RFETS-2002-RFCA-GWMR

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FINAL

2002 Annual Rocky Flats Cleanup Agreement (RFCA) Groundwater Monitoring Report for the Rocky Flats Environmental Technology Site

February 2004

Text and Figures
Appendices on CD

Environmental Media Management
Rocky Flats Environmental Technology Site

Review Exemption: CEX-105-01

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EXECUTIVE SUMMARY

This report summarizes the groundwater monitoring activities at the Rocky Flats Environmental Technology Site (RFETS or Site) for calendar year (CY) 2002. It is required annually by the Rocky Flats Cleanup Agreement (RFCA) as outlined in the Integrated Monitoring Plan (IMP). Specifically, this document discusses groundwater flow conditions, groundwater monitoring in the vicinity of the groundwater remedial systems, groundwater characterization, the extent of groundwater contaminants, environmental persistence evaluations, and the well abandonment and replacement program (WARP) for CY 2002.

Groundwater evaluations and analyses of sampling data presented in this report have been implemented in support of Site closure. To maintain consistency throughout this report, only CY 2002 (and previous) data are used in the analyses described in this document, with the following two exceptions. A summary of the plume degradation evaluation and the CY 2003 "Snapshot" Sampling Project (Snapshot) are presented because of their relevance and importance in making groundwater closure decisions.

The upper hydrostratigraphic unit (UHSU) at RFETS consists of the unconsolidated surficial deposits, weathered bedrock, and sandstones hydraulically connected to the overlying units. Groundwater in the UHSU is unconfined. In most areas, the UHSU conveys very little water; sometimes insufficient for sample collection. Generally, the groundwater table in the UHSU becomes shallower and thinner from west to east across the Industrial Area (IA). UHSU groundwater that has been currently impacted by Site activities discharges to surface water prior to leaving RFETS. The lower hydrostratigraphic unit (LHSU), which consists of unweathered bedrock of the Arapahoe and upper Laramie Formations, is not in hydraulic communication with the overlying UHSU.

Groundwater flow conditions during CY 2002 generally resemble flow conditions described for recent years with slight variations depending on the monitoring location and the localized precipitation variations at RFETS. The main variations observed are a result of regionally dry conditions in CY 2002. This suggests that closure activities undertaken to date have had little impact on the UHSU, especially in the IA.

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The current monitoring results show, as in previous RFCA Annual Groundwater Reports, that volatile organic compounds (VOCs), nitrate, and uranium are the only groundwater contaminants that form plumes of significant areal extent. There are only isolated occurrences of metals above their respective RFCA Tier I action levels. VOCs are the most widespread contaminants at the Site. VOC plumes have locally discharged to South Walnut Creek downgradient (north) of the East Trenches Plume; VOCs have approached Woman Creek downgradient (south) of the 903 Pad and Ryan's Pit. A large portion of the East Trenches VOC Plume is treated by the East Trenches Plume Treatment System (ETPTS).

The need for groundwater accelerated actions will be specifically evaluated in the Sitewide Groundwater Interim Measure/Interim Remedial Action (IM/IRA).

Areas in which performance monitoring of groundwater remedial systems and accelerated actions is conducted include the Mound Site, former Solar Evaporation Ponds (SEPs), East Trenches, 881 Hillside, and Ryan's Pit. Contaminant concentrations in some of the VOC plumes associated with these areas suggest that residual contamination remains where accelerated actions have been completed. These residual VOCs have the potential to impact groundwater for an extended period of time.

The principal nitrate and uranium plume at the Site occurs beneath and downgradient of the former SEPs and is known as the Solar Ponds Plume (SPP). A large portion of this plume is treated by the Solar Ponds Plume Treatment System (SPPTS); however, the northernmost extent of this plume has reached North Walnut Creek.

UHSU groundwater leaving RFETS at Indiana Street is not impacted by Site contaminants. At current RFETS Boundary wells, VOCs and nitrate have not been detected at concentrations above Tier II action levels. Uranium isotopes detected at Boundary well 06491 have been determined to be naturally occurring (RMRS, 2000d).

Decontamination and Decommissioning (D&D) groundwater monitoring activities have been updated for CY 2002. Since only a few of the D&D wells contribute "essential" Site knowledge

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uniquely suited for the purpose of protecting surface water, discontinuation of all or a portion of this monitoring program will be proposed at future IMP meetings.

In CY 2002, conditions at the Present Landfill appear to be generally consistent with the results of previous monitoring. Regardless of the source of groundwater contamination immediately downgradient of the Landfill Pond, there is no significant impact to surface water because surface water discharge along this reach does not occur every year and evapotranspiration losses in No Name Gulch are high. Groundwater monitoring activities associated with the Present Landfill closure will be discussed in the Present Landfill IM/IRA.

A Site-wide plume biodegradation evaluation indicated that the biodegradation of chlorinated solvent compounds dissolved in groundwater is taking place locally in the IA and East Trenches. However, the biodegradation rates are very slow, and are near the low end of the range of rates published for other industrial sites. These slow rates may mean that Monitored Natural Attenuation is not a practical groundwater remedial option for RFETS.

1.0 INTRODUCTION

This Annual Groundwater Monitoring Report summarizes the groundwater monitoring activities and results at RFETS for CY 2002, as required in the Rocky Flats Cleanup Agreement (RFCA, 1996) and outlined in the 2002 Integrated Monitoring Plan (IMP) (Kaiser-Hill [K-H], 2002e).

1.1 Site Description

The RFETS is located 16 miles northwest of Denver in Jefferson County, Colorado. The Site is a U.S. government owned, contractor operated, facility that encompasses approximately 6,550 acres (Figure 1-1). Site ownership, however, does not include surface and subsurface minerals or water rights. Site construction was initiated in 1951 and operations began in 1952.

Prior to the current closure mission, RFETS was part of the nationwide nuclear weapons research, development, and production complex. The plant produced metal components for nuclear weapons from plutonium, uranium, beryllium, and stainless steel. Other production activities included chemical recovery and purification of recyclable transuranic radionuclides, metal fabrication and assembly, and related quality control functions. The plant conducted research and development programs in metallurgy, machining, nondestructive testing, coatings, remote engineering, chemistry, and physics. Parts manufactured at the Site were shipped offsite for final assembly.

Major plant structures, including all production buildings, are located within the centralized 400-acre IA of the Site that is surrounded by a 6,150-acre Buffer Zone (BZ). Industrial activity immediately adjacent to the Site includes present and/or prior coal and clay mining, petroleum recovery, and aggregate quarrying. Other activities include cattle ranching and wind energy research. Several irrigation ditches traverse the Site, transmitting water for downstream agricultural, industrial, and municipal purposes. None of these irrigation ditches receives any water that originates in the IA. Three ephemeral streams, Rock Creek, Walnut Creek, and Woman Creek, and several tributaries and surface water diversion ditches drain the Site and flow eastward (see Figure 1-2).

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1.2 Geology

The Site is situated approximately two miles east of the Front Range of Colorado on the western margin of the Colorado Piedmont section of the Great Plains Physiographic Province (Spencer, 1961). Haun and Kent (1965) have summarized the geologic history of the Colorado Rocky Mountain region, which includes the Site area. The elevation at the Site is approximately 6,000 feet above mean sea level (ft msl). The IA is located on a pediment covered by alluvium. The surface of the alluvium slopes to the east at 1 to 2 degrees. Most of the surrounding BZ is more prominently dissected with intermittent streams. A detailed description of RFETS geology can be found in the Sitewide Geologic Characterization Report (EG&G, 1995a).

1.2.1 Stratigraphy

The approximately 9,000-foot thick stratigraphic sequence that underlies the Site extends from the crystalline Precambrian gneiss, schist, and granites at 3,000 feet below msl to the unconsolidated Quaternary deposits at the surface approximately 6,000 feet above msl. A large amount of lithologic information has been gained with respect to the Site. These data have been obtained from interpretation of aerial photographs, field geologic mapping, coal and aggregate mine development, petroleum exploration, and the completion of hundreds of onsite boreholes and monitoring wells. The generalized stratigraphic section in the area of RFETS is shown in Figure 1-3.

The Cretaceous Pierre Shale and Fox Hills Sandstone underlie the Site, with the latter exposed in quarries along the western boundary. The Cretaceous Laramie and Arapahoe Formations are exposed at the surface or underlie the Site. The Quaternary Rocky Flats Alluvium, and to a limited extent Verdos Alluvium, unconformably overlie the Arapahoe and Laramie Formations in the central portion of the Site. More recent Valley Fill Alluvium and colluvium are also present. The unconsolidated surficial deposits, combined with the weathered portion of subcropping bedrock formations, form the sequence of rocks that have the greatest importance regarding groundwater flow and contaminant transport at the Site.

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1.2.2 Structure

The Site is located along the western margin of the Denver Basin, an asymmetric basin with a steeply east dipping western flank and a gentle west dipping eastern flank. The interpretation of the subsurface structure is generalized in the east-west geological cross section of the Site area presented in Figure 1-4. A monoclinal fold limb west of the Site is the most significant structural feature in the vicinity of the Site. Along the west limb of the fold, an angular unconformity exists between the Cretaceous bedrock and the base of the Rocky Flats Alluvium.

No active faults have been identified at the Site. Several high angle bedrock faults have been inferred to exist in the IA based on various stratigraphic and borehole correlation criteria. These faults appear to have only a limited hydrologic significance with regard to vertical groundwater movement and contaminant transport (RMRS, 1996a).

1.2.3 Hydrology

Characterization of the hydrologic setting is based on the conceptual geologic and hydrogeologic models described in the Sitewide Geoscience Characterization Study (EG&G, 1995a; 1995b; 1995c). These models are used to predict the direction and rate of groundwater flow, identify potential pathways for contaminant migration, and determine the extent of contaminant plumes given varying physical, chemical, and biological factors. Section 3.0 of this report presents current hydrologic conditions at RFETS.

The UHSU at RFETS consists of the unconsolidated surficial deposits, weathered bedrock, and sandstones hydraulically connected to the overlying units. Groundwater in the UHSU is unconfined and is considered to be equivalent to the uppermost aquifer at the Site, although in many areas of the site the amount of water available in the UHSU is insufficient to meet the definition of an aquifer. The depth to UHSU groundwater generally becomes shallower and the alluvial saturated thickness, thinner, from west to east across the IA as the Rocky Flats Alluvium pinches out and the underlying weathered bedrock is closer to the ground surface. All current UHSU groundwater impacted by Site activities discharges to surface water before it leaves RFETS. Beneath the surficial materials and the consolidated deposits of the UHSU are the geologic units of the LHSU. The LHSU consists of the consolidated, unweathered bedrock zone of the Arapahoe and upper Laramie Formations not in hydraulic communication with the overlying UHSU.

1.3 Environmental History

Processing and fabrication of weapons-related components began at the Site in 1952 and continued through 1989. Fabrication of stainless steel components continued in one building, however, through the early 1990s. During operation, environmental protection measures were established that at the time seemed consistent with prudent environmental management. However, some activities resulted in the contamination of portions of the Site. Efforts to investigate the extent of Site environmental releases became a major focus in the 1980s and continue today in accordance with the Resource Conservation and Recovery Act (RCRA), the Colorado Hazardous Waste Act, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the RFCA, an agreement between the U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), and Colorado Department of Public Health and Environment (CDPHE). In addition, a Historical Release Report (HRR) (DOE, 1992a) has been developed that documents contamination arising from past practices and incidents. The HRR is updated on an annual basis with the knowledge gained from ongoing monitoring, accelerated actions, and investigative activities. These annual updates are submitted to the EPA and CDPHE as addenda to the original document.

Documented areas of known or suspected soil contamination have been designated as Individual Hazardous Substance Sites (IHSSs), Potential Areas of Concern (PACs), and Under Building Contamination (UBC). Many of these IHSSs, PACs, and UBCs have been characterized as part of the Remedial Investigation/Feasibility Study (RI/FS) process which was conducted under an Interagency Agreement (IAG, 1991) between DOE, CDPHE, and EPA. Accelerated Actions have been completed at some IHSSs, PACs, and UBCs.

Groundwater investigations at the Site have determined that some IHSSs have released hazardous and radionuclide contaminants to groundwater. The most widespread contamination is that of VOCs. The current extent of VOC contamination in the UHSU is presented in this report. Plume

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definition is subject to professional judgment because of limitations in well coverage, sampling frequency, variability of hydrostratigraphic conditions, local variations in groundwater velocity, and uncertainty regarding some source area locations. Previously published VOC plume maps can be found in past RFCA Annual Reports (RMRS, 1997e; DOE, 1998b; RMRS, 1999m and 2000d; and SSOC, 2001a and 2002b), annual RCRA Groundwater reports (EG&G, 1992; 1993c; 1994b; 1995d; and RMRS/K-H, 1996), the Well Evaluation Report (EG&G, 1994a), and in individual Operable Unit RCRA Facility Investigation/Remedial Investigation (RFI/RI) reports.

Based on spatial distribution, mobility, and concentration considerations, VOCs, uranium (U) isotopes, and nitrate in groundwater at RFETS have the potential to reach surface water in some areas, and have reached it in others. It is important to remember that all current UHSU groundwater impacted by Site activities discharges to surface water before it leaves RFETS. The VOC plumes (and some containing other contaminants) have been defined on the basis of concentration values in comparison to RFCA groundwater Tier I and Tier II action levels. Tier I and Tier II action levels at RFETS are derived from regulated maximum concentration limits (MCLs). Tier II action levels equal the MCLs or equivalent preliminary remediation goals (PRGs), where no MCL exists. To delineate areas of high groundwater contaminant concentrations, Tier I action levels equal 100 x Tier II action levels (or 100 x PRGs where no MCL exists). The most likely sources of VOC contamination were identified using the results of recent and past sampling events and knowledge of Site processes (RMRS, 1996b).
Six VOC groundwater plumes have been identified where contaminant concentrations are above Tier I action levels. These plumes include the IHSS 119.1 Plume, Mound Plume, 903 Pad/Ryan's Pit Plume, Carbon Tetrachloride Plume (IHSS 118.1), East Trenches Plume, and IA Plume (a collection of merged plumes in the central part of the IA). In addition, there is a VOC plume with contaminant concentrations above Tier II action levels associated with the Property Utilization and Disposal (PU&D) Yard.

In addition to the VOC plumes, there is a nitrate and U plume that emanates from the recently closed SEPs. There are also some isolated point sources with constituents that are above Tier II action levels. These are evaluated on a case-by-case basis.

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Much of the groundwater contamination has been addressed by accelerated actions performed by ER. Groundwater remediation systems have been installed downgradient of the Mound Site, East Trenches, and former SEPs. For background information, construction details, and treatment system influent/effluent sampling results, review the *Annual Report for the Rocky Flats Environmental Technology Site Groundwater Plume Treatment Systems, January through December 2002* (K-H, 2003a).

1.3.1 Rocky Flats Cleanup Agreement

The Rocky Flats Cleanup Agreement was adopted on July 19, 1996 (RFCA, 1996). The RFCA replaced the IAG as the environmental cleanup agreement for RFETS. The RFCA outlines the goals, objectives, and strategies that will lead to the RFETS cleanup and closure mission objectives. The Action Level Framework (ALF) attachment to the RFCA contains specific requirements for environmental monitoring and reporting, and it sets action levels for contaminant concentrations in groundwater (identified in Section 1.3.2 of this report) and in other media. The IMP is required under RFCA to implement the monitoring programs at the Site.

To align the groundwater monitoring program with the RFETS closure mission and RFCA requirements, the monitoring network is being reevaluated during 2003 and will be discussed in the 2003 RFCA Annual Report. A data quality objective (DQO) process will be used to determine what decisions are necessary for groundwater and the function of each well in the network in supporting those decisions. DOE, CDPHE, EPA, and stakeholders will be directly involved in decisions involving the monitoring network. The IMP is discussed below.

1.3.2 Integrated Monitoring Plan for Groundwater

The IMP outlines the goals for groundwater monitoring (and other environmental media), and it describes the various components of the groundwater monitoring program. The IMP is presented in two parts: a background document (K-H, 2002e) and a summary document (K-H, 2002f). Factors influencing groundwater-monitoring requirements include the RFCA ALF for groundwater, the Site history and areas of contamination, the physical and hydrogeologic setting of the Site, the effect of contaminated areas on groundwater, the nature of the groundwater contaminant plumes, and remediation of areas of contamination. This information is presented in the IMP Background Document (K-H, 2002f), and Appendices A, B, C, and D of the groundwater section of the IMP Background Document. Appendix E of the groundwater section lists the wells that will be monitored for water quality or groundwater flow.

The IMP serves as the Groundwater Monitoring Plan for the Site, and it replaced the Groundwater Protection and Monitoring Program Plan (EG&G, 1993d). It also revises the requirements of the routine groundwater monitoring portion of the IA IM/IRA Decision Document (DOE, 1994b) and the French Drain Performance Monitoring Plan (DOE, 1992c). The original IMP was published in May 1997. The IMP and IMP Background Document are updated annually with any changes to the monitoring programs.

Most groundwater reporting has been integrated under the IMP. Four quarterly reports are produced that document groundwater concentration values above RFCA action levels. The quarterly reports provide the preliminary groundwater quality analytical data and an evaluation of data quality. A RFCA Annual Groundwater Monitoring Report is also required to summarize all actions taken for groundwater compliance within each calendar year. The RFCA Annual Report provides a summary and interpretation of the extent of groundwater contamination at the Site.

The groundwater monitoring network, as defined in the IMP (K-H 2002f), has eight categories of monitoring wells. These well categories include: Boundary (B), D&D (DD), Plume Definition (PD), Plume Extent (PE), Drainage (D), Performance Monitoring (PM), RCRA, and Plume Degradation (PA). The wells in the 2002 monitoring program and the analytical suites associated with each well can be found in the IMP. The decision rules presented in the original IMP have been retained for determining Tier I and II exceedances of groundwater action levels. The IMP Background Document (K-H, 2002e) provides a detailed discussion of each of these well types.

1.3.3 Changes to the Groundwater Monitoring Program

Wells have been added to or removed from the Site monitoring network based on groundwater character or in support of groundwater evaluations, accelerated actions, and closure activities.

Plate 1 shows the locations of all existing monitoring wells at RFETS, and identifies those that form the active monitoring network as of the end of 2002.

New or replacement wells were installed in several areas to support the groundwater monitoring network. Others were installed for non-routine monitoring purposes. Well abandonments and installations are discussed in detail in Section 8.0, Well Abandonment and Replacement Program. In summary, monitoring wells or piezometers were installed in the following areas:

- Southern IA, in the vicinity of Seventh Sreet
- Downgradient of the PU&D Yard
- IA south of Building 371
- Solar Ponds Plume Treatment System
- Solar Evaporation Ponds
- 903 Pad
- 700 Area/IHSS 118.1
- Building 886

Well installations and replacements were performed largely as part of the WARP. The main purpose of the WARP, which was begun in FY02, is to abandon unnecessary wells and streamline the monitoring network as the Site nears closure. Concurrently, the IMP is revised to reflect the abandonment of wells that were previously actively monitored and the addition of new or replacement wells.

Wells are proposed for removal from the Site monitoring network either to facilitate improvements to the network, because of well damage, or because of Site closure activities. In 2002, most of the changes were either additions to the sampling network or deletions to the flow-monitoring network. These changes are summarized in the table below.

Table 1-1 Changes to the Integrated Monitoring Plan for 2002.

