pellets

Depth top of sand pack: [192.3-ft]
8↔12-mesh silica sand

Depth top of screen: [198.5-ft]
4-in, #10-slot, stainless steel with channel pack

Depth bottom of screen [219.8-ft]

Depth to bottom of borehole: [221.9-ft]

Drawing By: RKL/2W15-22.ASB Date: 19Apr93

Reference: WHC-SD-EN-DP-041

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W15-22

WELL DESIGNATION	:	299-W15-22
CERCLA UNIT	:	200 Aggregate Area Management Study
RCRA FACILITY	:	Single Shell Tanks
HANFORD COORDINATES	:	N 41,504 W 76,150 [200W-01Apr91
LAMBERT COORDINATES	:	N 446,610 E 2,219,069 [HANCONV]
	:	N 136,111.19m E 566,683.32m [NAD83-01Apr91]
DATE DRILLED	:	Jan91
DEPTH DRILLED (GS)	:	221.9-ft
MEASURED DEPTH (GS)	:	Not documented
DEPTH TO WATER (GS)	:	198.1-ft, 17Dec90; 202.4-ft, 19Apr93
CASING DIAMETER	:	4-in stainless steel, +1.8↔199.8-ft; 6-in stainless steel, +3.1↔˜0.5-ft
ELEV TOP CASING	:	670.77-ft, [NGVD'29-01Apr91]
ELEV GROUND SURFACE	:	667.71-ft, Brass cap [NGVD'29-01Apr91]
PERFORATED INTERVAL	:	Not applicable
SCREENED INTERVAL	:	198.5↔219.8-ft, 4-in #10-slot stainless steel, with channel pack
COMMENTS	:	FIELD INSPECTION, 20Jan92 6-in stainless steel casing. 4-ft by 4-ft concrete pad, 4 posts, 1 removable capped and locked, brass cap in pad with well ID. Not in radiation zone. OTHER:
AVAILABLE LOGS	:	Geologist, driller
TV SCAN COMMENTS	:	Not applicable
DATE EVALUATED	:	Not applicable
EVAL RECOMMENDATION	:	Not applicable
LISTED USE	:	SST Monthly water level measurement, 01Jul91↔26Mar93,
PUMP TYPE	:	Hydrostar
MAINTENANCE	:	

0502373

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Air Rotary - TUBEX	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W15-40 B8550 TEMPORARY WELL NO: Not Allowed
Drilling Fluid Used:	Reverse Air	Additives Used:	None	Coordinates: N	Not documented
Driller's Name:	Willie Franklin	WA State Lic Nr:	Not Available	Coordinates: E	Not documented
Drilling Company:	Layne Christensen	Company Location:	Salt Lake City, Ut	Start Card #:	Not Available
Date Started:	25Aug98	Date Completed:	10Sep98	Elevation Ground Surface:	Brass Marker

Depth to Water: 218.08 ft 10Sep98
(Ground surface)

GENERALIZED STRATIGRAPHY — **Geologist's Log & Geophysical Logs**

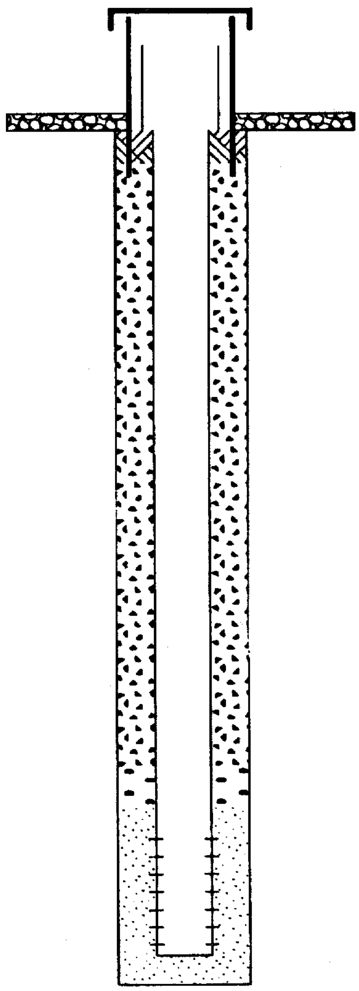
Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 10.1 ft

Type of Surface Seal: 4x4 Concrete Pad

0 - 1 ft : Backfill (silty sandy gravel)
1 - 2 ft : Sand
2 - 7 ft : Sand
7 - 67 ft : Sandy gravel
67 - 80 ft : Sand (vc-vf)
80 - 97 ft : Sand (m-vf)
97 - 98 ft : Sand
98 - 98.3 ft : Silty sandy gravel
98.3 - 101 ft : Slightly silty sand
101 - 107 ft : Silt
107 - 113.5 ft : Silty sand
113.5 - 118 ft : Gravelly sandy silt
118 - 125 ft : Silty gravelly sand
125 - 132 ft : Silty sand
132 - 167 ft : Silty sandy gravel
167 - 183 ft : Sandy gravel
183 - 187 ft : Silty sand
187 - 220 ft : Silty sandy gravel
220 - 262 ft : Sandy gravel



Fill	*Casing*	*Screen*
0 - 10.1 ft : 9.125-inch hole Cement Seal	0 - 217.95 ft : 4 inch 4" Sch. 5 SS Csg.	
10.1 - 195.4 ft : 9.125-inch hole Bentonite Chips		
195.4 - 208.3 ft : 9.125-inch hole Bentonite Pellets		217.95 - 253.08 ft : 4 inch 4" Wire Wrap SS Screen .010 Slot
253.4 - 208.3 ft : 9.125-inch hole 20-40 Silica Sand		
253.4 - 262.4 ft : 9.125-inch hole 20-40 Silica Sand	253.08 - 253.4 ft : 4 inch 4" SS End Cap	

262.4 ft : Borehole drilled depth

0 - 262.4 ft : 9.125-in. 8-5/8" CS Temp. Csg.

Report Form: WELLS Project File: WELLS.GPJ

Drawing By: TGB
Reference: Hanford Wells
Revision: 0
Revision Date: 21Sep98
Print Date: 28Dec98

BECHTEL

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-W15-40

WELL DESIGNATION	:	299-W15-40
CERCLA UNIT	:	
RCRA FACILITY	:	
DEPTH DRILLED (GS)	:	262.4 ft
MEASURED DEPTH (GS)	:	
AVAILABLE LOGS	:	Data not available
DATE EVALUATED	:	Data not available
EVAL RECOMMENDATION	:	Data not available
LISTED USE	:	Data not available
CURRENT USER	:	Data not available
PUMP TYPE	:	Data not available
MAINTENANCE	:	Data not available
COMMENTS	:	

TV SCAN COMMENTS :

Report Form: WELLS Project File: WELLS.GPJ

Drawing By:	TGB
Reference:	Hanford Wells
Revision:	0
Revision Date:	21Sep98
Print Date:	28Dec98

BECHTEL

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool/Air Rotary	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W15-41 B8815 TEMPORARY WELL NO: Not Allowed
Drilling Fluid Used:	water as needed	Additives Used:	None	Coordinates: N	Not documented
Driller's Name:	Wes Worth	WA State Lic Nr:	Not Available	Coordinates: E	Not documented
Drilling Company:	Resonant Sonic Intl.	Company Location:	Woodland, Ca.	Start Card #:	R43396
Date Started:	30Nov99	Date Completed:	17Jan00	Elevation Ground Surface:	Brass Marker

0515334

Depth to Water: 213.3 ft. ft 17Jan00
(Ground surface)

Elevation of Reference Point: m

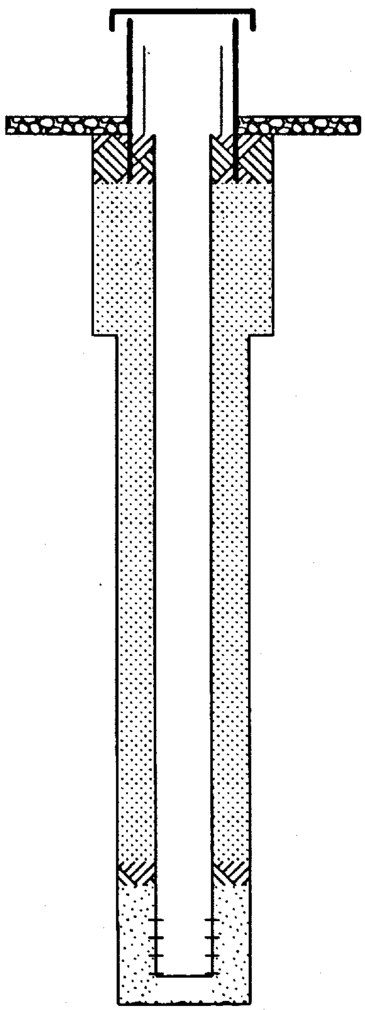
Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 13.5 ft.

Type of Surface Seal: 4x4 Concrete Pad

GENERALIZED STRATIGRAPHY Geologist's Log

0 - 2 ft : Gravel drill pad
2 - 5 ft : Gravelly SAND
5 - 48 ft : Sandy GRAVEL
48 - 55 ft : Gravelly SAND
55 - 93 ft : SAND
93 - 104 ft : Silty SAND
104 - 112 ft : Calcareous Silty SAND
112 - 121 ft : Silty SAND
121 - 132 ft : Silty Sandy GRAVEL
139 - 147 ft : Gravelly SAND
147 - 180 ft : Sandy GRAVEL
180 - 199 ft : Silty Sandy GRAVEL
199 - 202 ft : Gravelly SAND
202 - 215 ft : Silty Sandy GRAVEL
215 - 227 ft : Sandy GRAVEL
227 - 239 ft : Silty Sandy GRAVEL



Fill	*Casing*	*Screen*
0 - 13.5 ft : 12.25-inch hole Cement Surface Seal	0 - 215.92 ft : 4 inch 4" 304 SS Sch. 5 well csg.	
13.5 - 55 ft : 12.25-inch hole Granular Bentonite		
55 - 200.1 ft : 9-inch hole Granular Bentonite		
200.1 - 206.6 ft : 9-inch hole Cement well seal		215.92 - 230.94 ft : 4 inch 4" 304 SS .010 Slot Wire Wrap Scrn.
206.6 - 238.1 ft : 9-inch hole 20/40 Silica Sand	230.94 - 231.29 ft : 4 inch 4" PVC End Cap	
238.1 - 239 ft : 9-inch hole Slough		

239 ft : Borehole drilled depth

0 - 55 ft : 12.25-in. Cable Tool 11-3/4" CS Temp. Csg. to 55 ft.
55 - 239 ft : 9-in. Air Rotary 8-5/8" CS Temp. Csg. to 239 ft.

Drawing By: JEA
Reference: Hanford Wells
Revision: 0
Revision Date: 07Mar00
Print Date: 06Mar00

BECHTEL

Report Form: WELLS Project File: WELLS.GPJ

Appendix C

Monitoring Efficiency Model Output Regarding New Well Locations

Appendix C

Monitoring Efficiency Model Output Regarding New Well Locations

Waste Management Area (WMA) TX-TY contains the 241-TX and 241-TY Tank Farms and is located in the northern portion of the 200 West Area of the Hanford Site (Figure 1.1) in southeastern Washington State. This appendix provides results of computer modeling used to guide locations for new monitoring wells to improve the probability of detecting contamination from WMA TX-TY. The model is an analytical Monitoring Efficiency Model, referred to as MEMO, which was developed to assist in design of monitoring well networks (Wilson et al. 1992). The model uses a plume generation routine to compute the size and shape of a plume from hypothetical source locations uniformly distributed within the source area (i.e., WMA). The model assumes the contaminant is released as a continuous line source to a uniform or homogeneous aquifer. If a contaminant occurrence is more of a short-term transient event, then there is likelihood that the computed monitoring efficiency may be overestimated because less lateral spreading will occur than with a continuous release source.

C.1 Model Input Parameters

Major input parameters needed include groundwater flow direction, longitudinal and transverse dispersivities, velocity, and buffer zone and well locations. The X-Y coordinates are entered to define well locations, the WMA boundary, and the buffer zone. The buffer zone is used to allow the hypothetical plume to expand to some point beyond the source area boundary. The further away the buffer boundary is set, the greater the lateral spreading that will occur in the vicinity of the line of compliance where the wells are located. Thus, there is a trade off between number of wells needed and the elapsed time when a contaminant plume would be detected. With a narrow buffer zone (boundary set close to the well locations), detection of hypothetical contaminant plumes would occur earlier but require more wells.

Longitudinal and transverse dispersivities, the parameters that control the extent of spreading of the plume, were previously determined using the observed distribution of the tritium plume in the 200 West Area.[a] These same dispersivities are deemed appropriate for WMA TX-TY because the aquifer beneath both the northern and southern part of the 200 West Area is in the same hydrogeologic unit. Other input

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[a] Golder Associates. 1990. "Groundwater monitoring." Section 5 in *Low Level Waste Burial Grounds RCRA Part B Permit Application*, pp. 903-1201. Golder Associates Inc., Redmond, Washington.

parameters and the parameter abbreviations as used in the computer code, together with the input values used for the WMA TX-TY computer iterations, are defined as follows:

- X-Y coordinates: State Plane, meters.

- C_D/C_0: Dilution contour where C_D is the detection standard selected as the limiting concentration to be detected by a monitoring well, and C_0 is the source concentration in groundwater at the location of origin within the WMA. To provide adequate early warning of a release, the model should be based on a dilution contour for the more mobile potential contaminants at the site. For the WMA TX-TY computer simulations, a detection limit of 10 pCi/L for technetium-99 is used as the detection standard (C_D) and 10,000 pCi/L is used as the source concentration (C_0), resulting in a dilution contour of (C_D/C_0) = (10 pCi/L)/(10,000 pCi/L) = 0.001.