Sampling Location	Previous Purpose	Change and Reason for Change
1587	Real-time flow monitoring	Deactivated: abandoned for 903 Pad remediation
09691	Not active	Activated: replaces 1587 in real-time flow monitoring network
B102289	Flow monitoring	Deactivated: abandoned
B102389	Flow monitoring	Deactivated: abandoned
B111189	Flow monitoring	Deactivated: abandoned
B410589	Flow monitoring	Deactivated: abandoned
B410689	Flow monitoring	Deactivated: abandoned
B410789	Flow monitoring	Deactivated: abandoned
B411289	Flow monitoring	Deactivated: abandoned
46292	Flow monitoring	Deactivated: abandoned
50494	Flow monitoring	Deactivated: abandoned
50694	Flow monitoring	Deactivated: abandoned
51194	Flow monitoring	Deactivated: abandoned
51294	Flow monitoring	Deactivated: abandoned
51594	Flow monitoring	Deactivated: abandoned
63795	Flow monitoring	Deactivated: abandoned
63895	Flow monitoring	Deactivated: abandoned
FD-991-1	D&D monitoring, B991	Deactivated: unable to locate
79102	New well	Activated: monitors SEP source area
79202	New well	Activated: monitors SEP source area
79302	New well	Activated: monitors SEP source area
79402	New well	Activated: monitors SEP source area
79502	New well	Activated: monitors SEP source area
P208998	Inactive	Activated: monitors SEP source area
P207989	Inactive	Activated: monitors SEP source area

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Sampling Location	Previous Purpose	Change and Reason for Change
71102	New piezometer	Activated: flow monitoring downgradient of SPPTS
71202	New piezometer	Activated: flow monitoring downgradient of SPPTS
4386	Flow monitoring	Activated: monitors 903 Pad remediation
00191	Flow monitoring	Activated: monitors 903 Pad remediation
50099	Inactive	Activated: monitors 903 Pad remediation
90402	New well	Activated: monitors 903 Pad remediation
07291	Flow monitoring	Activated: monitors 903 Pad remediation
90502	New well	Activated: monitors 903 Pad remediation
23196	Monitored 903 Pad	Deactivated: not located appropriately
2987	Monitored 903 Pad	Deactivated: not located appropriately
3087	Monitored 903 Pad	Deactivated: not located appropriately
18299	Monitored IHSS 118.1	Deactivated: redundant
18599	Monitored IHSS 118.1	Deactivated: redundant
18699	Monitored IHSS 118.1	Deactivated: redundant
18899	Monitored IHSS 118.1	Deactivated: redundant, dry
21098	Inactive	Activated: monitors IHSS 118.1
41199	D&D monitoring, B886	Destroyed during D&D, replaced with 41102
41102	New well	Activated: B886 D&D; replaced destroyed well 41199
4486	Flow monitoring	Destroyed during D&D, replaced with 44202
44202	New well	Activated: flow monitoring: replaced destroyed well 4486
60699	Inactive	Activated: B707 D&D monitoring
61299	Inactive	Activated: flow monitoring
01097	Inactive	Activated: PU&D Yard biodegradation monitoring
01497	Inactive	Activated: PU&D Yard biodegradation monitoring
01697	Inactive	Activated: PU&D Yard biodegradation monitoring
02097	Inactive	Activated: PU&D Yard biodegradation monitoring
30100	Sampled outside the IMP	Activated: PU&D Yard biodegradation monitoring

Sampling Location	Previous Purpose	Change and Reason for Change
30900	Sampled outside the IMP	Activated: PU&D Yard biodegradation monitoring
20998	Monitored B771	Deactivated: abandoned; replaced with better-constructed 20902
20902	New well	Activated: B771 D&D; replaces 20998
21098	Monitored IHSS 118.1	Deactivated: abandoned; replaced with better-constructed 20902
21002	New well	Activated: IHSS 118.1; replaces 21098
4786	Real-time flow monitoring	Formalized purpose by inserting in IMP

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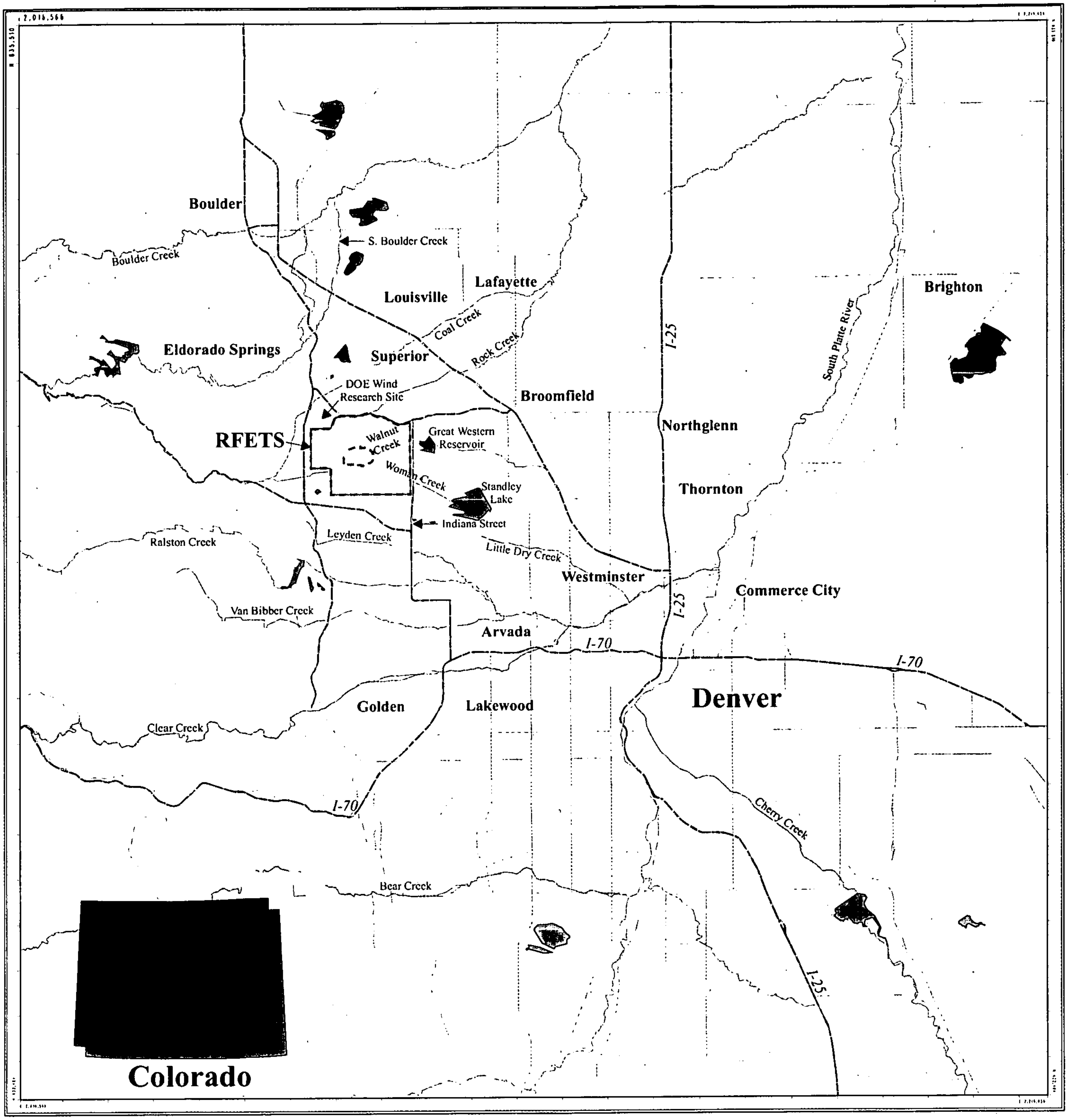

Figure 1-1 Location of Rocky Flats Environmental Technology Site (RFETS) 2002 Annual RFCA Groundwater Monitoring Report

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5,000' 0' 10,000' 20,000'
Scale in Feet

w:/projects/fy2002/02-0781/fig1-1.cdr

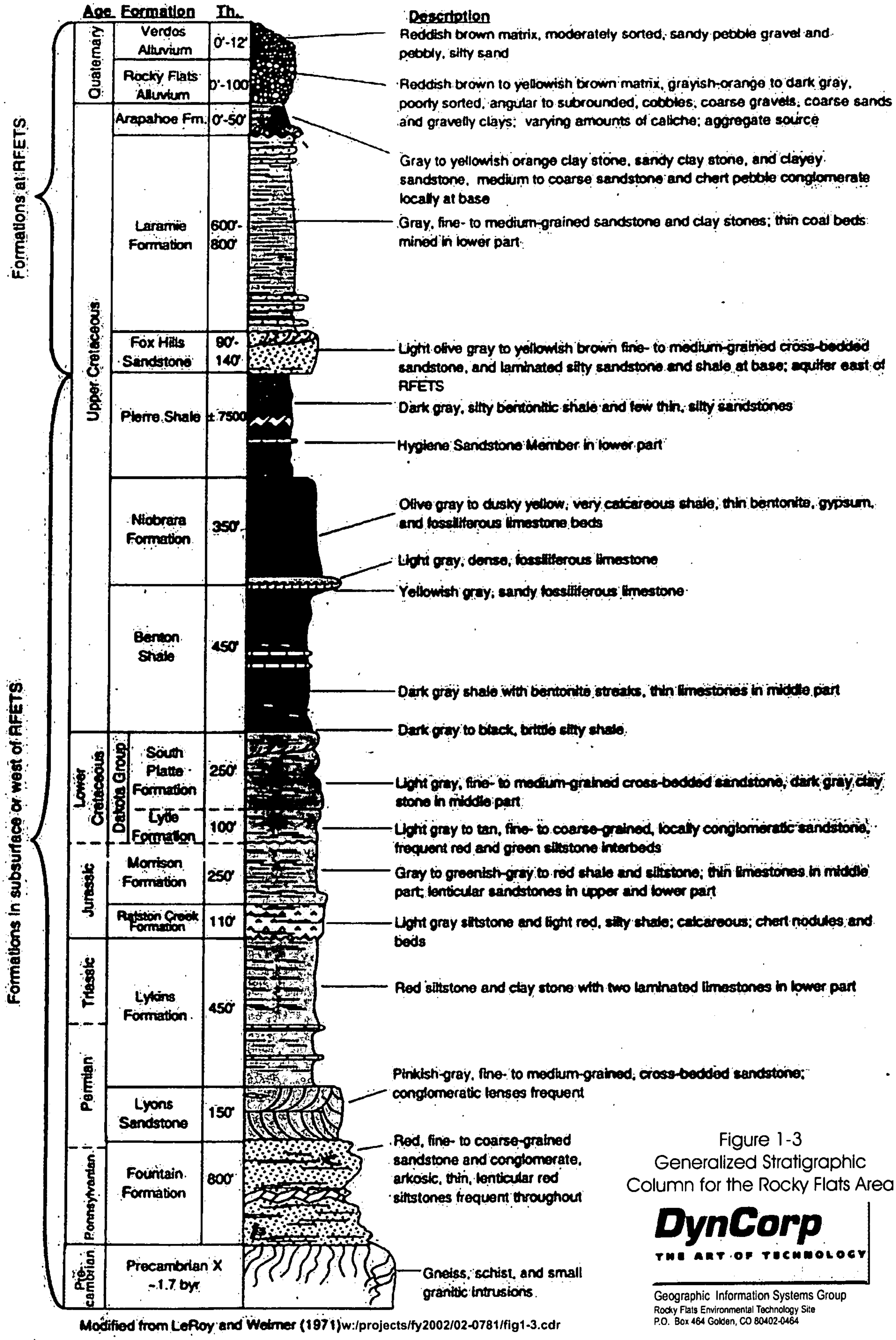

Figure 1-3
Generalized Stratigraphic Column for the Rocky Flats Area

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Geologic Units

- Qv — Verdos Alluvium
- Qrf — Rocky Flats Alluvium
- Ka — Arapahoe Formation
- Kl — Laramie Formation
- Kfh — Fox Hills Sandstone
- Kp — Pierre Shale/Hygiene Member
- Kn — Niobrara Formation
- Kb — Benton Shale
- Kd — Dakota Group
- Jm — Morrison Formation
- TRPl — Lykins Formation
- PIPf — Lyons & Fountain Formations
- p€ — Undivided Igneous & Metamorphic Units

Structural interpretation from EG&G, 1993a.

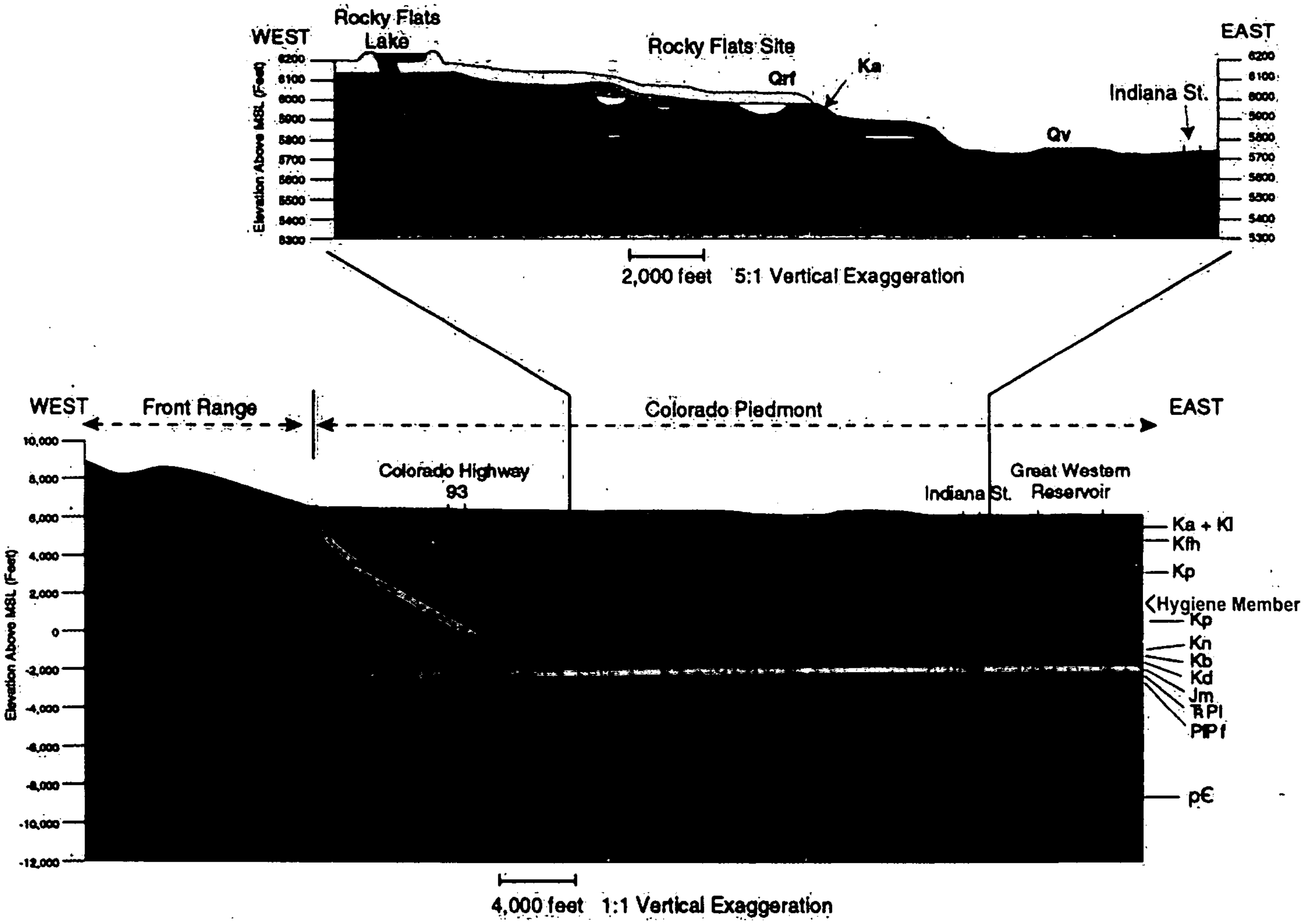

Figure 1-4
Generalized Geologic Cross Section of the Front Range and the Rocky Flats Area

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Projects/fy2002/02-0781/fig1-4.cdr

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2.0 GROUNDWATER FLOW CONDITIONS

Groundwater elevation data collected during CY 2002 were reviewed to determine whether significant changes in groundwater flow direction, flow velocity, and quantity have occurred within the UHSU. For the past several years, CY 1996 data has been used as a sitewide baseline because it was the year prior to the commencement of major D&D activities. In that regard, it was thought that the 1996 data could be used to assess annual changes to the hydrologic regime at RFETS during the remaining years of plant closure and the post-closure monitoring period. To date, there have been no major D&D activities that have greatly impacted or altered the overall hydrologic regime and, therefore, we have chosen 2001 as our current baseline year because of its similarity in annual precipitation to the average yearly precipitation for the Site (Table 2-1).

The hydrologic data review included preparation of 2nd and 4th quarter 2002 potentiometric surface maps, linear flow velocity calculations, and water level change maps. Data review also included a current evaluation of the real-time groundwater-monitoring network, which includes 33 monitoring wells outfitted with downhole automated dataloggers that continuously measure water levels. Comparison of the 2002 data to previous potentiometric surface maps (from previous RFCA Annual Reports) and historical water level trends, presented in the real time groundwater-monitoring well hydrographs, provide a framework for identifying the type of potentiometric configurations, seasonal fluctuations, and long-term trends typically associated with pre-D&D Site operations.

Sitewide precipitation data from 1993 through 2002 (Table 2-1) indicate that the average CY precipitation was 12.7 inches per year, based on averaged rain gauge totals from all RFETS Water Program surface water monitoring stations. This includes the low precipitation amount of 7.9 inches in CY 2002. The CY average before 2002 was 13.2 inches per year; the 2002 total had a noticeable effect on the yearly average.

2.1 Potentiometric Maps

Potentiometric maps of the Site (Plates 2 and 3) were constructed from water level data collected during the 2nd and 4th quarters (April and October, respectively) of 2002. Previously, two potentiometric maps were constructed in the Annual Report for each of the 2nd and 4th quarters. One was for the entire Site,

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including the BZ, and the other was specifically for the IA. Because of the progress of the WARP, there is less areal well coverage and fewer wells; therefore, we have combined the two maps for each quarter into one. The IA portion of each map, which requires greater detail for interpretation of groundwater conditions in specific areas, is drawn with five-foot potentiometric contours.

Potentiometric maps constructed for the UHSU were based entirely on data from wells screened in unconsolidated surficial deposits and weathered bedrock units (including the Arapahoe No.1 Sandstone) thought to be representative of Site shallow groundwater flow conditions. For this reason, wells completed in perched groundwater, such as well 50694 in the West Spray Field, are not utilized for construction of potentiometric contours. Nested UHSU well pairs that show one dry well and the other with a current water level elevation generally consist of one well screened to the base of the alluvium (the dry well); and the other well screened through the base of the alluvium into the upper weathered bedrock, or screened just in the upper weathered bedrock. Areas previously labeled as unsaturated alluvium are evaluated and reconfigured each year utilizing current well coverage and water elevation data. It is important to note that just because an area is mapped as unsaturated alluvium on a potentiometric map does not mean that there is no UHSU groundwater at that location. It is an indication that the well does not fully penetrate the UHSU; instead, it only penetrates the alluvial portion of the UHSU. At that location, the UHSU groundwater is flowing through the weathered bedrock.

The potentiometric maps provide information on groundwater flow direction and alluvial saturated extent that were used in the selection of wells for flow velocity calculations and definition of plume extent and migration. When the measured depth to water was below the bottom of the well screen (in the case where a sump is present), the well was assumed to be dry. Potentiometric contour refinements were made with respect to building foundation drain elevations. Non-contoured areas on Plates 2 and 3 indicate areas where well coverage is absent. These areas have increased substantially, especially in the BZ, as the WARP (Section 8.0) continues to abandon a significant number of wells each year. Information on seep areas was added to Plates 2 and 3 from the 1995 Hydrogeologic Characterization Report (EG&G, 1995b). The seep areas are probably less extensive than depicted on the maps because of the relatively dry conditions experienced in 2002. Seep areas may be overlain by a current area of unsaturated alluvium. This situation can exist because the seep may be a result of an area of saturated weathered bedrock that crops out on a hillside or the alluvium/colluvium at a specific location may be eroded or slumped.

The more detailed configuration of the IA potentiometric surfaces were prepared to facilitate more precise groundwater evaluations where there is denser well coverage and building foundation drains. In the future, after the completion of D&D activities, the effects of certain building foundation drains may still be observed. If the drains are gravity flow in nature, they will continue to impact the water table even after a given building has undergone D&D. This assumes that structures that are below ground level are left in place and not completely plugged, including the backfilled foundation drain trench. In the case of a building where the foundation drain does not operate by gravity flow, but rather groundwater is collected and pumped, the water table should equilibrate within and around the building to a normal elevation after D&D activities cease and the pumping system is inoperable.

The configuration of the 2nd and 4th quarter Site potentiometric surfaces (Plates 2 and 3), depicted on a 20-foot contour interval in the BZ and on a five foot contour interval in the IA, generally matches the configurations depicted in previous Annual Reports. Plant operations appear to have locally impacted groundwater flow patterns in areas where potentiometric contours deviate from ground surface topography and/or bedrock surface topography. The presence of irregular potentiometric contours suggests that the groundwater surface is influenced by the presence of subsurface barriers, sinks (such as foundation drains and storm drains), subsurface utility corridors, and extensive paved areas. The configuration of potentiometric contour lines in the immediate vicinity of Buildings 371/374, 771/774, 991, and the entire area encompassed by buildings 881, 883, 865, and 886 suggest that foundation drains have localized impacts on UHSU groundwater flow in the IA (Plates 2 and 3). Compressed potentiometric contours on these maps indicate steeper hydraulic gradients in many of those areas that are associated with building foundation drains and/or steep hillsides. The most extensive area of steep hydraulic gradient and redirected flow lines exists in the northwest and north-central IA. This area, including Buildings 371/374, 566, the northwest portion of 776, and the southeast portion of 771, presents a complex combination of artificial and bedrock controls on the UHSU potentiometric surface configuration.

Unsaturated alluvium depicted on the 2002 maps was more extensive than shown on maps presented in previous Annual Reports. A comparison of the 2002 to 2001 potentiometric maps, with respect to unsaturated alluvium, revealed that the 2002 maps for both the 2nd and 4th quarters exhibited much more extensive areas. The main areas where the 2002 maps exhibited more unsaturated alluvium than the 2001 maps are listed below:

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- The area encompassing and east-northeast of the 903 Pad;
- The area encompassing and northeast of the former SEPs;
- The area encompassing Building 881 and west of Building 881 (the area of former Building 850); and
- The area south of the Landfill Pond.

In addition, on the 4th quarter 2002 map, there is an area of unsaturated alluvium on the hillside above Woman Creek, to the south of the Building 400 complex, which is much more extensive than the 2nd or 4th quarters of 2001. In part, these conditions probably reflect the fact that almost no precipitation occurred during the second half of 2001 and the Site precipitation total for 2002 was well below average. Table 2-1 presents the average RFETS precipitation, by CY, since 1993. Table 2-1 also shows the mean precipitation for the periods 1993 through 2001 and 1993 through 2002.

Table 2-1 Calendar Year Precipitation Totals.

Calendar Year	Average Precipitation (inches)
1993	12.26
1994	10.64
1995	16.50
1996	12.36
1997	15.05
1998	12.86
1999	14.30
2000	12.29
2001	12.76
2002	7.94
1993 – 2001 (mean)	13.2
1993 – 2002 (mean)	12.7

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2.2 Average Linear Flow Velocities

Linear flow velocities can be used together with potentiometric and water level change maps, real-time water level hydrographs, and chemistry data to evaluate contaminant plume migration toward surface water. Groundwater flow velocities can be used as estimates of the migration rate for conservative (i.e., non-reactive) groundwater constituents. Because they do not consider the effects of sorption and chemical reactions (e.g., volatilization, biodegradation, and dissolution/precipitation) on the concentrations of constituents along a flowpath, seepage velocities approximate only the unattenuated migration rate for dissolved constituents in groundwater. Reactive constituents will likely exhibit migration rates slower than the average linear velocity of groundwater flow. Using data from wells that are screened across different lithologies could also result in variation between actual contaminant migration rates and average calculated rates.

Average horizontal linear groundwater flow velocities (seepage velocities) were calculated for UHSU well pairs located generally within and adjacent to the IA (Figure 2-1). The original list of linear flow velocity well pairs was amended in the 2001 Annual Report to include wells which are pertinent to current and future groundwater monitoring and Site closure activities, and because in certain areas of the Site the alluvium has become unsaturated because of climatic conditions. In addition, discrete areas of RFETS have had the local hydrologic regime altered by remediation systems (i.e., groundwater collection trenches or treatment cells). In future RFCA Annual Reports, the well pair list may vary each year depending on the current groundwater monitoring objectives, water table conditions at that time, and the availability of remaining Site wells in pertinent locations. The current well pairs were selected based on flowpaths derived from data depicted on the 2002 potentiometric surface maps (Plates 2 and 3).

The Darcy equation was used to calculate the seepage velocity (v):

$$v = \frac{K}{n}(dh / dl)$$

where:

K = hydraulic conductivity
n = effective porosity
dh/dl = hydraulic gradient

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Values for hydraulic gradient were calculated from CY 2002 quarterly or biannual water level measurements made between well pairs located along an identified groundwater pathway. The current well pairs were chosen on the basis of their perpendicular or nearly perpendicular orientation to potentiometric contour lines (i.e., flow lines). Hydraulic conductivity values used for velocity calculations were obtained from the geometric mean values reported for the Rocky Flats Alluvium (Qrf), Quaternary colluvium (Qc), Valley Fill Alluvium (Qvf), and weathered bedrock Arapahoe No.1 Sandstone (KaNo.1ss) presented in Table G-2 of EG&G (1995b). For each well pair, the K value chosen for the calculation was based on the predominant lithologic unit comprising the flowpath between the wells. In the case of four well pairs, the K value utilized was the average of the hydraulic conductivities of the Qrf and the Qc, Qrf and the Qvf, or Qc and the KaNo.1ss. This was done because approximately half of the lengths of the groundwater flowpath for each well pair were located in each of the Qrf and Qc, Qrf and Qvf, or Qc and KaNo.1ss. In the absence of measured values of *n* (effective porosity), a conservative value for unconsolidated material of 0.1 is assumed based on its usage in previous velocity calculations performed at RFETS.

The Site K values calculated for the Qrf and the Qvf have changed since the 1999 RFCA Annual Report. The previously used data, presented in Table G-2 of EG&G (1995b), did not include data from approximately 40 aquifer tests performed in 1995. These tests were performed only on wells completed in the Qrf and Qvf; therefore, the geometric mean K values calculated for the other water bearing formations listed in Table G-2 have not changed. The geometric mean K value for the Qrf changed from 2.10×10^{-4} cm/sec to 4.18×10^{-4} cm/sec based on the new data. The geometric mean K value for the Qvf changed from 2.54×10^{-3} cm/sec to 9.197×10^{-4} cm/sec based on the new data.

Linear flow velocity calculations are sensitive mainly to the magnitude of the hydraulic gradient (order of magnitude or greater changes) and also to the K value (factor of four to five change between Qrf and Qc); the assigned value of *n* being constant. Hydraulic gradients are usually higher on hillslopes; the hydraulic gradients associated with Qc in this discussion are generally an order of magnitude higher than hydraulic gradients associated with Qrf.

Table 2-2 presents calculated 2nd and 4th quarter 2002 linear flow velocities. As shown in Table 2-2, the calculated 2002 groundwater flow velocities for all formations ranged from a minimum of 41.3 ft/yr on

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the pediment northwest of the IA, to a maximum of 717.4 ft/yr downgradient of the Mound Site. The minimum value is associated with the Qrf; the maximum value is associated with the KaNo.1ss.

Linear flow velocities calculated for the Qrf ranged from 41.3 ft/yr to 181.1 ft/yr. Linear flow velocities calculated for the Qc ranged from 83.6 ft/yr to 233.3 ft/yr. Linear flow velocities calculated for the two well pairs completed in the KaNo.1ss ranged from 663.5 to 717.4 ft/yr. The linear flow velocity for the one well pair completed in Qvf averaged 502.3 ft/yr. In general, flow velocity ranges for the Qrf and the Qc are similar. The average linear flow velocity for the Qrf is 90.7 ft/yr; the average for the Qc is 119.7 ft/yr. The flow velocities for the two well pairs where the K value consists of the averaged K values of the Qrf and Qc ranged from 49.2 ft/yr to 230.3 ft/yr with an average of 139.8 ft/yr. The average flow velocity for the well pair where the K value consists of the averaged K values of the Qrf and Qvf was 437.0 ft/yr. The average flow velocity for the well pair where the K value consists of the averaged K values of the Qc and KaNo.1ss was 645.2 ft/yr.

For well pairs that were represented by both 2nd and 4th quarter 2002 data, the flow velocities are consistent between the quarters; always within 10 percent. Differences in flow velocity from quarter to quarter result from variations in the hydraulic gradient that are caused by seasonal fluctuations in water levels at one or both of the two wells constituting a well pair.

Historically, the major changes in flow velocities (when comparing previous years with data for the same well pairs, for instance 1996 and 2000) were at well pairs located in or immediately downgradient of the IA. Current and flow velocities are generally higher than velocities reported in pre-1996 annual RCRA groundwater monitoring reports largely because sitewide mean K values are now employed in the calculations instead of the OU-specific mean K values that were used in the past.

The area encompassed by well pair 1490/1290, located on the pediment northwest of the IA, may be most representative of the actual flow velocity of groundwater through a relatively level portion of Qrf without the anthropogenic affects of the IA. Regardless of the anthropogenic effects of the IA, the Qrf, Qc, and Qvf are heterogeneous materials and linear groundwater flow velocity variations are inherent within these materials from location to location.

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Table 2-2 Linear Flow Velocities.

Well Pair	Area	2002 Qtr	Geologic Unit	WL Elevation Well 1	WL Elevation Well 2	dh (ft)	dl (ft)	dh/dl (hydraulic gradient)	K (cm/sec)	n	v (cm/sec)	v (ft/yr)	Time to Traverse Transect (yrs)
P415989 60399	West Central IA	2	Qrf	6034.29	5979.64	54.65	2904.50	0.0188	4.18E-04	0.1	7.86E-05	81.4	35.69
P415989 60399	West Central IA	4	Qrf	6032.69	Dry	ND	2904.50	ND	4.18E-04	0.1	ND	ND	ND
P416089 P416689	Southwest IA	2	Qrf	6037.74	6005.31	32.43	1304.07	0.0249	4.18E-04	0.1	1.04E-04	107.6	12.13
P416089 P416689	Southwest IA	4	Qrf	6035.38	6005.47	29.91	1304.07	0.0229	4.18E-04	0.1	9.59E-05	99.2	13.15
10498 40499	Buildings 123/444	2	Qrf	6024.73	6007.76	16.97	438.06	0.0387	4.18E-04	0.1	1.62E-04	167.5	2.61
10498 40499	Buildings 123/444	4	Qrf	6026.08	6007.74	18.34	438.06	0.0419	4.18E-04	0.1	1.75E-04	181.1	2.42
40499 P416889	Building 444 and SE	2	Qrf	6007.76	6000.54	7.22	593.80	0.0122	4.18E-04	0.1	5.08E-05	52.6	11.29
40499 P416889	Building 444 and SE	4	Qrf	6007.74	6000.07	7.67	593.80	0.0129	4.18E-04	0.1	5.40E-05	55.9	10.63
41299 62893	Building 444 to OU5	2	Qrf Qc	6006.1	5994.48	11.62	625.00	0.0186	2.56E-04*	0.1	4.75E-05	49.2	12.71
41299 62893	Building 444 to OU5	4	Qrf Qc	6005.61	5993.47	12.14	625.00	0.0194	2.56E-04*	0.1	4.97E-05	51.4	12.16
56994 57094	OU5, Old Landfill	2	Qc	6003.15	5938.18	64.97	268.79	0.2417	9.33E-05	0.1	2.26E-04	233.3	1.15
56994 57094	OU5, Old Landfill	4	Qc	6003.3	Dry	ND	268.79	ND	9.33E-05	0.1	ND	ND	ND
12191 95899	East Trenches	2	KaNo.1ss	5927.88	5888.46	39.42	484.38	0.0814	7.88E-04	0.1	6.41E-04	663.5	0.73

Well Pair	Area	2002 Qtr	Geologic Unit	WL Elevation Well 1	WL Elevation Well 2	dh (ft)	dl (ft)	dh/dl (hydraulic gradient)	K (cm/sec)	n	v (cm/sec)	v (ft/yr)	Time to Traverse Transect (yrs)
12191 95899	East Trenches	4	KaNo.1ss	5928.13	5888.61	39.52	484.38	0.0816	7.88E-04	0.1	6.43E-04	665.2	0.73
37191 61295	OU1, 881 Hillside	2	Qc	5935.87	5863.35	72.52	547.96	0.1323	9.33E-05	0.1	1.23E-04	127.8	4.29
37191 61295	OU1, 881 Hillside	4	Qc	5934.26	5862.8	71.46	547.96	0.1304	9.33E-05	0.1	1.22E-04	125.9	4.35
0987 23096	904 Pad Ryan's Pit	2	KaNo.1ss Qc	5962.15	5825.53	136.6	966.82	0.1413	4.41E-04**	0.1	6.23E-04	644.8	1.50
0987 23096	904 Pad Ryan'sPit	4	KaNo.1ss Qc	5962.3	5825.5	136.8	966.82	0.1415	4.41E-04**	0.1	6.24E-04	645.6	1.50
06991 90099	903 Pad Ryan's Pit	2	Qc	5953.73	5839.04	114.7	1171.90	0.0979	9.33E-05	0.1	9.13E-05	94.5	12.40
06991 90099	903 Pad Ryan's Pit	4	Qc	Abandoned	Dry	ND	1171.90	ND	9.33E-05	0.1	ND	ND	ND
00897 02291	Mound	2	KaNo.1ss	5945.94	5922.57	23.37	265.60	0.0880	7.88E-04	0.1	6.93E-04	717.4	0.37
00897 02291	Mound	4	KaNo.1ss	5945.85	5922.96	22.89	265.60	0.0862	7.88E-04	0.1	6.79E-04	702.6	0.38
00100 70799	Solar Ponds	2	Qrf Qc	5969.77	5884.7	85.07	977.21	0.0871	2.56E-04*	0.1	2.23E-04	230.3	4.24
00100 70799	Solar Ponds	4	Qrf Qc	5970.88	Dry	ND	977.21	ND	2.56E-04*	0.1	ND	ND	ND
P207889 1386	Solar Ponds	2	Qc	5957.5	5837.07	120.4	1390.60	0.0866	9.33E-05	0.1	8.08E-05	83.6	16.63
P207889 1386	Solar Ponds	4	Qc	Dry	5833.24	ND	1390.60	ND	9.33E-05	0.1	ND	ND	ND
85102 56301	West Central IA	2	Qrf	6009.29	5984.37	24.92	1140.60	0.0218	4.18E-04	0.1	9.13E-05	94.5	12.07
85102 56301	West Central IA	4	Qrf	6010.06	5988.17	21.89	1140.60	0.0192	4.18E-04	0.1	8.02E-05	83.0	13.74

Well Pair	Area	2002 Qtr	Geologic Unit	WL Elevation Well 1	WL Elevation Well 2	dh (ft)	dl (ft)	dh/dl (hydraulic gradient)	K (cm/sec)	n	v (cm/sec)	v (ft/yr)	Time to Traverse Transect (yrs)
56301 1986	B371/B771 Drainage	2	Qrf Qvf	5984.37	5941.09	43.28	718.80	0.0602	6.69E-04***	0.1	4.03E-04	416.7	1.72
56301 1986	B371/B771 Drainage	4	Qrf Qvf	5988.17	5940.68	47.49	718.80	0.0661	6.69E-04***	0.1	4.42E-04	457.2	1.57
P114789 1986	B371/B771 Drainage	2	Qvf	6003.24	5941.09	62.15	1187.50	0.0523	9.20E-04	0.1	4.81E-04	498.0	2.38
P114789 1986	B371/B771 Drainage	4	Qvf	6003.89	5940.68	63.21	1187.50	0.0532	9.20E-04	0.1	4.90E-04	506.5	2.34
02097 B208789	PU&D Yard	2	Qc	5966.76	5902.81	63.95	719.16	0.0889	9.33E-05	0.1	8.30E-05	85.8	8.38
02097 B208789	PU&D Yard	4	Qc	5966.45	5901.52	64.93	719.16	0.0903	9.33E-05	0.1	8.42E-05	87.2	8.25
1490 1290	Northwest BZ	2	Qrf	6015.7	5987.19	28.51	2957.22	0.0096	4.18E-04	0.1	4.03E-05	41.7	70.93
1490 1290	Northwest BZ	4	Qrf	6014.97	5986.75	28.22	2957.20	0.0095	4.18E-04	0.1	3.99E-05	41.3	71.65

Notes: ND = no data; * = averaged K value of Qrf and Qc, ** = averaged K value of Arapahoe No. 1 sandstone and Qc, *** = averaged K value of Qrf and Qvf

2.3 Water Level Change Maps

If groundwater levels within RFETS have reached a steady-state condition since the cessation of production operations in 1989, it is conceivable that Site D&D activities could disrupt the stasis and cause water levels in specific areas of the Site to rise or fall, depending on the closure action. Water level change maps (Figures 2-2 and 2-3) were prepared comparing 2nd and 4th quarter data from 2002 and 2001. As discussed in the introduction to Section 2.0, 2001 is the current baseline year.

Figures 2-2 and 2-3 were prepared utilizing the difference between 2002 and 2001 water levels at wells that had water level measurements in common for the two periods. The water level change maps indicate areas of the site where changes in saturated thickness, either positive or negative, have taken place between the baseline year (2001) and the current year (2002). It is important to note that wells that were purged (for sample collection) prior to the utilized water level measurement, and that have a slow recharge rate, can reflect a large discrepancy in water level change from the baseline year to the current RFCA Annual Report year. Well locations are labeled as dry on the water level change maps if they are determined to be dry for both years that are being compared. If a well is dry for only one of the two years (for a given quarter), the data are not utilized because there is no logical way to determine the amount of water level change.

Although precipitation at the Site was well below average during 2002, water levels, for the most part, fluctuated within previously observed ranges. Seventy-five percent of the 2002 precipitation fell during the 2nd and 3rd quarters of 2002. Many Site wells had higher water levels during the typically drier 4th quarter than the 2nd quarter, which is typically wetter. There were nine percent more dry wells during the 4th quarter of 2002 as compared to the 2nd quarter. This suggests that although the recent (2nd and 3rd quarter 2002) recharge had some effect on water levels, the overriding effect is less saturated alluvium/colluvium in certain areas of the Site. Overall, groundwater levels were lower in 2002 than 2001. 2001 water levels were thought to reflect the residual influence of the generally high precipitation experienced in 1995 through 1999 (an average of 14.2 inches per year).

2.3.1 Comparison of Second Quarter 2001 and 2002

Figure 2-2 indicates that there was generally a negative (i.e., lower in 2002) to negligible water level change at the Site between 2nd quarter 2001 and 2002. More negative areas occur in the west half of the IA and westward. The eastern portion of the Site generally exhibits negligible water level change, but includes many dry wells.

The IA experienced negligible (0.5 to -0.5 feet; effectively no change), slightly negative (-0.5 to -1 feet), and moderately negative (-1 to -5 feet) water level changes during 2002 as compared to 2001. Areas of negligible change in the IA include the area encompassing the Solar Ponds and east and southeast through Building 991; and the area encompassing Buildings 559, 776, 707, the 750 Pad and south and east through the 904 Pad and the western portion of the 903 Pad. In addition, the area south and west of Building 371/374 and the area around Building 444, especially south and east, showed negligible change. The IA experienced slightly negative water level change in the area north and east of Building 371/374 and extending across the North Perimeter Road. The IA experienced moderately negative water level change in an area northeast, east, and southeast of Building 771, and another area to the north, west, and southwest of Building 460. There were only eight wells in the IA that showed a positive water level change in 2002 versus 2001. Positive water level changes (i.e., higher in 2002) typically occur at individual wells and are not areally extensive.

In the western BZ, a large area of moderately negative water level change extends west, north, and south of the Building 130 area encompassing the T130 area and the Raw Water Reservoir. The Present Landfill exhibits the most dynamic area of water level change with the western portion of the landfill (including the northeast portion of the PU&D Yard) exhibiting moderately negative water level change, and the extreme eastern portion of the landfill, the steep eastern face, and western half of the Landfill Pond exhibiting moderately (1 to 5 feet) positive water level change. The extensive area of moderately positive water level change east/southeast of the Present Landfill, encompassing Ponds A-1 and A-2, is due the positive change in the isolated well located within the drainage between the two ponds. Another area of moderately positive water level change is observed along the southeast perimeter of the IA. As stated above, the eastern BZ exhibits a large area of generally negligible water level change; the southern BZ is similar.

2.3.2 Comparison of Fourth Quarter 2001 and 2002

Figure 2-3 indicates that there were generally moderately negative to negligible water level changes from 4th quarter 2001 to 2002. From the central portion of the IA to the east there were numerous, varied instances of water level change, mostly negative; to the west from the center of the IA a consistent negative change is depicted. The northern, southern, and eastern BZ exhibits large areas of generally negligible water level change. The eastern/southeastern BZ includes many dry wells.

The IA experienced moderately positive (1 to 5 feet) to moderately negative (-1 to -5 feet) water level change during 2002 as compared to 2001. For 4th quarter data, the western half of the IA generally exhibited negligible (-0.5 to 0.5 feet) water level change and the eastern half of the IA generally exhibited slightly negative (-1 to -0.5 feet) water level change during 2002 as compared to 2001. The exceptions in the western half of the IA were moderately positive water level changes north and east of Building 444, along the eastern portion of Buildings 707 and 777, encompassing Building 750, and along the northern side of the Building 771 complex. Exceptions occur in the eastern half of the IA where areas of moderately negative water level change occur around the SEPs; north of Buildings 776 and 779; and the Water Treatment Plant, all of which are superimposed on an a larger area of slightly negative water level change encompassing the eastern third of the IA. Positive water level changes typically occur at individual wells and are not areally extensive.

For the 4th quarter data, the entire western BZ and the northern BZ east to approximately the center of the Present Landfill consists of an area of moderately negative water level change when comparing 2002 to 2001. The rest of the northern BZ and the southern BZ are generally areas of negligible water level change with isolated wells exhibiting moderately positive and negative changes. East of the IA, in the area of the East Trenches and extending north to South Walnut Creek, there is an area of moderately negative water level change, which is superimposed on a larger area of slightly negative water level change that extends east on both sides of South Walnut Creek.

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2.4 Real-Time Groundwater Monitoring Network

As a requirement of the IMP, a real-time water level monitoring network was established for the UHSU during late 1998, and expanded during 1999. The network currently consists of 33 monitoring wells equipped with downhole Troll® data loggers. The 33 monitoring stations were chosen based on location, historical groundwater occurrence at each location, stratigraphic completion interval, and monitoring well construction details. As shown on Figure 2-4 and Plate 4, monitoring wells utilized for the real time groundwater monitoring network are located to provide sitewide coverage with additional specific coverage in the IA, immediately east (downgradient) of the IA, and in the north BZ. In addition, locations were chosen to monitor water levels in Qc, Qrf, and Qvf deposits, and weathered bedrock units within the UHSU. The arrangement of Trolls® allows observation, simultaneously across the Site, of the impact of a precipitation event on the UHSU. The location of the Trolls® within the various sedimentary depositional environments and weathered bedrock units which comprise the UHSU allows for a better understanding of the relationship between groundwater and surface water at various locations around RFETS.

The monitoring wells in the 2002 real-time groundwater monitoring network include: 0186, 1086, 3686, 3986, 4786, 5586, 6886, 0187, 1487, 1587 (replaced by well 09691 in June 2002, see discussion below), 4287, P114889, P115489, P119389, P209889, P213689, P414189, P415889, P416589, B200589, B200889, B210489, 1190, 03791, 05191, 20691, 20991, 37591, 77492, 05293, 10794, 11494, and 51494.

The goals of the real-time groundwater monitoring network are to provide ample, concurrent, water level measurements for environmentally or hydrogeologically sensitive areas of RFETS, such as beneath and downgradient of the IA; along stream channels to the north, south, and east of the IA; and in undisturbed or background areas. Hydrographs for the real-time groundwater monitoring network wells are presented on Plate 4. In addition to illustrating seasonal and diurnal fluctuations in water table elevation, hydrographs are useful for evaluating trends that might result from either anthropogenic activities (plant closure) or natural causes (climate). The analysis of hydrograph data from IA wells versus hydrograph data from wells upgradient or downgradient of the IA may suggest whether trends observed in the IA are natural or anthropogenic. These data, also utilized for the Site-wide Water Balance (SWWB) (K-H, 2002c), are important to modeling and understanding groundwater dynamics on a short-term scale that quarterly or even monthly water level measurements do not allow. Combined with precipitation and surface water monitoring data, this information allows a greater understanding of the effects of infiltration events and ET on the UHSU.

Data presented on Plate 4 are from calendar years 1999 through 2002. Data downloaded from the real-time monitoring network for CY 2002 are complete except for wells 1587 and P209889. Well 1587 was removed from the real-time groundwater monitoring network on June 6, 2002, and subsequently abandoned because of the remediation of the 903 Pad. The Troll® from this well was decontaminated and placed in well 09691, which is located approximately 400 feet southeast of the 903 Pad, on June 6, 2002. In addition, well P209889 had very little data available for CY 2002. When an attempt was made to download the data from the Troll® in this well in April of 2002 (for the 2001 Annual Report) it was found to have failed. Data retrieved from it by In-Situ, Inc. were collected through September 2, 2001 (as depicted on Plate 14 of the 2001 Annual Report). The unit was repaired by In-Situ, Inc. and replaced in well P209889 on September 6, 2002. There is a data gap on the hydrograph for this well from early September 2001 until early September 2002.