- ldisp. Longitudinal dispersivity, meters. A value of 8.5 m (28 ft) was used based on tritium plume dimensions in the 200 West Area.[a]

- tdisp. Transverse dispersivity, meters. A value of 2.5 m (8 ft) was used based on tritium plume dimensions in the 200 West Area.[b]

- diffc. Effective molecular diffusion coefficient (insignificant for this application, so set to zero).

- source width, meters. The length in meters of the initial source dimension (modeled as a line source of the same length spaced evenly over the entire source area). A line source length of 6 m (20 ft) was used.

- lmb. First order radioactive decay constant. This term was set to zero because no decay was assumed.

- cvel. Average contaminant velocity, meters/day (m/d). A value of 0.1 m/d was used for computational purposes.

C.2 Model Output

The MEMO model output using existing usable WMA TX-TY network (299-W15-40, 299-W10-17, 299-W10-26, 299-W14-12, 299-W14-13, 299-W14-14, 299-W14-6, 299-W14-5, and 299-W15-41) is shown in Figure C.1. Flow directions, as inferred from the most recent water-table elevations, are more easterly in the northern part of the WMA and then shift to a more southerly direction at the south end of the WMA (see Figure C.1). Input parameters and coordinates used for Figure C.1 are listed in Table C.1.

---

[a] Golder Associates. 1990. *Low Level Waste Burial Grounds RCRA Part B Permit Application*. Golder Associates Inc., Redmond, Washington (p. 102).
[b] Golder Associates. 1990. *Low Level Waste Burial Grounds RCRA Part B Permit Application*. Golder Associates Inc., Redmond, Washington (p. 102).

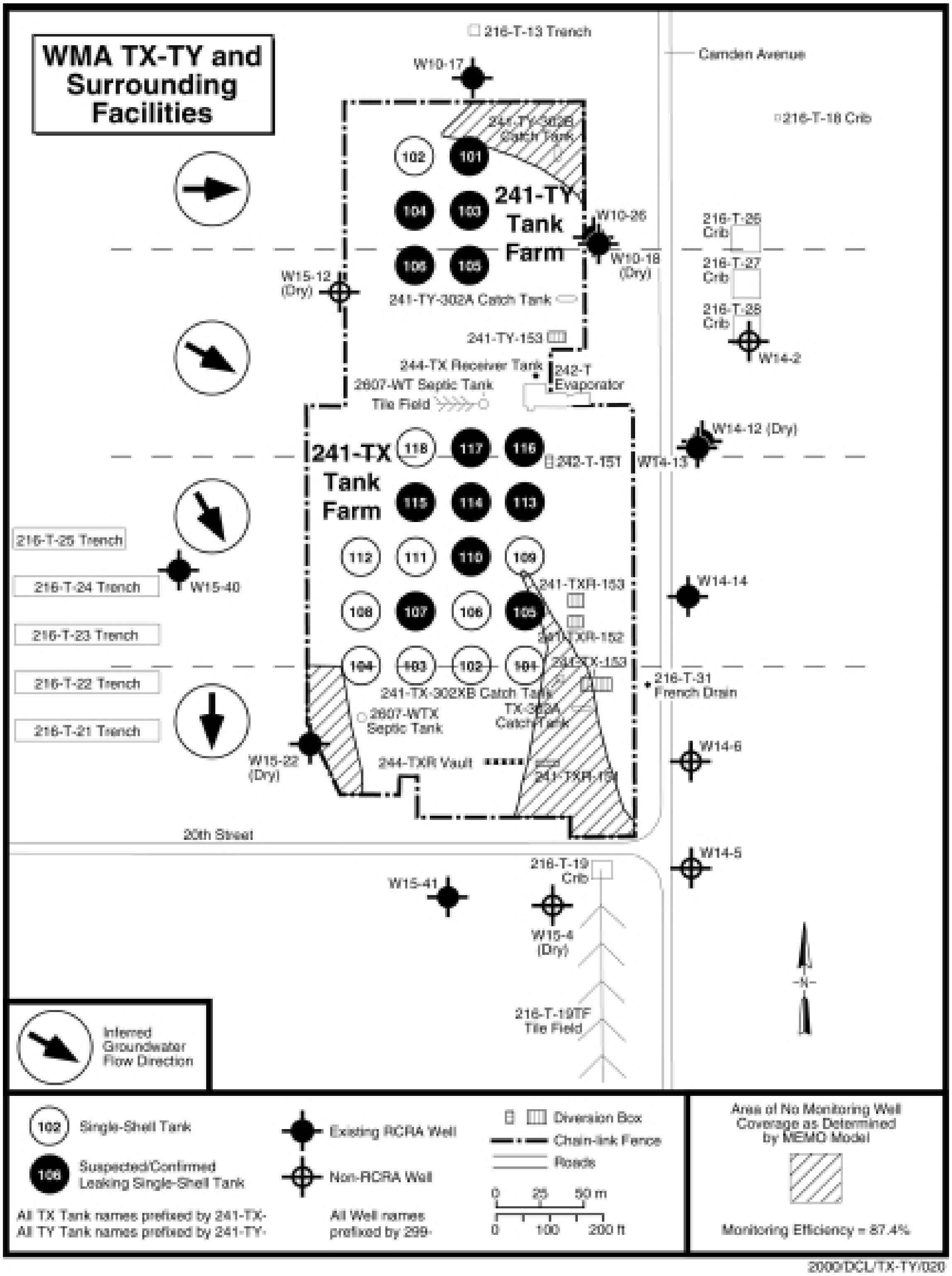

Figure C.1. WMA TX-TY and Surrounding Facilities

Table C.1. Input Parameters for Monitoring Efficiency Model

sp0r1.txt

```
++++++++++++++++++++++++++++++++++++++++++
++        MEMO Data File                ++
++                                      ++
++     Monitoring Analysis Package      ++
++        MAP Version   1.1             ++
++                                      ++
++       GOLDER ASSOCIATES INC.         ++
++                                      ++
++    Run on 05/18/00 at 15:25:34       ++
++++++++++++++++++++++++++++++++++++++++++


------------------------------------------
< TX-TY Tank Farm                        >
------------------------------------------


 *   SCALE FACTOR
       1.000000
 *   SOURCE GRID PARAMETERS (x0,y0,grid spacing,max x incr,max y
incr)
   566680.800000   136057.800000        3.000000
          63          140
 *   POTENTIAL SOURCE AREA COORDINATES (#,x,y,unit#)
   1       566699.90      136082.30         1
   2       566681.30      136122.20         1
   3       566680.80      136304.00         1
   4       566702.80      136303.90         1
   5       566702.40      136477.30         1
   6       566838.40      136477.60         1
   7       566839.40      136336.20         1
   8       566830.90      136304.30         1
   9       566863.70      136304.50         1
  10       566866.50      136300.90         1
  11       566867.40      136058.30         1
  12       566830.90      136057.80         1
  13       566830.70      136069.10         1
  14       566743.80      136069.30         1
  15       566743.80      136092.30         1
  16       566733.70      136092.50         1
  17       566733.40      136082.00         1
 *   LINE OF COMPLIANCE COORDINATES (#,x,y)
   1       566699.90      136082.30
   2       566681.30      136122.20
   3       566680.80      136304.00
   4       566702.80      136303.90
```