Data presented in this Annual RFCA Groundwater Monitoring Report from the real-time groundwater monitoring network has been analyzed for the period of January 1999 through December 2002. Four annual cycles of water level fluctuations and precipitation data are displayed. Plate 4 presents the 33 monitoring locations with a hydrograph of the groundwater elevation data collected from each station. Please note that the water table elevation scale, located on the left side of the hydrograph, encompasses a span of 16 feet on each graph. Sixteen feet is the greatest variation seen at any of the wells and allows for the reader to see the relative magnitude of water level change at each well. Superimposed on each hydrograph is precipitation data from the nearest RFETS surface water station instrumented with a rain gauge. There are a few gaps in the precipitation data because of problems that are inherent with unheated rain gauges.

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Comparison of 2002 groundwater level data with the past real-time monitoring record (1999 through 2001) suggests the following:

- The hydrographs indicate that responses to precipitation events and subsequent groundwater recharge are varied and depend on the location and hydrologic parameters at the specific monitoring locations.

- Wells located in the western and northern BZ exhibit background baseflow without the anthropogenic effects of the IA, and they generally show a very subtle response to below average precipitation as compared to above average precipitation. Two wells immediately east of the IA exhibit this same phenomenon. Three western BZ wells showed no seasonal (spring) recharge on their hydrographs during 2002.

- Certain wells located east and southeast of the IA exhibit almost no recharge during lower than average precipitation year 2000 and no recharge during 2002.

- Certain wells located in the IA exhibit a relatively greater response to the below average precipitation that occurred during 2002 than BZ wells.

- Wells located in or adjacent to streambeds are the most sensitive to precipitation and pond discharge events with respect to groundwater recharge and dewatering response times and hydrographs graphically show the effects of evapotranspiration (ET) depending on the season.

Data collected from the real-time groundwater monitoring network during 2002 indicates that the Site experienced lower water levels in 2002 than the previous years depicted on the hydrographs. The 2002 data also show that there is less fluctuation of the water levels, and the wells were generally less responsive to recharge events in 2002.

Hydrographs from the series of BZ wells, trending from the south to the north and then northeast along the pediment surface northwest and north of the IA, reflect in-situ groundwater baseflow conditions without the anthropogenic effects of the IA. Generally, these wells exhibit a high

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water level achieved during the spring or summer of 1999 because of the high precipitation during 1999. Most show minimal spring responses to precipitation that occurred in 2000 and 2002 compared to 1999 and 2001. The diurnal fluctuations observed on these hydrographs may be related to ET and/or may be attributed to the pumping of groundwater from the adjacent gravel pits.

Wells in the IA generally exhibit baseflow and a relatively high overall response to less than average precipitation, superimposed with acute responses to precipitation events or a series of precipitation events (or some other recharge event, possibly lawn watering) that take place over a period of a week or two. There are a few exceptions to this depending on the location of a well with respect to impervious areas, foundation drains, and the former SEPs.

Wells in or immediately adjacent to streambeds generally exhibit an almost immediate, although varying in magnitude and length, response to precipitation events during times of the year with low ET. These same wells will show minimal to no response to precipitation events during high ET times of year (approximately July through September). The dry time periods displayed on the hydrographs for these wells are dependent on the depth of well penetration into the Qvf. The streambeds are not dry at depth; the wells just do not penetrate the water table all year. The near-stream wells generally exhibit a sustained, relatively high water table elevation for the fall, winter, and mid-spring. The hydrographs for these wells reflect the lag time resulting from a stream receiving groundwater recharge from precipitation combined with low ET during the cooler time of year, which encompasses late fall through mid-spring. Well 10794, located downstream of the A- and B-Ponds, exhibits distinct responses to discharges from terminal Ponds A-4 and B-5.

Wells located east of the IA generally exhibit baseflow conditions with little or no response to individual precipitation events. These wells show a relatively smooth decline in water level during the last six months of 1999, almost no response to year 2000 precipitation, a moderate response to above average 2001 precipitation, and generally no response to 2002 precipitation.

Eight of the 33 wells have at least one sampling event depicted on their hydrograph. Four of the wells exhibit a relatively rapid recovery time after the well casing was purged and samples collected. Another four wells exhibit a very long recovery time after the well casing was purged and samples collected. Of the four wells with long recovery periods, all are apparently completed in Qrf, although two are located in areas where there is potentially artificial fill. Assuming that all these wells are completed in Qrf, the reasons for the long delay in recovery times could be any combination of the following: variability in Qrf K values over the Site (the Qrf is a heterogeneous material and variation is inherent), which includes variability in specific yield; well conditions, which could include silted in gravel packs and screens; and recharge rates. The wells that have the longer recharge times (on the order of 5 months) are located in parking lots and surrounded by large areas of relatively impermeable ground surface.

2.5 Summary

Groundwater flow conditions for 2002 appear to generally resemble flow conditions described for recent years with slight variations depending on the monitoring location and the localized precipitation variations at RFETS. This suggests that closure activities undertaken to date have had little areal impact on the UHSU, especially in the IA. Potential groundwater level impacts are localized.

The depth to UHSU groundwater generally becomes shallower and the alluvial saturated thickness, thinner, from west to east across the IA as the Qrf pinches out and the underlying weathered bedrock is closer to the ground surface.

Variations in water levels and linear flow velocities from year to year are probably a result of the timing of water level measurements with respect to natural recharge (precipitation) or anthropogenic events. Anthropogenic events may involve recharge or dewatering related to construction, demolition, onsite industrial processes, water line leaks, monitoring well sampling, and building foundation drain activity or inactivity.

The horizontal flow velocity of UHSU groundwater in areas of unsaturated alluvium may be less than expected as the existing UHSU groundwater flows through the lower K weathered bedrock. However, the overall effect on groundwater flow velocity at the Site is probably negligible.

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Negative water level changes observed west of the IA during 2002 may be a result of the lingering effects of the low precipitation during the 2nd half of 2001, which continued through 2002, after an extended period with consistently high precipitation (1995-1999). Another factor may be the groundwater discharge associated with the pumping of the gravel pits in the western BZ.

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3.0 DATA EVALUATION

3.1 Evaluation Approach

Section 4.0 provides an overview of the 2002 Quarterly RFCA Groundwater Monitoring Reports (quarterly reports) with respect to Boundary, Drainage, Plume Definition, and Plume Extent wells. A discussion of Performance Monitoring wells has also been added to Section 4.0. Other well categories are discussed in the following sections D&D wells are discussed in Section 5.0; and RCRA wells, all of which are associated with the Present Landfill, are evaluated in Section 6.0. The location of all Site monitoring wells is shown on Plate 1.

Groundwater analytical data for 2002 were evaluated with regard to groundwater action levels as described in RFCA Attachment 5 (K-H, 2000) and as set forth in the IMP. Since many decisions rely on Tier I or Tier II groundwater action levels for evaluating action, the discussion below focuses on "reportable" occurrences. The decision rules that define the conditions under which values above action levels become "reportable" are detailed in Section 4.0 for the Boundary, Drainage, Plume Definition, and Plume Extent wells. The general decision rules for all eight well classes are presented in the IMP Background Document (K-H, 2002e) and in the quarterly reports.

No summary or conclusions regarding the data were presented in the quarterly reports, which are used for data transmittal. Except for the direct comparison of groundwater data to action levels and the data quality assessment (DQA) included in the quarterly reports, interpretation of the analytical data and an evaluation of the extent of contaminants with respect to Site geochemistry and hydrology is provided in the Annual RFCA Groundwater Monitoring Reports. Groundwater analytical data generated by RFETS during CY 2002 have been classified and evaluated during the production of the quarterly reports as described below.

3.2 Data Processing

Data evaluated in this report were retrieved from the Soil and Water Database (SWD) and processed as follows:

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- RFETS Groundwater analytical results for each quarter were uploaded from SWD into a local Microsoft Access database. This local database and the queries used to process the data are archived on the Water Programs server.

- Analyses of dissolved gases in groundwater and associated laboratory quality control (QC) records were not available from SWD. These records were hand entered into an Access table, and then appended to the local database.

- Access queries were written to examine the data and to identify potential problems. Any identified data issues are referred to the SWD administrator.

- Field and laboratory QC data were split into a set of separate Access data tables for more convenient use in the DQA. Queries were also written to create and export suitable Excel tables for the written reports.

- The DQA follows requirements set forth in the *Quality Assurance Program Plan For The Groundwater Monitoring Program, Rocky Flats Environmental Technology Site* (RMRS, 2001c). DQAs are presented in the quarterly reports and are not repeated in this document.

- The concentrations or activities of analytes in primary (REAL) and field duplicate (DUP) groundwater samples were screened against RFCA Tier I and Tier II ALF criteria, with the following exceptions.

    1. Non-detect results (with a "U" laboratory qualifier)
    2. Results rejected in validation or verification ("R" or "R1" qualified)
    3. Surrogate compounds added by the laboratory for analytical quality control

- Ratios of the analyzed concentrations or activities, calculated by dividing by the Tier II action levels, or by the background mean plus two standard deviations (M2SDs), or by the historic M2SDs, are used to identify IMP reportable results. "M2SD" indicates that

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two standard deviations have been added to the background mean or to a historic mean concentration.

- If no historic M2SD is available for an analyte in a well, an evaluation of the concentration of the analyte over time may be made by visual inspection of the associated trend plot, if four or more data points are available.

- Most metals, radionuclides, and water quality parameters have had background values established. Therefore, when measurements are above the ALF action levels, the analytical data are compared with the Sitewide background M2SD values, and with the historic M2SD values. The historic M2SD values are well- and analyte-specific, in contrast to the background M2SDs, which are analyte-specific only for groundwater from the UHSU.

- Because VOCs and polychlorinated biphenyls (PCBs) have no background concentrations at RFETS, they are simply compared to available historic M2SDs.

Historic trend plots of wells with reportable contaminant concentrations for Boundary, Drainage, Plume Definition, Plume Extent, and Performance Monitoring wells are presented in Section 4.0. With the exception of radionuclides, background values are based on the *1993 Background Geochemical Characterization Report* (DOE, 1993b). Background values for radionuclides have been taken from the *Draft Background Comparison for Radionuclides in Groundwater Report* (DOE, 1997a).

The analyte-well-specific historic M2SDs have previously been calculated for analytes in groundwater from wells with five or more sampling events during the years 1991 to 1995. However, this methodology prevents the calculation of baseline M2SDs for wells installed since about 1994. RFETS plans to recalculate the historic M2SDs for all analytes in all wells for which at least 5 data points are available more recently than January 1, 1991. Data for the first 5 sampling events for each analyte in each well will be used to compute the M2SDs. This new and enlarged set of historic M2SDs should be available for use starting with the second quarter 2003 groundwater monitoring report.

4.0 PLUME MONITORING

This section provides an evaluation of the IMP plume monitoring on a plume-by-plume basis. This section also presents a summary of the current extent of contaminants in groundwater. Results presented in this section are based on sampling conducted during 2002 and the Snapshot sampling completed during the spring and summer of 2003. The results of the Snapshot are included to provide the most current and comprehensive evaluation of the extent of VOCs in groundwater at the site for use in making closure decisions.

4.1 IMP Well Class Definitions

The Site groundwater monitoring well network is described in the IMP. Wells monitored at the site are placed within one of eight well classifications depending upon the DQOs satisfied by each well. The following sections provide a definition of the well classes discussed in this section and provides a brief discussion of reportable results and groundwater action levels.

4.1.1 Plume Definition Wells

Plume Definition wells are located within groundwater contaminant plumes and contain one or more analyte concentrations that are greater than Tier II action levels. However, many of these groundwater concentrations are below the Tier I action levels established in the ALF.

A "reportable" result occurs at a Plume Definition well when the measured concentration is above a Tier I action level, and is greater than the background M2SD or historic M2SD. To be conservative, the result is reported if it is above Tier I in the absence of both background M2SD and historic M2SD. In the absence of only one of the M2SDs, the result is reported if it is above Tier I and the available M2SD. If the result is reported, then it reclassifies the well as a "Tier I reportable result well". Whether they constitute reportable events or not, all values above Tier I action levels are tabulated in the quarterly reports.

If a Plume Definition well has produced a Tier I result, then during the development of the Annual RFCA Groundwater Monitoring Report, historic data for the well are reviewed to

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determine if the well should be prioritized for further evaluation based on potential impacts to surface water. If the data show an increasing concentration trend over a two-year period, or the well has not been previously prioritized, then the well priority will be updated for evaluation.

Twenty-four Plume Definition wells were monitored during 2002. These wells monitored the following areas: the 903 Pad/Ryan's Pit Plume, the PU&D Yard Plume, the East Trenches Plume, the 881 Hillside Plume, the Carbon Tetrachloride Plume (IHSS 118.1), the Industrial Area VOC Plume, and the SPP. Plate 1 presents the locations of all Site wells.

4.1.2 Plume Extent Wells

Forty-four (44) Plume Extent wells are located at the edges of groundwater contaminant plumes, along pathways to surface water. These wells monitor groundwater for increases in concentration that may indicate the potential for future impacts to surface water. A reportable result occurs if the measured concentration is greater than the Tier II action level and the background M2SD value. If there have not been previous reportable results, or the recent concentration is greater than the M2SD concentration in the well, then monthly sampling is initiated. During monthly sampling, if measurements are above action levels for three consecutive months, then RFCA Parties are notified via a subsequent quarterly report. Potential impacts to surface water from plumes monitored by these wells are evaluated in the Annual RFCA Groundwater Monitoring Report, as necessary.

4.1.3 Performance Monitoring Wells

Performance monitoring refers to monitoring the effectiveness of a groundwater remedy, as required in the RFCA. For the performance monitoring discussed in this section, trend diagrams have been prepared for all of the analytes of interest. Each diagram includes a regression analysis of the data, which plots a trend line indicating whether the analyte is increasing or decreasing in concentration over time. The ER Group's *Annual Report for the Rocky Flats Environmental Technology Site Groundwater Plume Treatment Systems, January through December 2002* (K-H, 2003a) should be referenced for background information, construction details, and treatment

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system influent/effluent sampling results. A complete set of analytical data for CY 2002 can be found in the quarterly reports.

The major difference between the ER report referenced above and this section is that this section provides a more detailed discussion of the Performance Monitoring wells and relatively little discussion of the influent/effluent samples collected at the groundwater treatment systems. In addition, this section provides discussion regarding the performance of the accelerated actions that have been undertaken to date. The ER report also discusses remedies at the Present Landfill and the PU&D Yard, which are not Performance Monitoring locations.

4.2 903 Pad/Ryan's Pit VOC Plume

The 903 Pad (IHSS 112), Ryan's Pit (IHSS 109), and associated groundwater plumes are located in the BZ Operable Unit near the southeast corner of the IA. Figure 4-1 shows the location of the 903 Pad and Ryan's Pit. The 903 Pad was used to store drums, from 1958 until 1967, that contained radioactively contaminated oils and VOCs. Most of the drums contained U and plutonium (Pu) contaminated liquids where the liquid phase was primarily lathe coolant and carbon tetrachloride (CT) in varying proportions. Some of the drums also contained hydraulic oils, vacuum pump oil, trichloroethene (TCE), tetrachloroethene (PCE), silicone oils, and acetone still bottoms (DOE, 1992). Leakage from these drums resulted in groundwater plumes that extend northeast to the East Trenches area and southeast towards Woman Creek.

Ryan's Pit, also known as Trench T-2, is located directly south of the 903 Pad (Figure 4-1). Ryan's Pit was used from approximately 1966 to 1970 for the disposal of liquid chemical wastes (RMRS, 1997a). The wastes were primarily solvents (PCE, TCE, and 1,1,1-trichloroethane [1,1,1-TCA]), paint thinners (toluene, ethylbenzene, and xylenes), diesel fuel, and other construction-related chemicals as described in the PAM (RMRS, 1995).

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4.2.1 Plume Definition Wells

Wells 00491, 6286, and 6386 are Plume Definition wells that monitor the 903 Pad/Ryan's Pit Plume. There were no reportable Tier I concentrations/radiological activities (activities) from any of these wells during 2002.

4.2.2 Plume Extent Wells

Potential migration of the 903 Pad/Ryan's Pit Plume toward Woman Creek is monitored by Plume Extent wells 23096, 23196, 90199, and 90299.

Well 90199 had no samples collected from it during 2002 because of dry conditions. Well 90299 had only a 1st quarter sample collected from it during 2002. There were no Tier II reportable concentrations from Plume Extent wells 23096, 23196, or 90299 during 2002.

4.2.3 Performance Monitoring Wells for the Ryan's Pit Accelerated Action

The Ryan's Pit accelerated action included the excavation and treatment of approximately 180 cubic yards of contaminated soil and debris. The material was excavated in September 1995, treated in February 1996 using low temperature thermal desorption technology to remove VOCs, and backfilled in September 1996. The *Closeout Report for the Remediation of Individual Hazardous Substance Site 109, Ryan's Pit* (RMRS, 1997a) summarizes the accelerated action.

Well 07391 is the closest downgradient well to Ryan's Pit and provides performance monitoring of the accelerated action. The concentration of PCE in well 07391 (Figure 4-2) has varied considerably since the well was first sampled in March 1992 but is consistently above the Tier I action level. Trend analysis of data collected to date indicates that PCE concentrations have declined slowly with time prior to and after the source removal with the current concentration similar to the result before the source removal. The 2002 data indicate that the concentration of PCE remains above the Tier I action level, but has generally decreased since September 1998.

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The TCE concentration in well 07391 (Figure 4-3) has varied significantly with time but consistently is greater than the Tier I action level. Sampling in 2002 indicates the TCE concentration is above 50,000 µg/L. A decreasing trend in TCE concentration prior to and post accelerated action is discernible; the concentrations prior to and after accelerated action are similar indicating that the TCE concentration in the well has remained essentially unchanged with time.

The concentration of 1,1,1-TCA in well 07391 has fluctuated above the Tier II action level with a maximum concentration of 1,700 µg/L in September 1998 (Figure 4-4); although, the concentration during 2002 was below the Tier II action level. However, despite considerable fluctuations, and the high proportion of nondetects (nearly 50 percent), the concentration of 1,1,1-TCA appears to have remained fairly constant and possibly decreased slightly.

The chloroform (CF) concentration in well 07391 has fluctuated substantially with time and has been consistently above the Tier II action level (Figure 4-5). CF concentrations have decreased slightly but remained fairly constant prior to and after the accelerated action at Ryan's Pit.

Elevated activities of U-235 and U-238 have been observed in well 07391. U-235 activities (Figure 4-6) exhibit a downward trend up to September 1995 when the accelerated action occurred at Ryan's Pit. However, U-235 activities after the accelerated action have increased above Tier II and the background M2SD. U-235 data collected in 2002 was above the background activity (1.79 pCi/L).

A similar trend occurs in the U-238 data (Figure 4-7) where activities appear to decrease prior to the accelerated action and increase after completion of the action. With the exception of the first sample, U-238 activities prior to the accelerated action were below the U-238 background level (41.8 pCi/L). U-238 activities subsequent to the accelerated action show a significant increasing trend where activities are greater than the U-238 background level and Tier I.

No activities above background levels were observed in well 07391 for U-233/234 and americium-241 (Am) isotopes, although, U-233/234 activities exhibit the same trend observed for

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the other U-isotopes discussed above. Pu-238/239 activities have been consistently below background levels since March 1995.

In summary, concentrations of VOCs emanating from Ryan's Pit and observed in downgradient well 07391 have generally remained constant with time. A review of the data for VOCs indicates there has been no significant trend to the data either before or after the accelerated action. Monitoring of this well will continue until VOC concentrations decrease to below Tier I action levels. Sampling and analysis of U-isotopes indicates that their activities have increased significantly since the accelerated action at Ryan's Pit. The reason for this increase in U-isotope activities is not known.

4.3 PU&D Yard Plume

The PU&D Yard Plume is located beneath the PU&D Yard (IHSS 174A) and extends east-northeast along the south side of the Present Landfill, a distance of about 3,000 feet. This area, which was formerly known as IHSS 170, was used to store empty drums, dumpsters, cargo boxes, and excess materials from 1974 until 1997. Previous investigations found VOC contamination in soils in the northeast corner of the PU&D Yard. The contamination is likely derived from the leakage of drums that contained residual VOCs and from equipment or other materials stored at the facility.

The PU&D Yard Plume Treatability Study was performed by the ER group to evaluate the effectiveness of Hydrogen Release Compound® in enhancing the natural attenuation of VOCs in soil and groundwater. For a full description of the project to date, including figures, diagrams, and tables, please review the *Annual Report for the Rocky Flats Environmental Technology Site Groundwater Plume Treatment Systems, January through December 2002* (K-H, 2003a).

4.3.1 Plume Definition Wells

Plume Definition wells 00597 and 77392 monitor groundwater in the PU&D Yard Plume. There were no reportable Tier I concentrations/activities from either of these wells during 2002.

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4.3.2 Plume Extent Wells

Plume Extent wells 00397 and 76992 monitor VOC contamination associated with the PU&D Yard Plume. Both of these wells were dry during 2002, and no samples were collected from them.

4.3.3 Performance Monitoring Wells

There are no Performance Monitoring wells defined for the PU&D Yard Plume.

In summary, all VOC contaminated groundwater associated with the PU&D Yard is below Tier I action levels. The VOC plume occurrence is restricted mainly to the narrow upland ridge that separates the North Walnut Creek and No Name Gulch drainages.

4.4 East Trenches Plume

The East Trenches Plume (Figure 4-8) is located north of Central Avenue and east of the IA. This groundwater plume contains VOC contamination and extends to the north and northeast where the plume discharges as seeps and subsurface baseflow to South Walnut Creek. Recent sample results above Tier I action levels in Performance Monitoring well 23296, near South Walnut Creek, and recent detections of VOCs in the B-ponds indicate that contaminated groundwater is reaching surface water.