Table C.1. (contd)

sp0r1.txt

```
    5       566702.40      136477.30
    6       566838.40      136477.60
    7       566839.40      136336.20
    8       566830.90      136304.30
    9       566863.70      136304.50
   10       566866.50      136300.90
   11       566867.40      136058.30
   12       566830.90      136057.80
   13       566830.70      136069.10
   14       566743.80      136069.30
   15       566743.80      136092.30
   16       566733.70      136092.50
   17       566733.40      136082.00
  *   ARRAY SPACING FOR BUFFER ZONE COORDINATES (max. spacing)
        7.000000
  *   INPUT BUFFER ZONE COORDINATES (#,x,y)
    1       566602.80      135982.30
    2       566602.80      136577.30
    3       566938.40      136577.30
    4       566938.40      135982.30
  *   MONITORING WELL COORDINATES (#,x,y)
    1       566653.00      136205.00
    2       566775.00      136491.00
    3       566843.00      136401.00
    4       566933.00      136341.00
    5       566902.00      136282.00
    6       566898.00      136181.00
    7       566899.00      136101.00
    8       566900.00      136040.00
    9       566758.00      136032.00
  *   CONTAM. TRAN. PARAMETERS (CD/C0,ldisp,tdisp,diffc,source wid
th,lmb,cvel)
    1.000000E-03       8.500000       2.400000    0.000000E+00
        6.000000    0.000000E+00    1.000000E-01
  *   GRADIENT ZONE COORDINATES (#,x,y,unit#,angle)
    1       566602.80      135982.30          1          270.00
    2       566602.80      136155.00          1          270.00
    3       566938.40      136155.00          1          270.00
    4       566938.40      135982.30          1          270.00
    5       566602.80      136155.00          2          300.00
    6       566602.80      136275.00          2          300.00
    7       566938.40      136275.00          2          300.00
    8       566938.40      136155.00          2          300.00
    9       566602.80      136275.00          3          330.00
   10       566602.80      136395.00          3          330.00
   11       566938.40      136395.00          3          330.00
   12       566938.40      136275.00          3          330.00
   13       566602.80      136395.00          4             .00
```

Table C.1. (contd)

sp0r1.txt

```
 14      566602.80     136577.30        4            .00
 15      566938.40     136577.30        4            .00
 16      566938.40     136395.00        4            .00
*   SOLUTION RESULTS
Maximum advection time =    36500.000000
Accuracy of solution =    1.000000E-04
Solution basis = buffer zone/advection time
Total # of source points =        7317
# of undetected leaks =        919
Monitoring efficiency = 87.4 %.
*   END OF MAP FILE
```

The shaded areas in Figure C.1 indicate that there is a major area of inadequate well coverage at the northeast corner of the 241-TY Tank Farm and at south and southwest end of 241-TX Tank Farm. The possible sources not likely to be covered by the current network include tanks (TY-101, TY-103, TY-104, TX-105, TX-110, TX-115, TY-114, TX-113, TX-116, and TX-117), diversion boxes (241-TX-153, 241-TXR-151, 241-TXR-152, and 241-TXR-153), and catch tanks (TX-302A and TX-302B) in the south area inside the 241-TX Tank Farm and in the northeast corner of the 241-TY Tank Farm fence line (Figure C.1).

C.3 Proposed Well Locations in Waste Management Area TX-TY

Five new wells were proposed for calendar year 2000 to eliminate areas of predicted non-coverage and to provide information for plume delineation (Figure C.2). One new downgradient well (well 4) is planned for the southern side of the WMA to enhance the spatial coverage and detection capability in that area. This well is proposed because: 1) groundwater flow direction, as a result or the 200-ZP-1 pump-and-treat operation, has a more southerly component than it did when the initial *Resource Conservation and Recovery Act* (RCRA) network was established; and 2) to replace a non-RCRA well (299-W15-4) that went dry.

In addition to this replacement well, two new wells east of the WMA were planned. One well (well 5) was added to enhance the spatial coverage near the 241-TY Tank Farm. Another well (well 2) to the south of well 299-W14-12 was proposed for determination of extent and rate of transport of contaminants. Groundwater sampled in well 299-W14-12 has exhibited elevated concentrations of technetium-99 and other contaminants since the inception of monitoring in this well in 1992. Groundwater flow directions have been generally toward the northeast or east during this period, and there are no monitoring wells to the east of well 299-W14-12 (Figure C.1). In addition, the May 1998 sampling in well 299-W14-2 indicated the possibility of a new tritium and iodine-129 plume in the same general area. In addition, high and increasing tritium concentrations (2,530,000 pCi/L, on January 13, 2000) have occurred in well 299-W14-13 (replacement for well 299-W14-12). Elevated chromium and

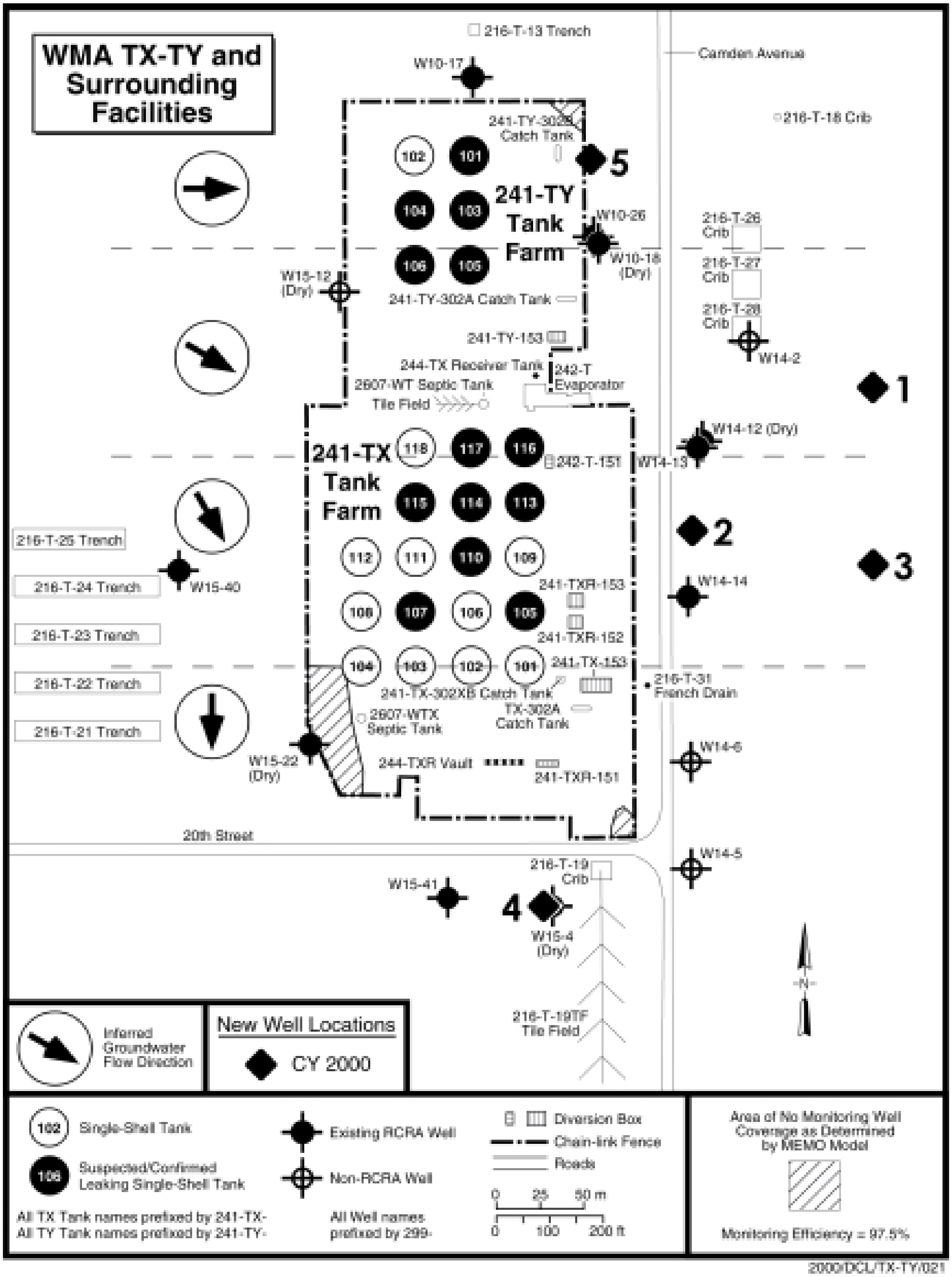

Figure C.2. WMA TX-TY and Surrounding Facilities

Table C.2. Extended Network Based on Monitoring Efficiency Model

sp4r1.txt

```
++++++++++++++++++++++++++++++++++++++++++++
++          MEMO Data File                ++
++                                        ++
++      Monitoring Analysis Package       ++
++          MAP Version   1.1             ++
++                                        ++
++         GOLDER ASSOCIATES INC.         ++
++                                        ++
++     Run on 05/18/00 at 15:30:44        ++
++++++++++++++++++++++++++++++++++++++++++++


--------------------------------------------
< TX-TY Tank Farm                          >
--------------------------------------------


  *   SCALE FACTOR
        1.000000
  *   SOURCE GRID PARAMETERS (x0,y0,grid spacing,max x incr,max y
incr)
   566680.800000   136057.800000        3.000000
          63          140
  *   POTENTIAL SOURCE AREA COORDINATES (#,x,y,unit#)
    1       566699.90      136082.30         1
    2       566681.30      136122.20         1
    3       566680.80      136304.00         1
    4       566702.80      136303.90         1
    5       566702.40      136477.30         1
    6       566838.40      136477.60         1
    7       566839.40      136336.20         1
    8       566830.90      136304.30         1
    9       566863.70      136304.50         1
   10       566866.50      136300.90         1
   11       566867.40      136058.30         1
   12       566830.90      136057.80         1
   13       566830.70      136069.10         1
   14       566743.80      136069.30         1
   15       566743.80      136092.30         1
   16       566733.70      136092.50         1
   17       566733.40      136082.00         1
  *   LINE OF COMPLIANCE COORDINATES (#,x,y)
    1       566699.90      136082.30
    2       566681.30      136122.20
    3       566680.80      136304.00
    4       566702.80      136303.90
```

Table C.2. (contd)

sp4r1.txt

```
   5       566702.40      136477.30
   6       566838.40      136477.60
   7       566839.40      136336.20
   8       566830.90      136304.30
   9       566863.70      136304.50
  10       566866.50      136300.90
  11       566867.40      136058.30
  12       566830.90      136057.80
  13       566830.70      136069.10
  14       566743.80      136069.30
  15       566743.80      136092.30
  16       566733.70      136092.50
  17       566733.40      136082.00
  *   ARRAY SPACING FOR BUFFER ZONE COORDINATES (max. spacing)
      7.000000
  *   INPUT BUFFER ZONE COORDINATES (#,x,y)
   1       566602.80      135982.30
   2       566602.80      136577.30
   3       566938.40      136577.30
   4       566938.40      135982.30
  *   MONITORING WELL COORDINATES (#,x,y)
   1       566653.00      136205.00
   2       566775.00      136491.00
   3       566843.00      136401.00
   4       566933.00      136341.00
   5       566902.00      136282.00
   6       566898.00      136181.00
   7       566899.00      136101.00
   8       566900.00      136040.00
   9       566758.00      136032.00
  10       566900.00      136231.00
  11       566816.00      136019.00
  12       566843.00      136441.00
  13       567002.00      136312.00
  14       567002.00      136212.00
  *   CONTAM. TRAN. PARAMETERS (CD/C0,ldisp,tdisp,diffc,source wid
th,lmb,cvel)
   1.000000E-03        8.500000        2.400000    0.000000E+00
      6.000000    0.000000E+00    1.000000E-01
  *   GRADIENT ZONE COORDINATES (#,x,y,unit#,angle)
   1       566602.80      135982.30          1          270.00
   2       566602.80      136155.00          1          270.00
   3       566938.40      136155.00          1          270.00
   4       566938.40      135982.30          1          270.00
   5       566602.80      136155.00          2          300.00
   6       566602.80      136275.00          2          300.00
   7       566938.40      136275.00          2          300.00
   8       566938.40      136155.00          2          300.00
```

Table C.2. (contd)

```
                              sp4r1.txt

   9       566602.80      136275.00         3          330.00
  10       566602.80      136395.00         3          330.00
  11       566938.40      136395.00         3          330.00
  12       566938.40      136275.00         3          330.00
  13       566602.80      136395.00         4             .00
  14       566602.80      136577.30         4             .00
  15       566938.40      136577.30         4             .00
  16       566938.40      136395.00         4             .00
 *   SOLUTION RESULTS
 Maximum advection time =    36500.000000
 Accuracy of solution =    1.000000E-04
 Solution basis = buffer zone/advection time
 Total # of source points =        7317
 # of undetected leaks =        186
Monitoring efficiency = 97.5 %.
 *   END OF MAP FILE
```

technetium-99 are also increasing in this well, 466 µg/L and 5,890 pCi/L, respectively, in samples collected on January 13, 2000. In addition, two wells (1 and 3) were proposed to delineate plume extent.

Printouts for the extended network (i.e., existing useable network plus five additional wells as indicated in Figure C.2), using input parameters values as provided above, are presented in Table C.2.

Based on the above analysis and professional judgment regarding actual site conditions (location of obstructions, contaminant observations, site-specific hydrogeology, etc.), the new well locations were chosen for enhancing spatial coverage for this WMA. Additional wells may be needed to further define contaminant movement to assess areal and vertical extent and to eliminate the remaining non-covered area in the southeastern part of the WMA.