Most of the groundwater contamination in the East Trenches Plume is believed to emanate from the trenches on the north side of the East Access Road, including Trenches T-3 and T-4 (RMRS, 1996c). Upgradient monitoring wells indicate that a component of the VOC-contaminated groundwater in this area is from the 903 Pad. The Arapahoe No.1 Sandstone is present beneath the East Trenches source area and constitutes a preferential groundwater flow pathway towards South Walnut Creek. This unit is continuous in the subsurface from the East Trenches to the northern end of the East Trenches plume; much of the groundwater flow and contaminant flux is through this material. In addition, contaminated groundwater from the East Trenches plume flows into the Qvf underlying South Walnut Creek (RMRS, 1999g).

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4.4.1 Plume Definition Wells

Plume Definition wells 03991 and 05391 monitor the East Trenches Plume for VOCs. There were no reportable Tier I concentrations/activities from either of these wells during 2002.

4.4.2 Plume Extent Wells

The East Trenches Plume is monitored by eight Plume Extent wells including 04091, 04591, 04991, 05091, 06091, 08091, 10194, and 23296. Wells 04091, 04591, 04991, 05091, 08091, and 10194 had no reportable concentrations during 2002.

Plume Extent well 06091 had reportable concentrations of CT (6.3 µg/L) and chromium (151 µg/L) during the 1st quarter. Because of an oversight, monthly sampling of well 06091 was not initiated immediately after these reportable concentrations were noted. This well was sampled again (routine semiannual) during the 3rd quarter and the results were below Tier II action levels for both CT (4.48 µg/L) and chromium (11.2 µg/L). Figures 4-9 and 4-10 depict well 06091 trend plots for CT and chromium, respectively. Figure 4-9 shows that CT is generally decreasing in this well since early 2000. Figure 4-10 shows that chromium concentrations in this well were consistent from 1993 through 1999, but then became erratic from 2000 through 2002. The low concentrations during the 2000 through 2002 time period occurred during the late summer. Only two of the historic chromium results have been greater than the Tier II action level.

Plume Extent well 23296 had 2nd and 4th quarter Tier II reportable results for CT (Figure 4-11); 1,2-dichloroethene (1,2-DCE; Figure 4-12); and PCE (Figure 4-13). TCE concentrations for both quarters (700 µg/L and 628 µg/L, respectively) are greater than the Tier I action level (Figure 4-14). The 4th quarter results also indicated Tier II reportable concentrations for cadmium (Figure 4-15) and nickel (Figure 4-16). This well is immediately downgradient of the ETPTS at the upstream end of Pond B-3. The ETPTS was completed in September 1999. As Figures 4-11, 4-13, and 4-14 show, within the first year of completion of the ETPTS there were sharp concentration increases (highest historic concentrations) for CT, PCE, and TCE. These increases may have resulted from the construction and installation of the ETPTS. Cis-1,2-DCE is the only one of the four VOCs whose concentration has returned to near the Tier II action level. The

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cadmium and nickel concentrations observed during the 4th quarter are the highest recorded concentrations of those analytes to date at well 23296. In the case of cadmium, this does not appear to indicate a trend. On the other hand, the nickel concentration in well 23296 has shown an increasing trend since late 1999.

Well 23296 is a well in transition. In this report it is discussed as a Plume Extent well (Section 4.4.2) and Performance Monitoring well (Section 4.4.3.2). Well 23296 is proposed to become a Performance Monitoring well only because its TCE concentration is typically greater than the Tier II action level for TCE, which precludes its use as a Plume Extent or Drainage well.

4.4.3 Performance Monitoring Wells

4.4.3.1 Trenches T3 and T4 Accelerated Action

The T3 and T4 accelerated action consisted of the excavation and treatment of approximately 3,800 cubic yards of soil contaminated with VOCs above Tier I action levels for subsurface soil (RMRS, 1996d). The excavated soil and debris were thermally treated (August 1996) to remove the VOCs, which consisted primarily of CT, TCE, and PCE (RMRS, 1996d). The remediated soil, which was then below Tier II action levels, was returned to the trench excavations (September 1996) and the area was revegetated (RMRS, 1996d). The *Completion Report for the Source Removal at Trenches T-3 and T-4 (IHSSs 110 and 111.1)* (RMRS, 1996d) summarizes the accelerated action.

Five Performance Monitoring wells (3687, 05691, 11891, 12191, and 12691) are used to monitor the accelerated action at former Trenches T3 and T4. PCE concentrations in well 3687 have declined with time (Figure 4-17). A trend plot for PCE in this well indicates a downward trend prior to the accelerated action. The data gap that occurs from 1995 to 1997 is when trench source material was removed. PCE data collected after removal of trench source material exhibit a slight upward trend. However, the results are generally less than or equal to the concentrations measured preceding the accelerated action. PCE results in well 3687 since mid-2000 have been below the Tier I action level.

TCE concentrations in well 3687 (Figure 4-18) have also been generally decreasing with time. The trend plot indicates a significant downward trend prior to excavation and treatment of contaminated soils in former Trenches T3 and T4. TCE data collected since the accelerated action exhibit a slightly increasing trend, although the most recent concentrations are less than the pre-accelerated action results. The TCE concentration in well 3687 is approximately two orders of magnitude greater than the PCE concentration. The TCE concentrations in 2002 during the 2nd and 4th quarters were 16,500 μg/L and 11,500 μg/L, respectively.

CF concentrations in well 3687 have been generally decreasing prior to the accelerated action (Figure 4-19). With the exception of an outlier in the 4th quarter 1998, CF concentrations since the accelerated action are similar to those observed prior to the accelerated action. CF concentrations in well 3687 during 2002 were slightly above the Tier II action level.

Since 1994, CT concentrations in well 3687 have remained fairly constant, as seen on Figure 4-20. The concentration of CT was generally declining before the accelerated action. CT concentrations have frequently been above the Tier I action level and consistently above the Tier II action level. The 2002 results fluctuate above and below the Tier I action level.

Trend plots of PCE, TCE, and CT for well 05691 are similar and show a general decrease in concentration up to the present time (Figures 4-21 to 4-23). All three figures display downward concentration trends prior to the removal of trench source material. Concentrations of PCE, TCE, and CT have been relatively constant since the accelerated action. The PCE, TCE, and CT concentrations in well 05691 have generally been above Tier II action levels since sampling began in 1991 and remain above Tier II in 2002.

PCE concentrations at well 11891 increased prior to the accelerated action and have remained the same since (Figure 4-24). PCE concentrations at this well range between 100 μg/L and 300 μg/L. TCE concentrations remained the same prior and subsequent to the accelerated action (Figure 4-25). Concentrations of PCE and TCE at this well have been consistently above Tier II action level.

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CT concentrations in well 11891 (Figure 4-26) have fluctuated above and below the Tier I action level. CT concentrations for the last four sampling events, including 2002, are below the Tier I action level. Concentration trends prior to and post source removal both have increasing trends. Although, since a high result in the fall of 1999, the concentration of CT has been steadily decreasing for the last six sampling events

Except for an outlier in May 1992, PCE, TCE, and CT concentrations at well 12691 (Figures 4-27 to 4-29) prior to and after source removal are relatively constant. PCE and TCE concentrations are greater than Tier II. The CT concentration has fluctuated slightly above and below the Tier I action level and is currently greater than Tier II.

The PCE concentration in well 12191 (Figure 4-30), which is located at the upgradient (south) edge of Trench T3, has fluctuated generally between 200 µg/L and 500 µg/L over a ten-year period but has never exceeded the Tier I action level. However, the long-term trend in PCE concentrations has increased as illustrated by the upward slope of the trend line since the accelerated action. Well 12191 may actually be upgradient of Trench T3, but close enough to the excavation that it might be affected by contamination from this burial site.

The TCE concentration in well 12191 (Figure 4-31) exhibits fluctuations similar to PCE prior to the accelerated action. Trend analysis of these data indicates there was a decreasing TCE concentration prior to the accelerated action and a slight increase to the TCE concentration post accelerated action. Post accelerated action TCE concentrations are about the same magnitude as the last result prior to the accelerated action.

CT concentrations in well 12191 (Figure 4-32) fluctuate and appear to be decreasing slightly since the accelerated action. There is an overall decline in CT concentrations since sampling began in 1992.

In summary, PCE, TCE, and CT concentrations downgradient of Trenches T3 and T4 in wells 3687, 05691, 11891, and 12691 have remained essentially unchanged or increased slightly since the accelerated action. One of these wells, 3687, exhibits continuing values for TCE that are more than an order of magnitude greater than the Tier I action level, suggesting a residual VOC

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contaminant source. Concentrations of PCE, TCE, and CT have either increased slightly or remained the same in upgradient/source well 12191. It is not clear whether well 12191 is actually upgradient of the contamination associated with Trench T3; and, therefore it may not be pertinent as a Performance Monitoring well. The VOC concentrations downgradient of Trench T3 are generally Tier II, which makes it harder to distinguish from the upgradient 903 Pad Plume than the Trench T4 concentrations, which are Tier I. VOC plume modeling currently being performed by the Water Program may clarify the relative contributions of each source area. Sampling of Performance Monitoring wells downgradient of Trenches T3 and T4 will continue until downgradient VOC concentrations decrease to below Tier I action levels.

4.4.3.2 East Trenches Plume Treatment System

During 1999, the ETPTS was installed to intercept East Trenches Plume groundwater along the southern edge of South Walnut Creek. Effluent samples collected from the ETPTS during 2002 were mostly nondetect and only one, a PCE concentration of 12 µg/L collected in April 2002, was above the Tier II action level.

Four monitoring wells, 23296, 95099, 95199, and 95299 are currently being sampled as Performance Monitoring wells for the ETPTS. Wells 95199, 95299, and 23296 are located downgradient of the treatment system. Well 95099 is located just upgradient of the treatment system at the northeast (downstream) end.

TCE has been detected in well 95199 at concentrations above Tier II action levels for all sampling rounds since the completion of the well in 1999. The maximum TCE concentration in well 95199 to date, 68.6 µg/L, was during the 4th quarter of 2002. As shown on Figure 4-33, the upward trend line indicates an increase in the TCE concentration since sampling commenced. There have not been any concentrations of PCE or CT above Tier II action levels in well 95199.

Since sampling was initiated, the PCE concentrations in well 23296 have consistently been above Tier II action levels as shown on Figure 4-13. Trend analysis of the data indicates there was generally no change in the mean concentration of PCE prior to and after the ETPTS installation. The highest PCE concentrations were observed immediately after construction.

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TCE concentrations in well 23296 (Figure 4-14) have consistently been above the Tier II action level and occasionally above the Tier I action level since the ETPTS was installed. Both of the 2002 results were above the Tier I action level; the high being 700 µg/L during the 2nd quarter 2002. Trend analyses for these data suggest a relatively constant concentration prior to and a slightly increasing trend since the installation of the ETPTS.

Concentrations of cis-1,2-DCE in well 23296 (Figure 4-12) have been frequently above the Tier II action level during the entire period of sampling; most of the concentrations above the Tier II action level have occurred since the completion of the ETPTS. Cis-1,2-DCE concentrations at this well have been erratic, ranging between approximately 5 µg/L and 170 µg/L. Trend analysis indicates an increase in concentration before and a slight decrease in concentration after installation of the ETPTS. Results in 2002 continue to be above the Tier II action level and are slightly higher in concentration compared to the pre-ETPTS installation results.

Well 95299 has been dry since it was installed and, therefore, has not been sampled. Very low, "J" qualified concentrations of CT (less than 1 µg/L) have been detected in well 95099.

Except for one effluent sample in 2002, the treatment system appears to be treating collected groundwater to below Tier II action levels for all VOCs. Well 23296, located downgradient of the groundwater remedial system, continues to exhibit elevated concentrations of VOCs, suggesting that the East Trenches Plume below the ETPTS continues to migrate towards the creek. This portion of the East Trenches Plume below the ETPTS was the northernmost extent of the East Trenches Plume prior to construction of the ETPTS. Monthly effluent sampling and IMP groundwater sampling during CY 2003 will continue to verify the performance of the treatment system.

4.5 Mound Site Plume

The Mound Site (IHSS 113) is located north of Central Avenue and northeast of the 903 Pad and consists of a former waste disposal area where approximately 1,400 drums were stored. Initially placed on the ground, the drums were buried with soil between April 1954 and September 1958. The waste originated in Buildings 444, 771, 776, and 883 and contained U- and beryllium-

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contaminated lathe coolant (a mixture of approximately 70 percent hydraulic oil and 30 percent CT), PCE and other VOCs, and low levels of Pu. Ten percent of the drums were suspected to have leaked, resulting in soil and groundwater contamination.

The Mound Site Plume is located north of Central Avenue and east of the PA fence. The plume discharged, prior to the installation of the Mound Site Plume Treatment System (MSPTS) in 1998, as seeps and subsurface flow into the South Walnut Creek drainage in the vicinity of seep SW059. VOC contamination, primarily PCE and TCE, has been identified along a line of monitoring wells downgradient (north) of the Mound Site, between the Mound Site and South Walnut Creek. Figure 4-34 presents the location of the Mound Site area and Mound Site Plume.

4.5.1 Plume Definition Wells

There are no Plume Definition wells defined for the Mound Plume.

4.5.2 Plume Extent Wells

The Mound Plume is monitored by Plume Extent wells 3586 and 75992. Well 75992 only produced enough water for 3rd quarter VOC and nitrate samples; there were no reportable concentrations in this well.

Well 3586, constructed of stainless steel, had a Tier II reportable concentration for manganese (1,200 µg/L) during the 4th quarter of 2002 (Figure 4-35). This was the highest concentration of manganese ever recorded at this well; the previous quarterly manganese concentration was the lowest ever recorded at this well. Sampling results for two of the three monthly samples confirmed the reportable concentration. Wetlands can be a natural source of manganese; there is a wetland located just east of Building 991. Historic data at surface water station GS-10, located just downstream of the wastewater treatment plant, has shown elevated concentrations of manganese (personal communication with George Squibb, Water Program). Manganese in groundwater is not evaluated since there is no longer a surface water standard for this analyte at RFETS (May, 2003 RFCA revision).

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4.5.3 Performance Monitoring Wells

4.5.3.1 Mound Site Accelerated Action

The purpose of the 1997 Mound Site accelerated action was to remediate 724.5 cubic yards of soils contaminated with VOCs at concentrations above Tier I action levels for subsurface soil (RMRS, 1997c). The excavation was completed in April 1997; soils were treated in August 1997 using low temperature thermal desorption to remove the VOCs. The treated soils were returned to the excavation in September 1997. The *Closeout Report for the Source Removal at the Mound Site, IHSS 113* (RMRS, 1997c) summarizes the accelerated action.

Well 00897 was installed in 1997 to monitor groundwater immediately downgradient of the Mound Site. PCE concentrations have fluctuated and range from a minimum of 7,400 µg/L in November 1998 to 26,000 µg/L in October 2002. As illustrated on Figure 4-36, PCE concentrations in well 00897 are greater than Tier I and exhibit a distinct upward trend since source removal. Based on a linear flow velocity of approximately 710 ft/yr calculated for groundwater flow downgradient of the Mound Site (based on the K value for the Arapahoe No. 1 Sandstone, Table 2-2), and a retardation (R) value of 7.32 for PCE, it would take approximately 1.3 years for PCE in groundwater to travel from the Mound source area to well 00897. Any PCE contaminated groundwater remaining between the source and well 00897 would have had ample time to flow past this well, yet the current concentrations suggest that a PCE source remains.

TCE concentrations in well 00897, as shown in Figure 4-37, range from a high of 2,000 µg/L in March and June 1998 to less than a 1,000 µg/L in October 1997 and November 1998. All TCE results at this well have been greater than the Tier I action level of 500 µg/L. The data exhibit a slight upward trend.

Well 02291 is also located downgradient of the Mound Site, approximately equidistant between the Mound Site and the MSPTS. PCE concentrations in this well (Figure 4-38) range from a minimum of 210 µg/L in December 1991 to a maximum of 6,800 µg/L in October 2001. A three-year data gap exists, from 1995 to 1998, as a result of removing well 02291 from the groundwater

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monitoring program. The PCE concentration in well 02291 appears to be increasing over time, although there was a noticeable decrease in concentration from the 4th quarter 2001 to the 2nd quarter of 2002. PCE concentrations have generally been above the Tier I action level for all sampling rounds. The trend line indicates that the PCE concentration exhibited a significant upward trend prior to the source removal; the trend since source removal is still increasing, but at a lesser rate.

The trend plot for TCE in well 02291 (Figure 4-39) is similar to PCE, but the TCE concentration is an order of magnitude lower than the PCE concentration. TCE concentrations vary and range from a minimum of 100 µg/L in December 1991 to a maximum of 740 µg/L in April 2000. TCE concentrations in well 02291 have generally exceeded the Tier I action level (500 µg/L) since the accelerated action. However, the last two sampling event results are below the Tier I action level but remain above Tier II. Similar to Figure 4-37, the trend line before the Mound Site accelerated action indicates that the TCE concentration was increasing. Data subsequent to the accelerated action still show an increasing trend, but at a lesser rate.

In summary, during the past seven years, concentrations of PCE downgradient of the Mound Site (wells 00897 and 02291) have increased and are approximately 10 times the Tier I action level. Although the excavation criteria established in the PAM for the Mound Site were met, all of the NAPL that leaked from the drums may not have been recovered. Because of the continuing high VOC concentrations since the accelerated action, the MSPTS was constructed. Monitoring will continue until VOC concentrations decrease to below Tier I action levels.

4.5.3.2 Mound Site Plume/SW059 Remediation System

Currently, four wells (3586, 15599, 15699, and 15799) are being sampled as Performance Monitoring wells for the MSPTS (Figure 4-34). These wells are all located downgradient of the MSPTS collection trench with well 3586 being farthest downgradient and adjacent to South Walnut Creek. The other three wells are immediately downgradient of the interceptor trench.

Vinyl chloride (VC) concentrations have generally been above Tier II action levels in well 3586 (Figure 4-40) since sampling started in September 1986. However, since April 1991, there has

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been a continuous decrease in the VC concentration at this location that may be indicative of biodegradation. Data from 2002 indicate that VC concentrations are nondetect.

Concentrations of PCE and TCE in well 15699 (Figures 4-41 and 4-42, respectively) have been elevated since sampling began in March 1999 and have generally been above Tier I action levels. Trend lines for PCE and TCE indicate that concentrations of these compounds have remained generally unchanged since sampling began. Concentrations of cis-1,2-DCE (Figure 4-43) and 1,1-dichloroethene (1,1-DCE; Figure 4-44) have been detected in well 15699 above Tier II action levels, which are 70 μg/L and 7 μg/L, respectively. The trend line for cis-1,2-DCE appears to indicate decreasing concentration. Since mid 1999, the concentration of cis-1,2-DCE and 1,1-DCE have generally decreased in this well. Concentrations of 1,2-dichloroethane (1,2-DCA), slightly greater than Tier II levels, have also been detected in well 15699 (Figure 4-45). However, since November 1999, the compound has been detected only once at a very low level (10 μg/L). High non-detect values from 2000 are due to elevated detection limits that result from sample dilution. Well 15699 was dry during 2002.

Well 15599 has been frequently dry since its installation and has not been sampled on a regular basis. Samples collected in May 2001 indicate the presence of PCE at 41 μg/L and TCE at 75 μg/L. No other samples have been collected from well 15599; it was dry during 2002. Well 15799, also dry during 2002, had groundwater samples collected from it in August and November of 1999, and June of 2000. U-isotopes U-233/234 and U-238, in August 1999, were the only analytes observed at a concentration greater than the Tier II action level. Almost all VOC results for well 15799 were non detect.

In summary, the fact that wells 15599, 15699, and 15799 are frequently dry points to successfully intercepting a large portion of the groundwater flow in the vicinity of the MSPTS. A slight decline in water level may have occurred in well 3586 as a result of the groundwater remedial system, but considering the distance that this well lies from the system, this decline may also be attributed to dry climatic conditions. No VOC samples were able to be collected from wells 15599, 15699, or 15799 during 2002, so a current assessment of these Performance Monitoring wells is not possible. Well 3586 did not exhibit any VOC concentrations greater than Tier II during 2002. A detailed analysis would be required to evaluate the hydraulics of the remedial system.

4.6 881 Hillside Plume

The 881 Hillside (formerly OU 1), is located just south and east of Building 881 and north of Woman Creek. Building 881 was used for enriched U operations, stainless steel component manufacturing, and laboratory analyses of the samples generated during production. Woman Creek and the South Interceptor Ditch (SID) are two surface water drainages that occur in the vicinity of the 881 Hillside. The SID crosses the 881 Hillside flowing west to east just north of and parallel to Woman Creek. Figure 4-46 shows the 881 Hillside area.

4.6.1 Plume Definition Wells

Four Plume Definition wells, 0487, 891COLWEL, P416789, and P416889 are used to monitor the 881 Hillside Plume. There were no reportable Tier I concentrations/activities from any of these wells during 2002.

4.6.2 Plume Extent Wells

Plume Extent wells 10992, 11092, 4787, and 4887 monitor the extent of the 881 Hillside Plume. Plume Extent well 5387 monitors the Building 881 Footing Drain Sump, which is also known as surface water monitoring station SW13494.

Well 4787 and 4887 were dry during 2002, and no samples were collected from them. Well 11092 produced only enough water during 2002 for a 1st quarter VOC sample.

Well 5387, constructed of stainless steel, had a concentration above the Tier II action level for nickel (Figure 4-47) in the 1st quarter; this well produced only enough water for a VOC sample in the 3rd quarter. Monthly sampling for metals was attempted in August and September; the well was dry during both of those visits. A sample was collected in November, and the nickel result was well below the Tier II action level. The first quarter reportable result was, therefore, not

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substantiated by the subsequent sampling. Before the reportable 1st quarter result, there had been eleven consecutive sampling events without a nickel concentration above the Tier II action level. There were no other reportable concentrations from this well during 2002.