C.4 References

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Appendix D

Preliminary Results for Fiscal Year 1999 and Fiscal Year 2000 Detailed Hydrologic Characterization Tests Conducted in the WMA S-SX, TX-TY, and T

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Date September 26, 2000

To V.G. Johnson

From F.A. Spane F.A. Spane

Subject Preliminary Results for FY-99 and FY-00 Detailed Hydrologic Characterization Tests Conducted in the WMA S-SX, TX-TY, and T

This letter report presents preliminary results obtained from detailed hydrologic characterization tests conducted within the WMA S-SX, TX-TY, and T during FY-99 and FY-00. These results are in the process of being formally documented in several PNNL technical reports (e.g., Spane et al. 2000). This letter report is being issued as an interim measure to meet current hydrologic data needs of various WMA projects, prior to formal technical report issuance. The letter report only provides the preliminary results for the various detailed hydrologic characterization test elements, and does not present discussions pertaining to test descriptions, and analytical methods and result comparison. These discussions will be presented in detailed fashion in the subsequent technical reports.

Detailed Hydrologic Characterization Program

As part of the Hanford Groundwater Monitoring Project, Pacific Northwest National Laboratory conducts detailed hydrologic characterization tests within wells at selected locations to provide information pertaining to the hydraulic properties and groundwater flow characteristics of the unconfined aquifer. The following identifies and briefly describes the various characterization components employed in FY-99 and FY-00, as part of the detailed hydrologic characterization program. Various individual test element activities include:

Groundwater Flow Characterization:	for quantitative determination of groundwater flow direction and hydraulic gradient conditions
Barometric Response Evaluation:	for determining well response characteristics to barometric fluctuations; for estimating vadose zone transmission characteristics; and for removal of barometric pressure effects from hydrologic test responses

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Slug Testing:	for evaluating well development conditions and to provide preliminary hydraulic property information (e.g., hydraulic conductivity) for design of subsequent hydrologic tests
Tracer-Dilution Test:	for determining the vertical distribution of hydraulic conductivity and/or groundwater flow velocity within the well-screen section, and for identifying vertical flow conditions within the well column
Tracer-Pumpback Test:	for tracer removal and characterizing effective porosity, an important hydraulic transport parameter
Constant-Rate Pumping Test:	conducted in concert with tracer-pumpback phase. Analysis of drawdown and recovery data provides quantitative, large-scale hydraulic characterization property information, e.g., hydraulic conductivity, storativity, specific yield
Step-Drawdown Test:	for determining well efficiency and well loss for the well-screen section; for removal of well loss effects from hydrologic test response
In-Well Vertical Tracer/Test:	for determining the existence of vertical flow within the well-screen section

Accurate delineation of the prevailing groundwater-flow direction and hydraulic gradient, I, conditions is critical for proper evaluation of groundwater contaminant movement. Within study areas of small size and/or having low gradient conditions, detailed groundwater flow characterization can be difficult. A method that facilitates groundwater flow characterization in such areas is the use of trend-surface analysis of representative monitoring well total head measurements (not well water-level elevation). A description of the use of trend-surface analysis for detailed characterization of groundwater flow conditions is presented in Spane (1999).

Slug testing is designed primarily to provide initial estimates of hydraulic conductivity, K, for the design of subsequent, more quantitative hydrologic tests. At each well, slug tests are conducted using at least two different stress levels to provide information pertaining to well development and possible presence of near-well heterogeneities. A detailed description of the design, performance and analysis of slug test characterizations is presented in Butler et al. (1994) and Butler (1997).

Tracer dilution and tracer pumpack/constant-rate pumping and recovery tests are conducted at single-well sites. For the tracer-dilution test, a bromide solution of known concentration is circulated/mixed within the well-screen section. The decline of tracer concentration (i.e., "dilution") with time within the well screen is monitored directly using a vertical array of bromide specific-ion electrode probes located at known depth intervals. Based on the dilution characteristics observed, the vertical distribution (i.e., heterogeneity) of hydraulic properties and/or flow velocity can be estimated for the formation within the well-screen section. The presence of vertical flow within the well screen can also be identified from the probe/depth dilution response pattern. A description of the performance and analysis of tracer-dilution test characterization investigations is provided in Halevy et al. (1966), Hall et al. (1991), and Hall (1993).

For the tracer pumpback, a constant-rate pumping test is initiated after the average tracer concentration has decreased (i.e., diluted) to a sufficient level within the well screen (usually a 1 to 2 order of magnitude reduction from the original tracer concentration). The objective of the pumpback test is to "capture" the tracer that has moved from the well into the surrounding aquifer. Tracer recovery is monitored by measuring the tracer concentration in water pumped from the well. The time required to recover the centroid of tracer mass/concentration provides information of the aquifer effective porosity, n_e. Effective porosity is a primary hydrologic parameter controlling contaminant transport. Once estimates for n_e, K, and I have been determined, the average aquifer groundwater flow velocity, v_a, can also be calculated.

The constant-rate pumping test may be extended for a time duration longer than required for capturing the tracer centroid. The extended pumping time enables quantitative large-scale characterization of the surrounding hydraulic properties. The time required to obtain representative hydrologic property results can be determined by using diagnostic derivative analysis results of the drawdown data obtained from the pumped and nearby observation well locations. A detailed description of the use of derivative analysis techniques is provided in Spane (1993) and Spane and Wurstner (1993).

Following termination of the constant-rate pumping test phase, the recovery of water levels within the pumped well and surrounding observation wells can also be monitored. The time required for recovery monitoring can be assessed in a manner similar to drawdown data collected during the pumping phase, through the use of diagnostic derivative analysis. For general planning purposes, however, recovery monitoring should be maintained for a period equal to the pumping period and preferably longer. Analysis of the associated pressure drawdown and recovery responses at the surrounding observation wells provides the basis for determining standard, large-scale hydraulic properties within the tested aquifer. These hydraulic properties include: horizontal conductivity (K_h), transmissivity (T), storativity (S), and specific yield (S_y). In addition, detailed hydrologic property characterization obtained from compositely analyzing drawdown and recovery data from multiple observation wells include: vertical anisotropy (K_v/K_h) and horizontal anisotropy (K_{hx}/K_{hy}). The vertical and horizontal anisotropy parameters are the principal hydraulic parameters controlling the directional contaminant transport within the local area.

A group of tables is presented in this letter report that summarize the results from various detailed hydraulic characterization activities. Table 1 provides a summary of the various detailed hydraulic characterization elements. Table 2 lists the preliminary analysis results for hydraulic conductivity and transmissivity determined from slug tests and constant-rate pumping tests. Table 3 presents pertinent information pertaining to tracer-dilution testing, and estimates for lateral groundwater flow velocity within the well screen, v_w. Table 4 presents results of tracer pumpback testing and associated estimates for effective porosity, n_e, and average aquifer groundwater flow velocity, v_a. Table 5 lists the results of groundwater flow characterization (hydraulic gradient, I, and groundwater flow direction), based on trend-surface analysis, for the various well sites selected for tracer testing.

Data Discussion

<u>Table 2</u>

Table 2 presents estimates obtained from slug testing and constant-rate pumping tests. The range for K listed for slug tests represent the average K value as determined using the Bouwer and Rice method and the type-curve matching procedure. Constant-rate pumping test results include the analysis of drawdown and/or recovery data using the methods identified previously. A close correspondence in estimates for K is evident between the two test methods. It should also be noted that the test analysis was completed independently by different analysts, i.e., F.A. Spane: slug tests and P.D. Thorne: constant-rate pumping tests.

<u>Table 3</u>

Table 3 lists pertinent information pertaining to the tracer-dilution tests performed. Several wells exhibited vertical flow conditions (denoted by VF in the table), which largely invalidate the results of the test. The vertical flow conditions detected during the tracer-dilution testing (i.e., well 299-W10-26: downward; well 299-W14-13: downward; and 299-W22-49: upward) were also corroborated independently directly using electromagnetic vertical flowmeter surveys conducted at these wells, as reported in Waldrop and Pearson (2000).

It should be noted that the v_w estimates based on the tracer-dilution tests are strictly for in-well groundwater flow conditions. The relationship between v_w and aquifer groundwater flow velocity, v_a, is shown in equation (1) below:

$$v_w = v_a \, n_e \propto \tag{1}$$

where, $\propto$ = groundwater flow distortion factor; dimensionless, common range 0.5 to 4

Average well flow velocities ranged between 0.007 to 0.311 m/d. It should be noted that the lowest average value of 0.007 m/d recorded at well 299-W22-48 (WMA S-SX), is a result of averaging depth/well velocity conditions that indicate very little flow within the lower part of the well screen. The value of 0.023 m/d indicated for the well screen maybe more reflective of actual aquifer conditions. The highest value of 0.311 m/d calculated for well 299-W15-41 (WMA T) is higher than expected, and may be the result of extraneous hydrologic effects imposed by the nearby 200-ZP-1 pump and treat facility. This well location is well within the potential radius of influence distances reported in Spane and Thorne (2000) and, therefore a possible cause for the observed elevated in-well flow velocities.

To assess the repeatability of the tracer-dilution test results, two separate tests were conducted at well 299-W22-50. A comparison of the tests indicates small, but discernable differences in the associated v_w estimates, i.e., Test #1 = 0.066 m/d; Test #2 = 0.046 m/d. Results for Test #2 are considered to be more representative based on the lower initial tracer concentration used (i.e., possible tracer concentration bias), and the longer tracer-dilution period exhibited.

A comparison of the observed depth/well velocity profiles provided information about permeability distribution within the well-screen sections at four of the wells. At wells 299-W10-24 (WMA TX-TY)and -W15-41 (WMA T) the highest flow velocities (and inferred permeabilities) were exhibited near the middle of the screen, with lowest flow velocities indicated near the top. Conversely, for well 299-W22-48 (WMA S-SX), the highest flow velocity was denoted near the top, with essentially little to no flow indicated for the lower part of the well screen. For well 299-W22-50 (southern boundary of WMA S-SX), relatively uniform depth/well velocity profiles were exhibited, indicating homogeneous conditions throughout the well-screen section. This condition was indicated for both tests conducted at the well site.

<u>Table 4</u>

Table 4 lists pertinent information pertaining to the tracer pumpback tests performed. As noted previously, several wells exhibited vertical flow conditions during the tracer-dilution tests (denoted by VF in the table). The fact that tracer only was emplaced into the aquifer within a small portion of the well screen, seriously impacts the assumptions of the test (which will be discussed in detail in the subsequent PNNL technical report). The tracer pumpback results for those wells affected by vertical flow conditions are highly questionable, and should not be used for quantitative assessment. The estimates calculated from the tests, however, are provided in the table (in parentheses) for only comparison/informational purposes.

Estimates for n_e for the reportable tests ranged between 0.068 and 0.257 (note: Test #2 for well 299-W22-50 is believed more representative, due to the fact that longer tracer drift times are less affected by well effects). This range for n_e falls within the common range usually reported for semi-consolidated to unçonsolidated alluvial aquifers of 0.05 to 0.30, and brackets the large-scale values for specific yield, S_y ($S_y \approx n_e$) of 0.11 and 0.17, reported in Newcomb and Strand (1953) and Wurstner et al. (1995), respectively for the 200-West Area. These large-scale analysis values were based on analyzing the growth and decline of the groundwater mound beneath the 200-West Area, that were associated with water disposal practices in the area.

Estimates for v_a for the reportable tests ranged between 0.013 and 0.374 m/d, and generally fall within a factor of 2 of the calculated in-well flow velocities, v_w. As noted previously for v_w at well 299-W15-41, the observed estimate for v_a of 0.374 m/d at this well site may be elevated due to affects imposed by operation of the adjacent 200-ZP-1 pump and treat system.

Table 5

Table 5 lists groundwater flow characterization results pertaining to determination of groundwater-flow direction and hydraulic gradient, I, conditions at the various test sites during the times of tracer testing. Groundwater-flow direction and hydraulic gradient were calculated using the commercially available WATER-VEL (In-Situ, Inc. 1991) software program. Water-level elevations from neighboring, representative wells were used as input with the WATER-VEL program to calculate groundwater-flow direction and hydraulic gradient conditions during the detailed characterization period. The program utilizes a linear, two-dimensional trend surface (least squares) to randomly located hydrologic head or water-level elevation input data. This method is similar also to the linear approximation technique described by Abriola and Pinder (1982) and Kelly and Bogardi (1989). A report that demonstrates the use of the WATER-VEL program for calculation of groundwater-flow velocity and direction is presented in Gilmore et al. (1992) and Spane (1999).

Calculations of I listed in Table 5 were used for estimates of n_e and v_a shown in Table 4. The indicated easterly groundwater flow directions for WMA S-SX and T sites and the southerly groundwater flow direction for the TX-TY directions is consistent with previous generalizations presented in Hartman et al. (1999) for these areas.

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Table 1. Detailed Hydrologic Characterization Elements

Characterization Element	Activities	Results
Groundwater Flow Characterization	Trend-surface analysis of well water-level data	Quantitative determination of groundwater flow direction and hydraulic gradient
Barometric Response Evaluation	Well water-level response characteristics to barometric changes	Aquifer/well model identification, vadose zone property characterization, correction of hydrologic test responses for barometric pressure fluctuations
Slug Testing	Multi-stress level tests conducted at each well site	Local K_h, T of aquifer surrounding well site.
Tracer-Dilution Testing	Monitoring dilution of administered tracer at injection well site	Vertical distribution of K_h, groundwater flow velocity at injection well location
In-Well Vertical Tracer Test	Monitoring the vertical movement of tracer within the well screen	Determination of vertical flow within the monitoring well screen section
Tracer Pumpback	Pumping/monitoring of recovered tracer and associated pressure response in monitoring wells	Large-scale, interwell n_e, K_h, K_v/K_h, K_{hx}/K_{hy}, T, S, S_y
Step-Drawdown Test	Determine well water-level response to selected pumping rates	Well loss characteristics