Well 10992 had Tier II reportable concentrations of nitrate (Figure 4-48) and selenium (Figure 4-49) during the 3rd quarter of 2002. Subsequent monthly sampling for the two analytes in January, February, and March 2003 confirmed the 3rd quarter 2002 elevated values for both analytes. The nitrate concentration observed at this well is an isolated occurrence and not associated with any known nitrate source. The selenium concentration at this location has been relatively consistent, and all historic results have been above the Tier II action level. The reportable selenium concentration was approximately an order of magnitude greater than the background value for selenium.

4.6.3 Performance Monitoring Wells

4.6.3.1 881 Hillside French Drain

During 1992, as an IM/IRA, a 1,435-foot long French drain (881 Hillside French drain) was constructed across a significant portion of OU 1, north of the SID. The French drain, combined with an upgradient extraction well (891COLWEL), constituted the 881 Hillside groundwater collection and treatment system (Figure 4-46).

Groundwater presence in the area is limited and primarily found in the unconsolidated surficial materials, in isolated northwest-southeast trending paleochannels incised into the bedrock, and in the weathered bedrock. Recharge to the unconsolidated surficial material is minimal and occurs primarily through infiltration of precipitation during spring and summer. Discharge occurs largely through evapotranspiration (ET) and also at seeps, Woman Creek, the SID, and the 881 Hillside French drain.

In accordance with the modification (limited groundwater pumping and monitoring) described in the *Major Modification to the Operable Unit 1:881 Hillside Area CAD/ROD* (DOE, 2001), pumping of 891COLWEL had been discontinued as of April 2002. As described in the

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document, 891COLWEL will now be designated a Plume Definition well to be monitored quarterly, consistent with the IMP. These activities hinged on the concentration of TCE in 891COLWELL with regard to the Tier I action level (500 µg/L). In addition, well 0487 will now be designated a Plume Definition well and will be monitored quarterly; wells 4787, 4887, 10992, and 11092 will now be designated as Plume Extent wells, to be monitored semiannually. If or when VOC concentrations in the Plume Definition wells (891COLWEL and 0487) fall below the Tier II action levels for four consecutive sampling events, monitoring will be discontinued. This is the last time that performance monitoring of the 881 Hillside French Drain will be presented in the Annual RFCA Groundwater Monitoring Report.

VOCs, including TCE, PCE, and CT, U-isotopes U-233/234 and U-238, and selenium have consistently exceeded Tier II action levels in 891COLWEL. Sample results from 891COLWEL in 2002 indicate no Tier I exceedances for VOCs. The TCE concentration in 891COLWEL has generally exhibited a steady decline since July 1994 (Figure 4-50). Since the decommissioning of the French drain, the concentration of TCE has increased slightly but remains below Tier I.

PCE in 891COLWEL has been consistently above the Tier II action level. As shown on Figure 4-51, PCE has been steadily decreasing since 1994. The PCE concentration has increased slightly since the French Drain was decommissioned. Even though the PCE and TCE data exhibit a slightly increasing trend since decommissioning of the French drain, the magnitude of the 2002 results are similar to the last results prior to decommissioning.

CT concentrations in 891COLWEL (Figure 4-52) have generally been above Tier II action levels, although just prior to decommissioning of the French drain, the results fluctuated about the Tier II action level. Since the decommissioning of the French drain, and cessation of 891COLWEL pumping, the concentration of CT has increased. The current concentration is above the Tier II action level; concentrations have returned to levels observed in 1995.

The concentration of 1,1-DCE in 891COLWEL (Figure 4-53) has generally been above the Tier II action level, although prior to decommissioning of the French drain the concentration was less than Tier II. There has been a slight increase in the 1,1-DCE concentration since the decommissioning of the French drain and cessation of 891COLWEL pumping.

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Selenium in 891COLWELL has been consistently above the Tier II action level (Figure 4-54). There has been almost no change to the selenium concentration in 891COLWEL with time; although, since the cessation of pumping of 891COLWEL in April 2002, the concentration of selenium has decreased considerably.

There were no VOC measurements above Tier II action levels for 881 Hillside French drain Performance Monitoring wells 10592, 10692, 10792, 10992, and 11092 during 2002.

Selenium in well 10592 has historically been above the Tier II action level but has been decreasing prior to the decommissioning of the French drain (Figure 4-55). The selenium concentration has increased since the decommissioning. Selenium in well 10792 has been decreasing since May 1998 and, as of 2002, is below the Tier II action level (Figure 4-56); the trend analysis shows a relatively constant selenium concentration except for an outlier in May 1998. Selenium concentrations in well 10992 have been above Tier II action levels since sampling began in September 1996 (Figure 4-49). Trend analysis prior to decommissioning of the French drain indicates a slightly decreasing slope; the selenium concentration has increased slightly since the decommissioning, although the concentrations prior to and post decommissioning are essentially the same.

Nitrate concentrations in well 10992 (Figure 4-48) are currently and historically above the Tier II action level with an increasing trend before and after the decommissioning of the French drain.

Two wells immediately east and southeast of 891COLWEL (4387 and 32591) have results above the Tier I action levels for VOCs. These wells trend northwest to southeast, subparallel to the axis of the paleochannel that is shown on Figure 4-46. Downgradient wells 10992 and 11092 had no VOC concentrations greater than Tier II action levels during 2002; therefore, there appears to be no threat to surface water from this isolated area of elevated VOC concentrations.

In summary, there were no VOC results above Tier II action levels for 881 Hillside French drain Performance Monitoring wells 10592, 10692, 10792, 10992, and 11092 during 2002. The nitrate concentration in well 10992 is currently above the Tier II action level. Wells 10592 and 10692

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are being considered for abandonment as they are not in locations that are pertinent to performance monitoring of the decommissioning of the French drain.

4.7 Carbon Tetrachloride (IHSS 118.1) Plume

The Carbon Tetrachloride Plume is located in IHSS 118.1 adjacent to Building 771. CT is the principal contaminant at IHSS 118.1 and resulted from spills or leakage at an underground CT storage tank, which was subsequently removed. Subsurface characterization was initiated in 1997 to identify the extent of the DNAPL source and dissolved plume and to determine the feasibility of extracting the DNAPL using pumping or excavation. Source removal was postponed because it was not feasible to excavate the source because of the number of active process lines and utilities in the area.

4.7.1 Plume Definition Wells

The Carbon Tetrachloride Plume (IHSS 118.1) is monitored by Plume Definition wells P209289, P209389, P209489, and P219189. There were no reportable Tier I concentrations/activities from any of these wells during 2002.

4.7.2 Plume Extent Wells

The Carbon Tetrachloride Plume (IHSS 118.1) is monitored by Plume Extent well 21098, which is discussed in Section 4.8.2, Plume Extent Monitoring Wells (for the IA VOC Plume). The current CT concentration in this well is five to six greater than the Tier I action level. The CF observed at this location, which is greater than the Tier II action level, is probably a degradation product of the CT emanating from IHSS 118.1.

4.7.3 Performance Monitoring Wells

There are no Performance Monitoring wells defined for the Carbon Tetrachloride (IHSS 118.1) Plume.

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In summary, source wells located in IHSS 118.1 show extremely high dissolved concentrations of CT and DNAPL, and Plume Extent well 21098 has current CT concentrations approaching 3000 µg/L (see Figure 4-60). A source removal/remedial action is planned for the near future.

4.8 Industrial Area (IA) VOC Plume

4.8.1 Plume Definition Monitoring Wells

The IA VOC Plume is monitored by Plume Definition well 22896. There were no reportable Tier I concentrations/activities from this well during 2002.

4.8.2 Plume Extent Monitoring Wells

Plume Extent wells that monitor the IA VOC Plume include 00197, 10994, 1986, 2186, 22596, 22696, 43392, 6186, P114389, P313589, P314289, and P416689. The Carbon Tetrachloride Plume (IHSS 118.1) is monitored by Plume Extent well 21098. Plume Extent well 22796 monitors an unnamed plume that lies to the north/northwest of Building 771.

Because of dry conditions, no samples were collected from Plume Extent wells 00197 and P314289.

Plume extent wells 2186, 22696, 43392, P114389, and P313589 did not have any Tier II reportable concentrations during 2002. Well 2186 will be dropped from the IMP after 2002 because it is not pertinent to monitoring the IA VOC Plume as it is located across the unnamed drainage (between B371/374 and B771) from the plume, and its depth and construction details indicate that it is a LHSU well. It is screened from 35 to 67 feet bgs and the top of bedrock was encountered at 15 feet bgs at that location.

Six Plume Extent wells that monitor the IA VOC Plume had Tier II reportable concentrations during 2002. Well 10994 had 1st and 3rd quarter reportable concentrations of nitrate (Figure 4-57) and selenium (Figure 4-58). Monthly sampling confirmed both the nitrate and selenium reportable concentrations. The historic nitrate concentrations at this location are fairly consistent,

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ranging from 6.5 to 19 mg/L. The origin of nitrate at this location is unknown as it is not located near any known nitrate sources. The selenium concentration has been above the Tier II action level but below the historic M2SD for every sample ever collected from this well. Because selenium is an anion, relatively mobile in groundwater, and not associated with a building or known incident at this location, it is assumed to be naturally occurring.

Well 1986, a stainless steel well equipped with a stainless steel pump, had 2nd and 4th quarter manganese concentrations of 3,760 and 3,489 µg/L, respectively (Figure 4-59). Subsequent monthly samples confirmed the reportable manganese concentrations. This well is completed in Valley Fill Alluvium and located in the unnamed drainage between B371/374 and B771. There is groundwater VOC contamination associated with IHSS 118.1 and radiological contamination associated with IHSS 131 (soil) and B559 and B371/374 (groundwater) in the vicinity that has not impacted the well. The fact that this well, completed in a relatively permeable medium, has not been impacted by other analytes, suggests that the manganese is naturally occurring or possibly leached from the stainless steel pump or well completion materials.

Well 21098 (replaced by well 21002 during late summer 2002) had 2nd and 4th quarter (well 21002) concentrations of CT (Figure 4-60) and CF (Figure 4-61) above RFCA action levels. The CT concentration in this well is greater than the Tier I action level and is a result of downgradient migration of dissolved phase CT from IHSS 118.1. Since this well is within the Carbon Tetrachloride Plume, it does not meet the definition of a Plume Extent well. Unfortunately, because of the configuration of the unnamed drainage, there is not an existing well that is better positioned for monitoring the extent of the plume. Monthly sampling of this well confirmed the Tier II reportable CF concentration. The CF observed at this location is probably a degradation product of the CT emanating from IHSS 118.1. CF at this location shows a decreasing trend, but is still above Tier II.

Well 22596 had a 3rd quarter thallium concentration that was reportable (Figure 4-62). Subsequent monthly sampling did not confirm that thallium was above the Tier II action level, and the previous eight quarterly events all resulted in thallium concentrations below the Tier II action level. This well will be removed from the IMP as a Plume Extent well because it is redundant with other wells that are more appropriately positioned to monitor the IA VOC Plumes.

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Well 6186, a stainless steel well that is not equipped with a pump, had a 3rd quarter nickel concentration that was reportable (Figure 4-63). This was the first observed nickel concentration above the Tier II action level at this location. Subsequent monthly sampling confirmed the initial reportable concentration of nickel. This well is not currently impacted by VOCs, nitrate, U-isotopes, or any other metals in concentrations greater than Tier II action levels; therefore, the high nickel concentration may be the result of corrosion of the stainless steel well casing and screen.

Well P416689 had a reportable nickel concentration during the 4th quarter (Figure 4-64). The results of subsequent monthly samples confirmed the reportable nickel concentration in this well. This well is constructed of PVC casing and screen and lies immediately south of the Building 460/444 area. Among other metals, Building 444 was known to have utilized stainless steel, and nickel as a coating or alloy material (DOE, 1994d). As with almost all Tier I metals detections in groundwater at RFETS, their occurrences are typically isolated at individual wells and do not constitute Tier I metals plumes.

4.8.3 Performance Monitoring Wells

There are no Performance Monitoring wells defined for the IA VOC Plume.

In summary, except for IHSS 118.1 and a few isolated occurrences, there is little VOC contamination in the IA Plume that is greater than the Tier I action levels.

4.9 Solar Ponds Nitrate/Uranium Plume

The SPP is an area of groundwater contamination that extends from the former SEPs to the northeast towards North Walnut Creek and to the southeast towards South Walnut Creek. The primary analytes of concern are nitrate (Figure 4-65) and various U-isotopes (Figure 4-66); however, other inorganic and organic compounds have also been identified at concentrations above Tier II action levels. VOCs, primarily PCE, TCE, and CT, have been detected in monitoring wells located in the western and southern portions of the former SEPs area. The VOC contamination, which is currently greater than Tier I action levels for TCE and CT at well

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P210189 (to be utilized beginning in 2004 as a Plume Definition well), is thought to have originated from an unidentified source to the west and southwest of the former SEPs, and therefore thought to be distinct from the SPP. Several metals have also been detected in SPP monitoring wells at concentrations above groundwater action levels.

4.9.1 Plume Definition Monitoring Wells

The SPP, which consists of groundwater impacted with nitrate and U-isotopes, is monitored by Plume Definition wells 00297, 79102, 79202, 79302, 79402, 79502, P207989, and P208989. Well 00297 has typically been dry and will be removed from the monitoring program and replaced during 2003. New downgradient wells 79102 and 79302 exhibited 3rd quarter results above Tier I for U-isotopes and nitrate, respectively. These were the only two Plume Definition wells for the SPP that had any reportable Tier I concentrations/activities during 2002.

Well 79102 exhibited U-233/234 and U-238 activities of 173 pCi/L and 142 pCi/L, respectively. Although these activities are greater than the Tier I action levels for those analytes, the ratio of the activities of the two isotopes implies a naturally occurring isotopic signature. Well 79302 exhibited a nitrate concentration of 1,690 mg/L during the 4th quarter of 2002, which is indicative of nitrate contamination associated with the SPP.

4.9.2 Plume Extent Monitoring Wells

Plume Extent wells 1386, 1786, 3386, B208289, B208789, P218389, and P219489 are located at the edge of the SPP and monitor nitrate and U-isotope contamination associated with the plume. Wells 1386 and 1786 are sampled quarterly; the rest are sampled semiannually.

Wells 3386, B208289, and P218389 were dry during the 2nd and 4th quarters and no samples were collected from them during 2002.

Plume Extent well 1786 had Tier II reportable concentrations of nitrate (Figure 4-67) for every sampling event since its inception and is shown within the SPP on Plate 13 from the 2001 Annual RFCA Groundwater Monitoring Report (Safe Sites, 2002b). This well will be eliminated as a

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Plume Extent well, and will be reclassified as a Plume Definition well in the future. In addition to nitrate, well 1786 had Tier II reportable concentrations of selenium (Figure 4-68) during the 2nd and 4th quarters, and reportable concentrations of U-235 (Figure 4-69) during the 3rd and 4th quarters. While the recent U-235 results are inconsistent (although consistent with past activities), the recent nitrate and selenium results show downward trends. The nitrate and U-isotope concentrations at this location are attributed to the SPP; the selenium may be naturally occurring. Monthly sampling confirmed the reportable concentrations; the appropriate parties were notified via quarterly reports. This well is located immediately west of the SPPTS discharge gallery, and at certain times of the year, especially wet periods, water has been observed to run overland down to the discharge gallery and North Walnut Creek from a seepage point located immediately east of the green, recently demolished, Interceptor Trench System (ITS) pumphouse (308D). Infiltration of this water, the origin of which is unknown but may be the ITS, may be responsible in part for the analyte concentrations observed in this well.

Plume Extent well 1386 had reportable nickel concentrations for both the 2nd and 4th quarters (Figure 4-70). Monthly sampling of this well was initiated and the appropriate parties notified after the 4th quarter reportable result was obtained. The monthly sampling confirmed the quarterly results. This well has had nickel concentrations above the Tier II action level and historic M2SD since late 1997. Well 1386 is constructed of stainless steel, which may be responsible for the nickel concentrations.

Of the remaining two Plume Extent wells (P219489 and B208789), B208789 did not have any reportable concentrations during 2002. Well P219489 had a reportable nitrate concentration during the 2nd quarter (Figure 4-71) and was dry during the 4th quarter. Nitrate concentrations at this well range between 30 and 60 mg/L and have been consistently above the Tier II action level since 1993 or 1994. This well will be reclassified as a Plume Definition well because it has shown consistent historical results for nitrate that are greater than the Tier II action level and is shown within the SPP on Plate 13 from the 2001 Annual RFCA Groundwater Monitoring Report (Safe Sites, 2002b).

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4.9.3 Performance Monitoring Wells

The predominant direction of SPP migration is toward the northeast and North Walnut Creek. The ITS was constructed in 1981 to dewater the hillside between the former SEPs and North Walnut Creek to prevent the SPP from advancing to the creek. The ITS was intercepted during the construction of SPPTS in 1999.

Four monitoring wells, 1386, 1786, 70099, and 70299 are designated for performance monitoring of the SPPTS. Nickel concentrations in well 1386 (Figure 4-70) have increased steadily since spring 1992 and, except for two samples, have been over the Tier II action level since spring 1993. The upward (positive) trend line shown on Figure 4-70 depicts an increase in nickel prior to installation of the treatment cell. There is no significant change in nickel concentration trend subsequent to the completion of the SPPTS.

Selenium in well 1786 (Figure 4-68) has been consistently above Tier II action levels since sampling was initiated in February 1990. Selenium concentrations increased prior to the installation of the SPPTS. After installation, concentrations increased until April 2001, at which time they started to decline. A trend line for post SPPTS data indicates there is a downward trend in the selenium concentration since the completion of the SPPTS; 2002 selenium results at well 1786 confirm this.

The nitrate concentration in well 1786 (Figure 4-67) generally increased since sampling began in 1987, but prior to installation of the SPPTS in 1999, the nitrate concentration began to decline in October 1997. A trend analysis for post-SPPTS nitrate data indicates a significant downward trend. Although the 2002 results increase slightly, they still confirm the downward trend of nitrate results since the completion of the SPPTS.

U-233/234 concentrations in well 70099 (Figure 4-72) have been elevated above background levels (60.7 pCi/L) since sampling was initiated in June 2000. The concentration trend is essentially constant. Similar to U-233/234, the U-235 concentration in well 70099 (Figure 4-73) has been elevated above the background level (1.79 pCi/L) since sampling was initiated in June 2000. There appears to be a slight increasing trend. The U-238 concentration in well 70099

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(Figure 4-74) has been above the background level (41.8 pCi/L) since sampling at the well began. The concentration trend is essentially constant.

The nitrate concentration in well 70099 has been below the Tier II action level since sampling began at this well and has continued to be below Tier II through 2002. Concentrations of U-233/234 and U-238 in well 70299 have been below background but above Tier II action levels through 2002. The U-235 concentration in well 70299 has been consistently below both background and Tier II action levels.

In summary, it appears that nitrate values at Performance Monitoring well 1786 have declined since the installation of the SPPTS, although the concentration is still higher than the Tier II action level. Nitrate at Performance Monitoring well 1386 has never been above the Tier II action level. The U-isotope activities in well 70099 are all above the Site background values and below the Tier I action levels for U-233/234 and U-238 and these activities are steady or increasing slightly. Sampling will continue to verify the near- and long-term performance of the SPPTS.

4.10 Drainage Monitoring Wells

Drainage wells are located in stream drainages downgradient of contaminant plumes and have the same IMP programmatic requirements as Plume Extent wells. A reportable result occurs if a measured concentration exceeds a Tier II action level and the background M2SD value. If there have not been previous reportable results, or the recent concentration exceeds the M2SD concentration in the well, the required action is to initiate monthly sampling. Under monthly sampling, if results are above RFCA action levels for three consecutive months, then RFCA Parties are notified via a subsequent quarterly report, and the possible impacts to surface water are evaluated in the Annual RFCA Groundwater Monitoring Report.

Five Drainage wells, 00997 (South Walnut Creek, between Pond B-4 and Pond B-5), 38591 and 5587 (west Woman Creek, south of the 881 Hillside Plume), 6486 (central Woman Creek, southeast of the 881 Hillside Plume), and 6586 (east Woman Creek, south of the 903 Pad/Ryan's Pit Plume) were sampled in 2002.

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Well 6486 was the only Drainage well that exhibited analyte concentrations during 2002 that were greater than Tier II action levels and the background M2SD values. The nickel (Figure 4-75) result from the 1st quarter was 5,390 µg/L, causing monthly sampling to be initiated in March. The results of the monthly samples were all greater than the Tier II action level, confirming the reportable value. Well 6486 also had a 1st quarter chromium (Figure 4-76) result of 649 µg/L, which constituted a reportable concentration. The first two monthly results for chromium were below the Tier II action level, and the third monthly sample exhibited a chromium concentration (427 µg/L) that was greater than the Tier II action level. Well 6486, dry during the 3rd quarter, is constructed of stainless steel and has a stainless steel pump in it.

In summary, well 6486, located southeast of the 881 Hillside Plume, was the only Drainage well that exhibited analyte concentrations during 2002 that were greater than Tier II action levels and the background M2SD values. The elevated metals concentrations associated with well 6486 may be attributed to corrosion of stainless steel well and pump materials. Concentrations of nickel and chromium in downgradient Boundary well 10394, which is located in the Woman Creek drainage adjacent to Indiana Street, are well below Tier II action levels.

4.11 Boundary Monitoring Wells

Boundary wells monitor groundwater at the eastern Site boundary that is within the alluvial deposits associated with a stream or intermittent stream. A reportable result occurs if a measured analyte concentration in groundwater exceeds a Tier II action level and the background M2SD value. If there have not been previous reportable results, or the recent concentration exceeds the M2SD concentration in the well, the required action is to initiate monthly sampling. Under monthly sampling protocols, if action levels are exceeded for three consecutive months, then RFCA Parties are notified via a subsequent quarterly report, and the possible impacts to surface water are evaluated in the Annual RFCA Groundwater Monitoring Report.