Hydrologic parameters:

K_h = horizontal hydraulic conductivity; (L/T)
K_v/K_h = vertical anisotropy; (dimensionless)
K_{hx}/K_{hy} = horizontal anisotropy; (dimensionless)
T = transmissivity; (L^2/T)
S = storativity; (dimensionless)
n_e = effective porosity; (dimensionless)

Table 2. FY-99 and FY-00 Hydraulic Property Test Analysis Summary for WMA TX-TY, T, and S-SX

WMA	Well	Hydrologic Characterization Tests		
		Slug Test	Constant-Rate Pumping Test	
		Equivalent Hydraulic Conductivity K_e m/d	Equivalent Hydraulic Conductivity K_e m/d	Transmissivity T m^2/d
TX-TY	299-W10-26	1.40 – 1.95	1.5	82
	299-W14-13	1.66 – 2.43	2.4	135
	299-W14-14	2.44 – 2.87	--	--
	299-W15-40	0.88 – 1.22	--	--
	299-W15-41	15.1 – 19.5*	19.6**	1130**
T	299-W10-23	1.65 – 2.35	--	--
	299-W10-24	1.04 – 1.68	1.2	66
S-SX	2-W22-48	1.55 - 1.98*	1.81**	127**
	2-W22-49	6.92 – 8.20*	7.17**	520**
	2-W22-50	5.18 – 5.46*	5.24**	385**

Note: unless otherwise indicated, slug test analysis range represents the average analysis value for the Bouwer and Rice and type-curve methods

* slug test results do not include analysis results for Bouwer and Rice method; listed range will be updated when analysis results are complete in FY-01

** preliminary pumping test analysis values, subject to revision; to be documented in FY-01

K_e assumes aquifer with uniform hydraulic conductivity value

-- constant-rate pumping test not conducted at the well site

Table 3. FY-99 and FY-00 Tracer-Dilution Test Analysis Summary for WMA TX-TY, T, and S-SX

WMA	Well	Test Interval m, btoc[a]	Tracer-Dilution Test Results					
			Date Test Initiated	Total Dilution Time t_d min	Average Initial Tracer Concent. C_o mg/L	Average Final Tracer Concent. C_t mg/L	Average Well Flow Velocity v_w m/d	Range Well Flow Velocity v_{wz} m/d
TX-TY	2-W10-26	67.4 - 77.8	4/23/99	7,259	219	<1.0	vf (0.086)	vf (downward)
	2-W14-13	67.1 - 77.9	3/26/99	8,575	VF	VF	VF	VF (downward)
	2-W15-41	66.3 - 71.1	5/8/00	2,714	152	< 1.5	0.311	0.232 – 0.401*
T	2-W10-24	72.4 - 82.6	4/9/99	17,455	148	26	0.012	0.009 – 0.017*
S-SX	2-W22-48	70.5 – 74.3	5/11/00	15,730	141	39	0.007	0.002 - 0.023**
	2-W22-49	67.3 – 71.9	4/17/00	4,175	145	4.0	vf (0.086)	vf (upward)
	2-W22-50	67.5 – 71.9	5/1/00 (Test #1)	5,765	190	5.2	0.066	relatively uniform
			5/26/00 (Test #2)	7,240	148	6.5	0.046	relatively uniform

* permeability profile indicates highest permeability (highest flow velocity) near the middle of well screen; lowest permeability near top

** permeability profile indicates highest permeability (flow velocity) near top of well screen, becoming progressively lower with depth within well screen

C_o estimated initial tracer concentration based linear back-projection of average well screen conditions

C_t average observed well-screen tracer concentration at termination of test

v_w average groundwater flow velocity within well

v_{wz} groundwater flow velocity range within well determined from individual probe/depth-settings

vf slight vertical flow conditions detected adversely affect tracer test results; vertical flow direction indicated in parentheses

VF significant vertical flow conditions in well invalidating tracer-dilution test; vertical flow direction indicated in parentheses

Table 4. FY-99 and FY-00 Tracer-Pumpback Test Analysis Summary for WMA TX-TY, T, and S-SX

WMA	Well	Aquifer Thicknes b m	Hydrologic Characterization Tests						
						Tracer Pumpback Test			
			Pumping Rate Q L/min	Hydraulic Gradient m/m	Trans-missivity T m^2/d	Tracer Drift Time t_d min	Tracer Recovery Time t_p min	Effective Porosity, n_e	Ground-Water Flow Velocity v_a m/d
TX-TY	2-W10-26	55.0	39.5	0.00073	82	7,259	16.0	vf (0.010)	vf (0.124)
	2-W14-13	55.0	48.9	0.00073	135	8,575	43.3	VF (0.009)	VF (0.191)
	2-W15-41	57.6	60.4	0.00129	1130*	2,714	109.0	0.068*	0.374*
T	2-W10-24	54.0	41.2	0.00172	66	17,455	37.1	0.072	0.029
S-SX	2-W22-48	70.1	7.0	0.00180	127*	15,730	159.1	0.257*	0.013*
	2-W22-49	72.5	42.2	0.00206	520*	4,175	14.9	VF (0.671*)	VF (0.022*)
	2-W22-50	73.5	28.5 (Test #1)	0.00206	385*	5,765	43.4	0.354*	0.030*
			29.2 (Test #2)	0.00206	385*	7,240	108.8	0.221*	0.049*

* preliminary hydraulic property estimate values (T); tracer pumpback results subject to revision
t_d time tracer allowed to drift from well into surrounding aquifer prior to pumpback
t_p time required to recover 50% of the tracer mass during the pumpback
v_a groundwater flow velocity within aquifer
(vf) slight vertical flow conditions in well detected; tracer test estimates for n_e and v_a are questionable
VF significant vertical flow conditions in well detected; tracer test estimates for n_e and v_a are highly questionable

Table 5. FY-99 and FY-00 Groundwater Flow Characterization Results Based on Trend-Surface Analysis for WMA TX-TY, T, and S-SX

WMA	Well	Measurement Date	Trend-Surface Analysis Results		
			Groundwater Flow Direction 0° = East; 90° = North	Hydraulic Gradient m/m	Wells Used in Analysis
TX-TY	2-W10-26	5/3/99	288°	0.00073	299-W10-17, -W10-18, -W14-12, -W15-12, -W15-22
	2-W14-13	5/3/99	288°	0.00073	299-W10-17, -W10-18, -W14-12, -W15-12, -W15-22
	2-W15-41	5/8-11/00	286°	0.00129	299-W14-5, -W14-6, -W14-14, -W15-40, -W15-41
T	2-W10-24	4/21/99	5°	0.00172	299-W10-8, -W10-12, -W10-22, -W10-24, -W11-23, -W11-27
S-SX	2-W22-48	5/18/00	2°	0.00180	299-W22-45, -W22-48, -W23-13
	2-W22-49	5/31/00	1°	0.00206	299-W22-49, -W22-50, -W23-14, -W23-15
	2-W22-50	5/31/00	1°	0.00206	299-W22-49, -W22-50, -W23-14, -W23-15

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