Six IMP-designated Boundary wells (0386, 06491, 10294, 10394, 41591, and 41691) were sampled in 2002. All of these wells are found along the eastern Site boundary adjacent to Indiana Street. Wells 0386 and 06491 are located in intermittent drainages north of the East Access Road and south of Walnut Creek. Well 10294 is located in the drainage below Pond D-2 in the extreme

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southeast portion of the BZ. Well 10394 is located in the Woman Creek drainage. Well 41591 is located in the intermittent drainage immediately south of the East Access Road. Well 41691 is located in the Walnut Creek drainage.

Boundary wells 10394 and 41691 did not have any reportable analyte concentrations during 2002.

Boundary well 0386 had a reportable concentration of selenium (51 µg/L) during the 3rd quarter (Figure 4-77). Monthly sampling resulted in one value slightly above and one value below the Tier II action level, which confirmed that the selenium concentration in this well is close to the Tier II action level. This well is constructed of stainless steel and is equipped with a stainless steel pump. The selenium concentration at this location is probably naturally occurring.

Well 06491 had a reportable occurrence of U-235 (3.75 pCi/L) during the 3rd quarter (Figure 4-78). This is the highest concentration of U-235 recorded at this well to date and is part of an increasing trend that began in 2000. Well 06491 was dry after August 2002, and monthly samples could not be collected. There was only enough water available during the next quarterly sampling event for VOC and nitrate samples.

Well 41591 had reportable concentrations of nickel (290 µg/L) and thallium (5.3 µg/L) during the 3rd quarter of 2002 (Figures 4-79 and 4-80). Monthly sampling confirmed the reportable concentrations for both analytes. This well is equipped with a stainless steel pump. The increase in nickel concentration beginning in early 1999 correlates with the installation of the pump and most likely relates to corrosion of the pump. The thallium concentration may also relate to corrosion of the pump or may be an analytical issue as it is not corroborated by upgradient groundwater data.

Well 10294 had the most reportable analyte concentrations of any Boundary well during 2002. It had a 1st quarter reportable sulfate concentration (Figure 4-81). It also had 3rd quarter concentrations of sulfate, lead (Figure 4-82), U-233/234 (Figure 4-83), U-235 (Figure 4-84), and U-238 (Figure 4-85) that were reportable. All of the reportable concentrations at well 10294 were confirmed by monthly sampling except for lead. The monthly sampling for lead produced two non detects and a low concentration detection that was well below the Tier II action level. The

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concentrations of sulfate observed in this well can easily occur in nature. Although the U-isotope activities are greater than their Tier II action levels and Site background values, the ratio of the activities to each other implies a naturally occurring isotopic signature. The reportable analytes at this well are assumed to occur naturally as this well is remotely located with respect to the IA or any other known contaminant source or pathway. For this reason, the Water Program will remove it from the IMP and abandon it.

In summary, at current Boundary wells (except 10294), VOCs, nitrate, and metals have not been detected at concentrations above Tier II action levels. U-isotopes detected at Boundary well 06491 have been determined to be naturally occurring by high resolution ICP/MS analysis (RMRS, 2000d).

4.12 Current Extent of Groundwater Contaminants

This section presents a discussion of the extent of VOCs and nitrate in groundwater at the Site. Figures 4-86 through 4-90 depict the interpreted extents for individual contaminant plumes. It is important to recognize that the term "plume" here refers to the distribution of individual VOCs. These maps do not represent contaminant plumes from individual sources, but rather the overall distribution of each contaminant plume currently recognized at the Site. This differs from previous Annual RFCA Reports (e.g., DOE 1998a; Safe Sites, 2001a; 2002b), that included "composite" VOC maps rather than constituent-specific maps and may be different than those generated by computer. It also differs from the "Plume Signature Areas" defined during the development of the VOC groundwater transport modeling which represents the maximum (historical) aerial extent of observed contamination (Kaiser-Hill 2004). Because of the lack of well control in some areas, professional judgment and Site knowledge has been used to infer the extent of contamination or to delineate between Tier I and Tier II concentration areas on these maps.

Individual contaminant source information (details of substances, dates, quantities, response actions, etc.) was not used to delineate discrete contaminant plumes on Figures 4-86 through

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4-90. Current groundwater modeling efforts performed by the Water Program are focused on specific VOC source areas identified in the HRR (DOE, 1992b). The results of the modeling efforts will be published in a separate report (Kaiser-Hill, 2004)

Contaminant extent maps were prepared for PCE (Figure 4-86), TCE (Figure 4-87), CT (Figure 4-88), VC (Figure 4-89), and nitrate (Figure 4-90). The following sections describe the methods used to create the plume maps, including a discussion of the 2003 Snapshot, and a discussion of the individual analyte maps.

4.12.1 Methodology

The contaminant extent maps were developed to reflect the "most current conditions" for each constituent selected for discussion. These maps provide the Site with the most current and comprehensive evaluation of the distribution of VOCs in Site groundwater and support accelerated actions, D&D, and long-term monitoring decisions. They also provide the most extensive view of current contaminant extents as many monitoring wells are currently being abandoned as the Site proceeds towards closure.

Since 1995, many monitoring wells at the Site had not been sampled or had been infrequently sampled. This has led to uncertainty concerning the current distribution of VOCs in groundwater. To address this uncertainty, a large-scale sampling project, termed the "Snapshot", was designed to collect samples from all wells in areas of interest that are not routinely sampled. The Snapshot was completed between April and August 2003 so that it would not adversely impact the WARP schedule. After a review of the Snapshot data, it became apparent that there were data gaps because of wells abandoned during the previous few years and Program wells that were not included in the Snapshot because they are routinely sampled during the year.

To fill in these data gaps, which were most obvious in the 903 Pad and former SEPs areas, the most recent sampling results since January 1, 2001 were selected for the abandoned and routine Program wells excluded from the Snapshot. January 1, 2001 was selected to include data from abandoned wells in areas of interest (903 Pad, former SEPs) and the most recent data from Program wells (K-H, 2003c). Analytical data for the selected wells (both Snapshot and non-

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Snapshot) were retrieved from SWD for each contaminant of interest, posted on maps, and hand contoured. Contour intervals depicted on the maps represent RFCA Tier I and Tier II action levels.

Although the Snapshot was conducted in the spring and summer of 2003, the resulting VOC data were used to create the maps for this CY 2002 report to avoid waiting another year to publish this useful data.

4.12.2 Extent of VOCs

VOCs are the most widespread groundwater contaminants at the Site. The most extensive VOC contaminant plumes include PCE, TCE, and CT. Although VC is not thought to be a primary contaminant at the Site, and does not form extensive plumes, it was selected for evaluation because, in the literature, it is an important indicator of biodegradation.

4.12.2.1 Extent of PCE

PCE is probably the most widespread of any of the four VOCs discussed in this section (Figure 4-86). A large area of PCE contamination above the Tier II action level is found east and southeast of the IA, in the BZ, and is associated with Ryan's Pit, the 903 Pad, the Mound Site, and the East Trenches. Superimposed on this eastern area of Tier II PCE contamination are three isolated areas of Tier I PCE contamination; one emanates from the 903 Pad, and another from Trench T4. The third area of Tier I PCE contamination is downgradient of the Mound Site; the eastern portion of this area may be associated with another source located immediately to the east of the Mound Site. There is no other Tier I PCE contamination at RFETS, with the exception of a single well in the area of IHSS 119.1.

Within the IA, a large area of Tier II PCE contamination exists. The northern extent of this plume trends east-west between B707 and former B335. The plume then narrows and extends south through former Buildings 334 and 551 and continues south through B444. Some contribution to this PCE plume comes from the southeast corner of former Building 123. From B444, the plume extends southeast through B664 and then northeast to B883. The unusual shape of this area of

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PCE contamination, with respect to observed groundwater flow lines, indicates that there are numerous groundwater sources contributing to this plume and suggests that the mapped areas may not be contiguous as shown on Figure 4-86.

Three additional areas of Tier II PCE contamination are worth noting. One occurs adjacent to B776, extends north towards B771, extends west to the unnamed drainage between B371/374 and B771. Another area is associated with the westernmost former SEP. A third area is associated with the PU&D Yard.

4.12.2.2 Extent of TCE

The Tier II TCE distribution (Figure 4-87) east of the IA is similar to the distribution of PCE, except that the easternmost extent of the Tier II TCE plume is less than PCE. TCE contamination is associated with Ryan's Pit, the 903 Pad, the Mound Site, and the East Trenches. Tier I TCE contamination is isolated to single wells at the 903 Pad, Mound Site, and a few wells downgradient of Trench T4. The major difference between the TCE and PCE distribution east of the IA is at Ryan's Pit, where there is an area of Tier II TCE contamination extending from Ryan's Pit to the southeast, a distance of approximately 900 feet. This Tier I portion of the plume is unusual because the orientation of the long axis of the plume is not coincident with groundwater flow direction in the area downgradient of Ryan's Pit. This indicates that there may be an additional contaminant source besides Ryan's Pit and that the Tier I area mapped may not be contiguous as shown on Figure 4-87.

Within the IA, an area of Tier II TCE contamination exists. It is not as widespread as the Tier II distribution of PCE in the IA. The Tier II TCE contamination associated with the former SEPs is much more widespread than for any of the other VOCs and encompasses the entire former SEPs area. Unlike PCE, there are three isolated areas of Tier I TCE contamination in the IA. The three isolated Tier I TCE contamination areas are located between Buildings 460 and 444; 400 feet due west of B559 adjacent to B223A; and just south of the westernmost former SEP. Tier II TCE distribution in the PU&D Yard is more extensive than PCE; Tier I and II TCE distribution at IHSS 119.1 is slightly more extensive than PCE.

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4.12.2.3 Extent of Carbon Tetrachloride

There is a large area of Tier II CT contamination (Figure 4-88) located east and southeast of the IA, in the BZ, that is associated with the 903 Pad and the East Trenches. Superimposed on the Tier II CT plume is a relatively large area of Tier I CT contamination that extends from immediately west of the 903 Pad east for approximately 1,300 feet and northeast for approximately 1,700 feet. This is the largest area of Tier I VOC contamination at RFETS. Based on the configuration of the CT plume in this eastern area, it does not appear that Ryan's Pit and the Mound Site are contributors.

The CT plume in the IA is confined to three distinct areas. A relatively small area (compared to PCE and TCE) of Tier II CT contamination is located in the vicinity of B559. The source of this contamination appears to be the storage pad located approximately 400 feet southwest of B559. The second area of CT contamination is associated with IHSS 118.1, a known area of previous CT bulk storage and documented releases. There is an extensive area of Tier II CT contamination associated with this location. The third area of CT contamination is located in the vicinity of the westernmost former SEP. There is only one additional isolated area of CT contamination at RFETS; a single well within IHSS 119.1.

4.12.2.4 Extent of Vinyl Chloride

The distribution of VC at RFETS is very limited (Figure 4-89). The most extensive area of Tier II VC contamination is delineated by three wells; one west, one south, and one east of the former B551. The only current Tier I VC occurrence at RFETS is immediately north of the former B335. Another small area of Tier II VC contamination is immediately north of B771, along the former PA perimeter road. Three isolated locations of Tier II VC contamination also exist; two are located along the diagonal road, just east of B371/374. VC also occurs in a single well downgradient of the Mound Site.

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4.12.3 Extent of Nitrate

Nitrate concentrations in groundwater that are greater than Tier II and Tier I action levels are illustrated on Figure 4-90. As with previous depictions of nitrate concentrations in groundwater (e.g., RMRS, 1999m; 2000d; Safe Sites, 2001a; 2002b), the main nitrate plume at RFETS, termed the SPP, is associated with the former SEPs. Tier II nitrate contamination has migrated to the north and south from the former SEPs. Tier I nitrate contamination is observed in this plume north of the central and eastern former SEPs. Nitrate concentrations in groundwater greater than the Tier I action level are not found anywhere else at RFETS.

The other nitrate plume at RFETS is located at the 903 Pad and is not very extensive compared to the SPP. The 903 Pad nitrate plume encompasses the eastern half of the pad and extends slightly to the northeast of the pad.

Fourteen isolated wells are shown on Figure 4-90 that exceed the Tier II nitrate action level. In addition, nitrate in groundwater exceeds Tier II immediately north of the western half of B771.

4.12.4 Current Extent of Groundwater Contamination Summary

The 2003 Snapshot sampling event provides the most current and comprehensive evaluation of the distribution of VOCs in Site groundwater and support accelerated actions, D&D, and long-term monitoring decisions. VOCs are the most widespread contaminants at the Site. VOC plumes have reached South Walnut Creek in the area of the East Trenches Plume and approach Woman Creek downgradient of the 903 Pad and Ryan's Pit. The principal nitrate and uranium plumes at the Site occur beneath and downgradient of the former SEPs; the northernmost extent of this plume has reached North Walnut Creek. These are the only contaminant plumes at the Site that discharge to surface water at this time.

At current Boundary wells (except 10294), VOCs and nitrate have not been detected at concentrations above Tier II action levels. U-isotopes detected at Boundary well 06491 have been determined to be naturally occurring by ICP/MS analysis (RMRS, 2000d). As stated above, there are no Tier I metals plumes at RFETS, only isolated Tier I occurrences.

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Figure 4-2
07391 Tetrachloroethene

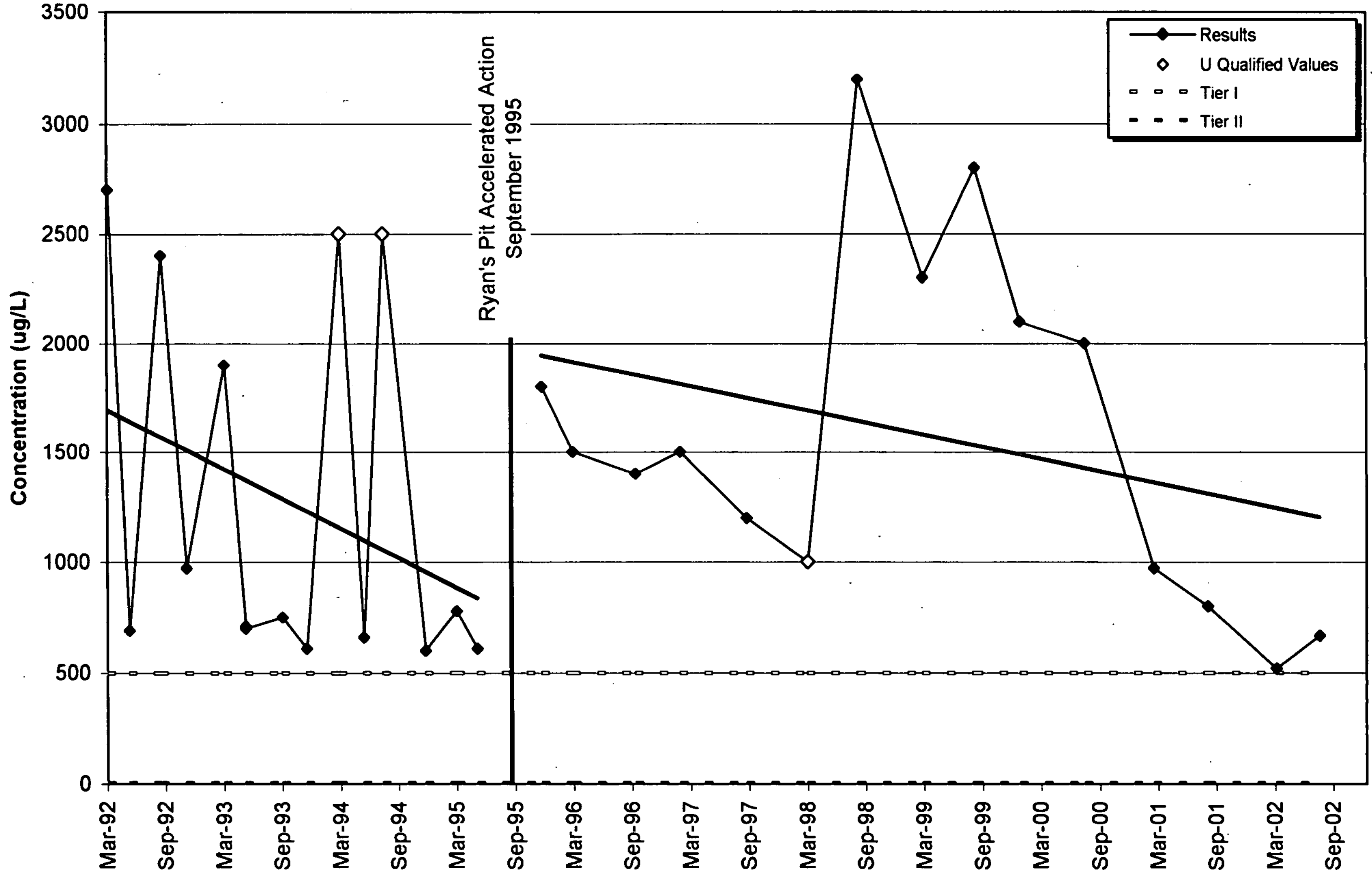

Figure 4-3
07391 Trichloroethene

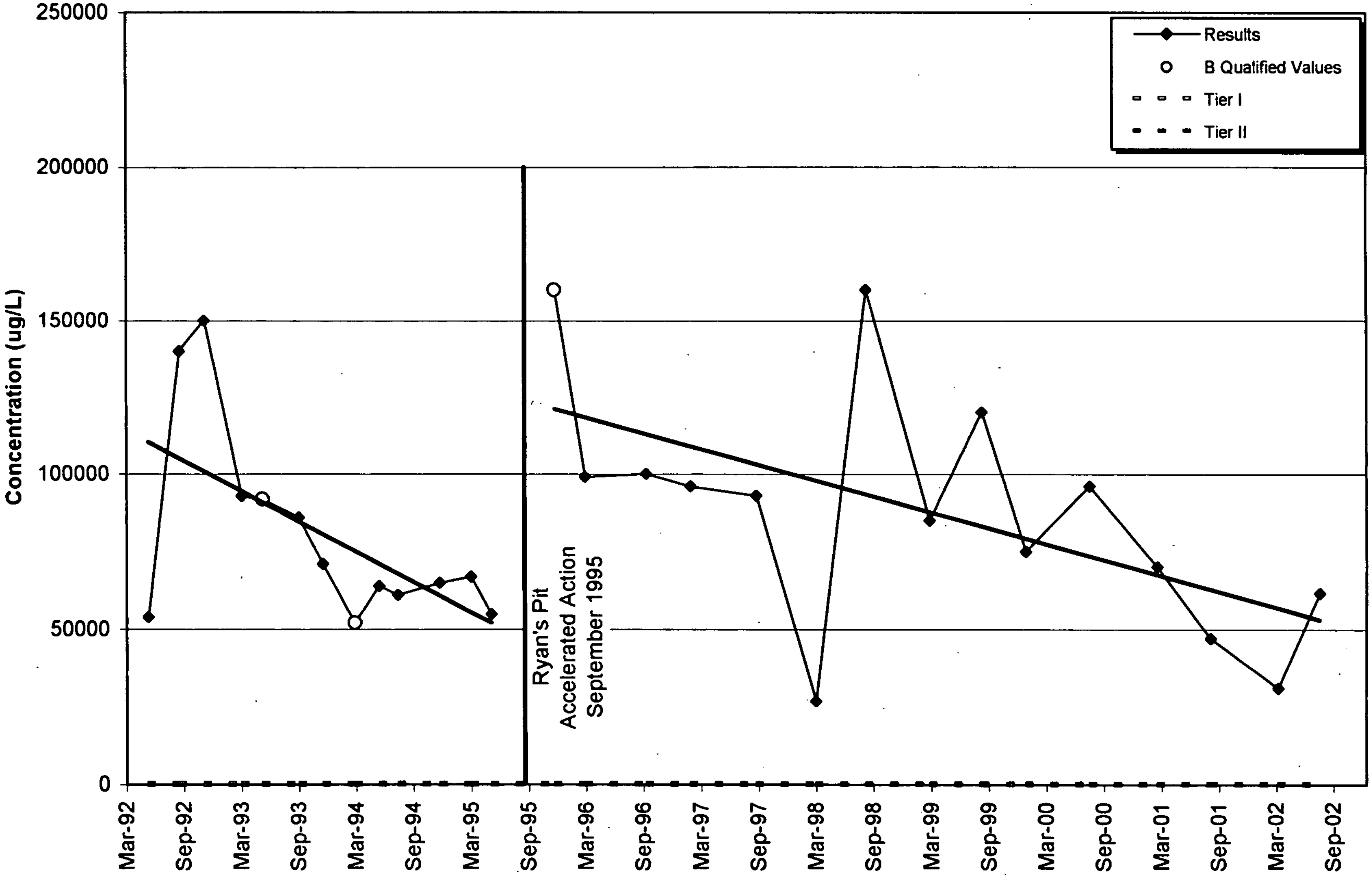

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Figure 4-4
07391 1,1,1-Trichloroethane

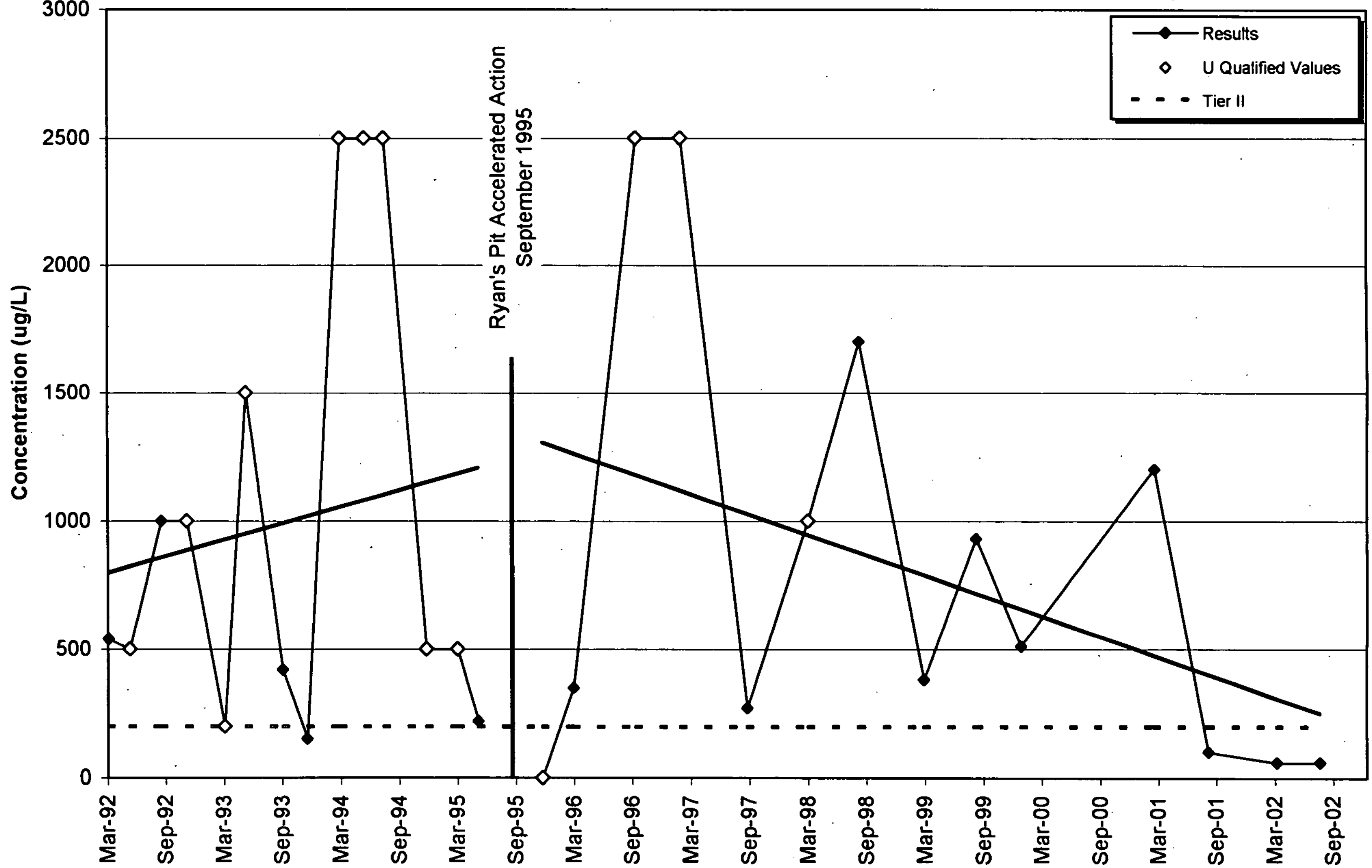

Figure 4-5
07391 Chloroform

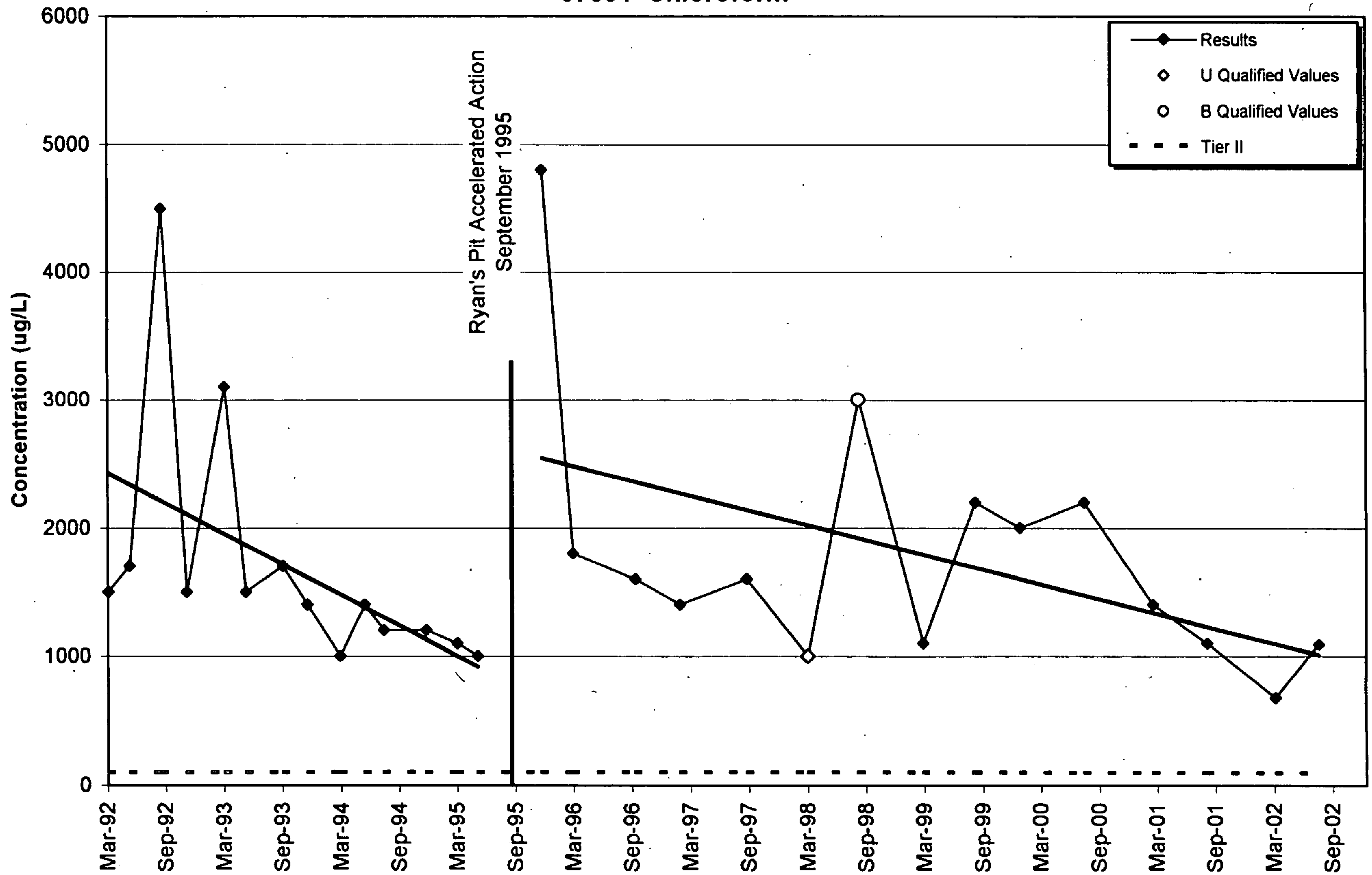

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Figure 4-6
07391 Uranium 235

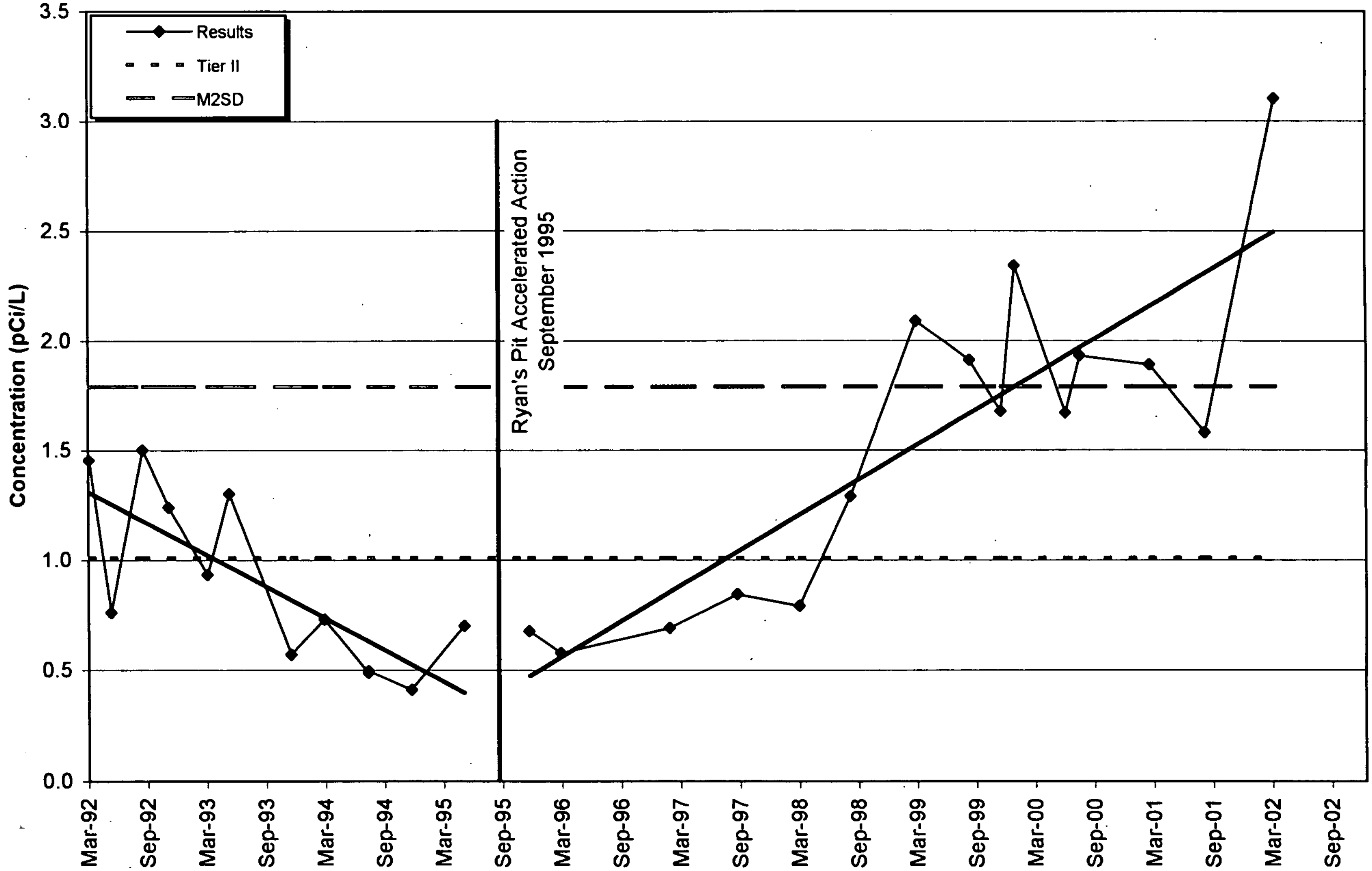

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Figure 4-7
07391 Uranium 238

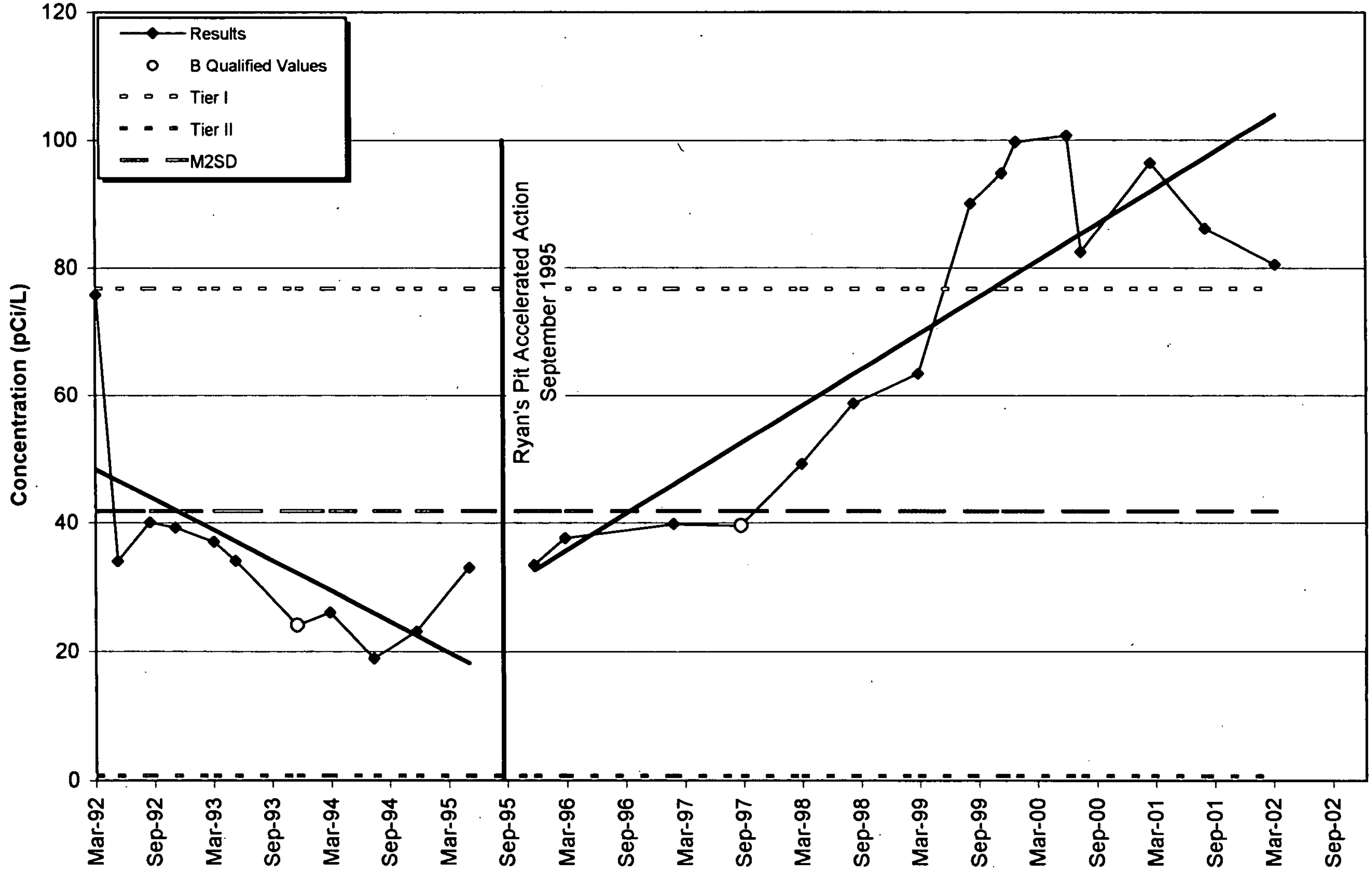

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Figure 4-9
06091 Carbon Tetrachloride

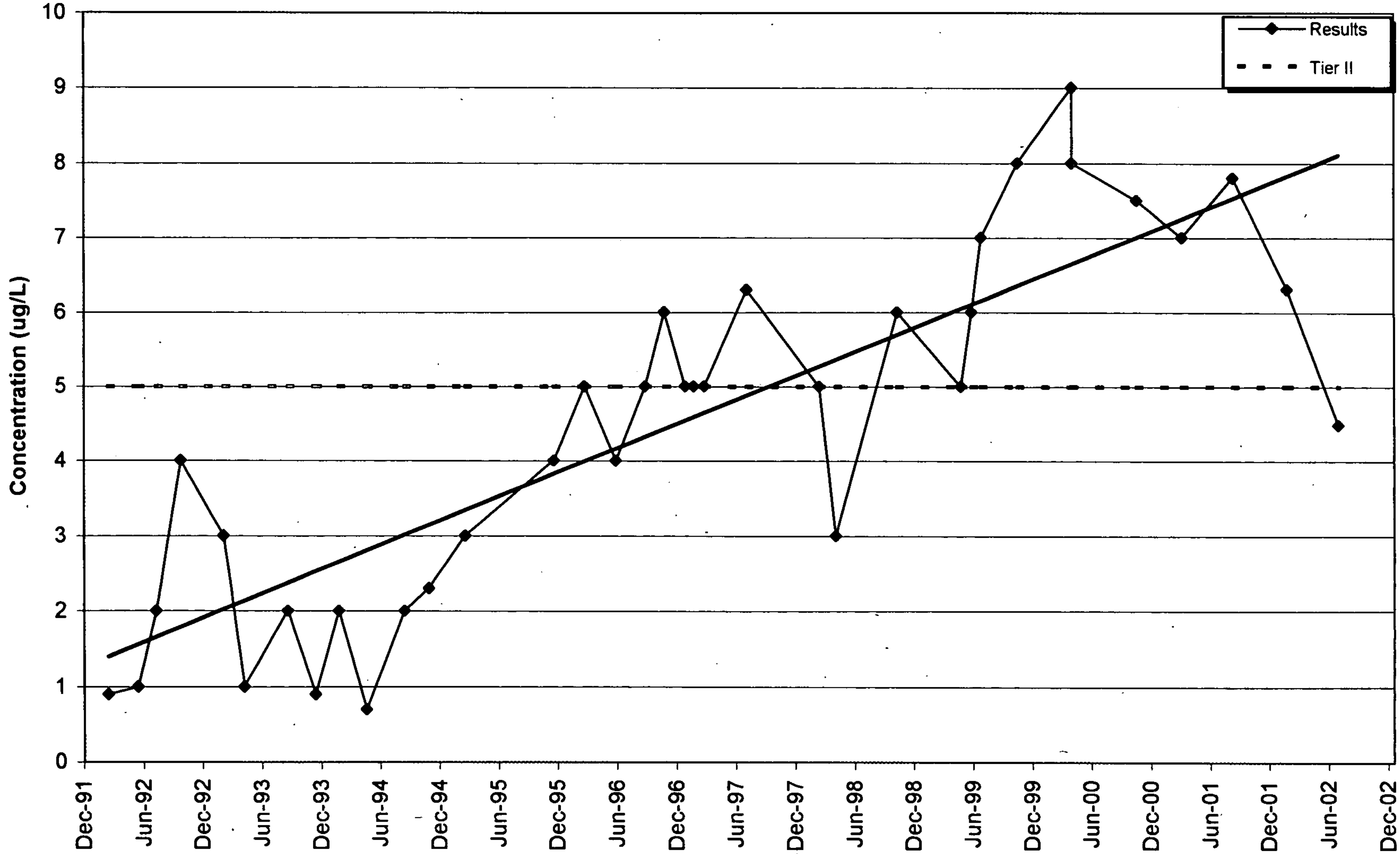

Figure 4-10
06091 Chromium

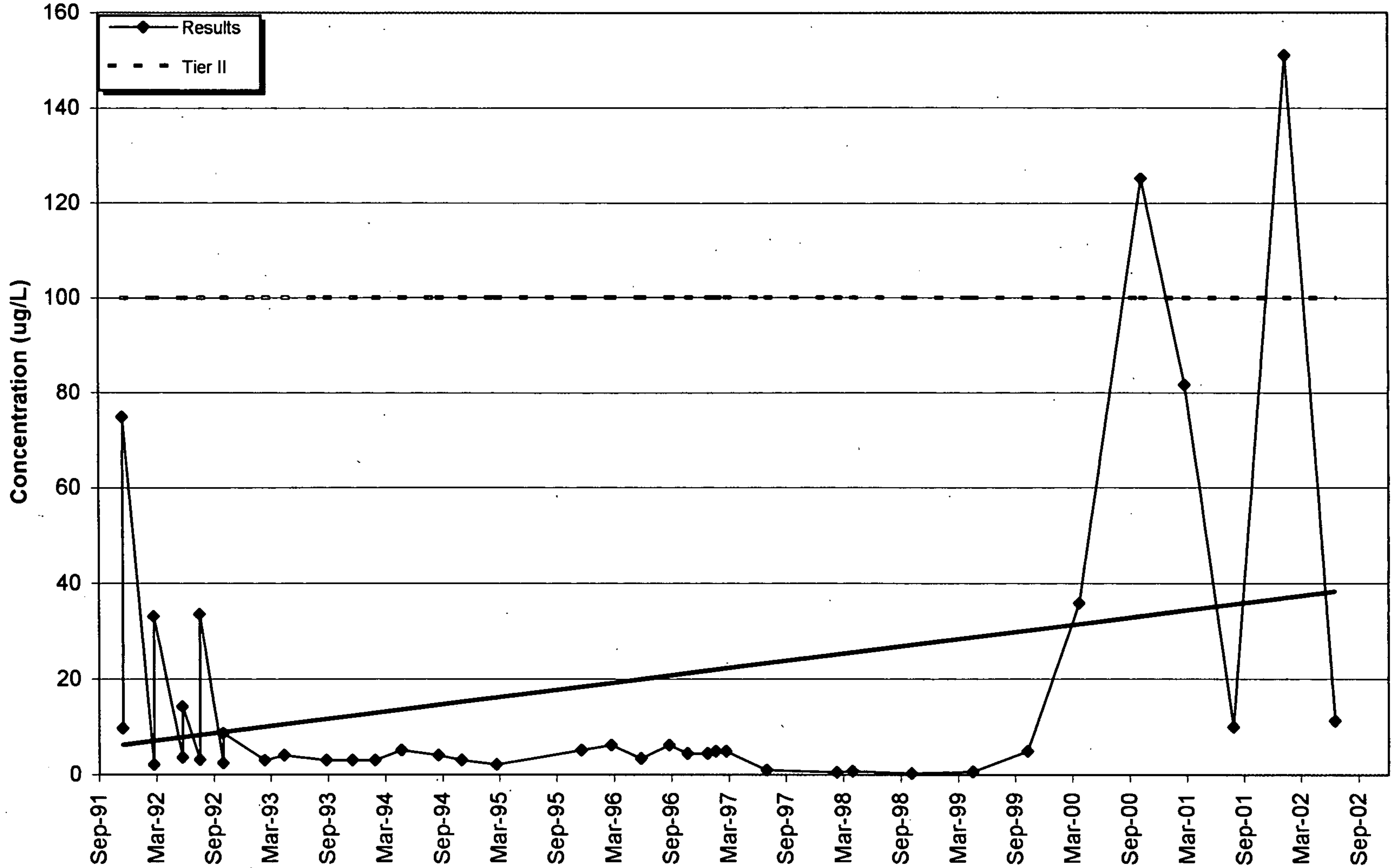

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Figure 4-11
23296 Carbon Tetrachloride

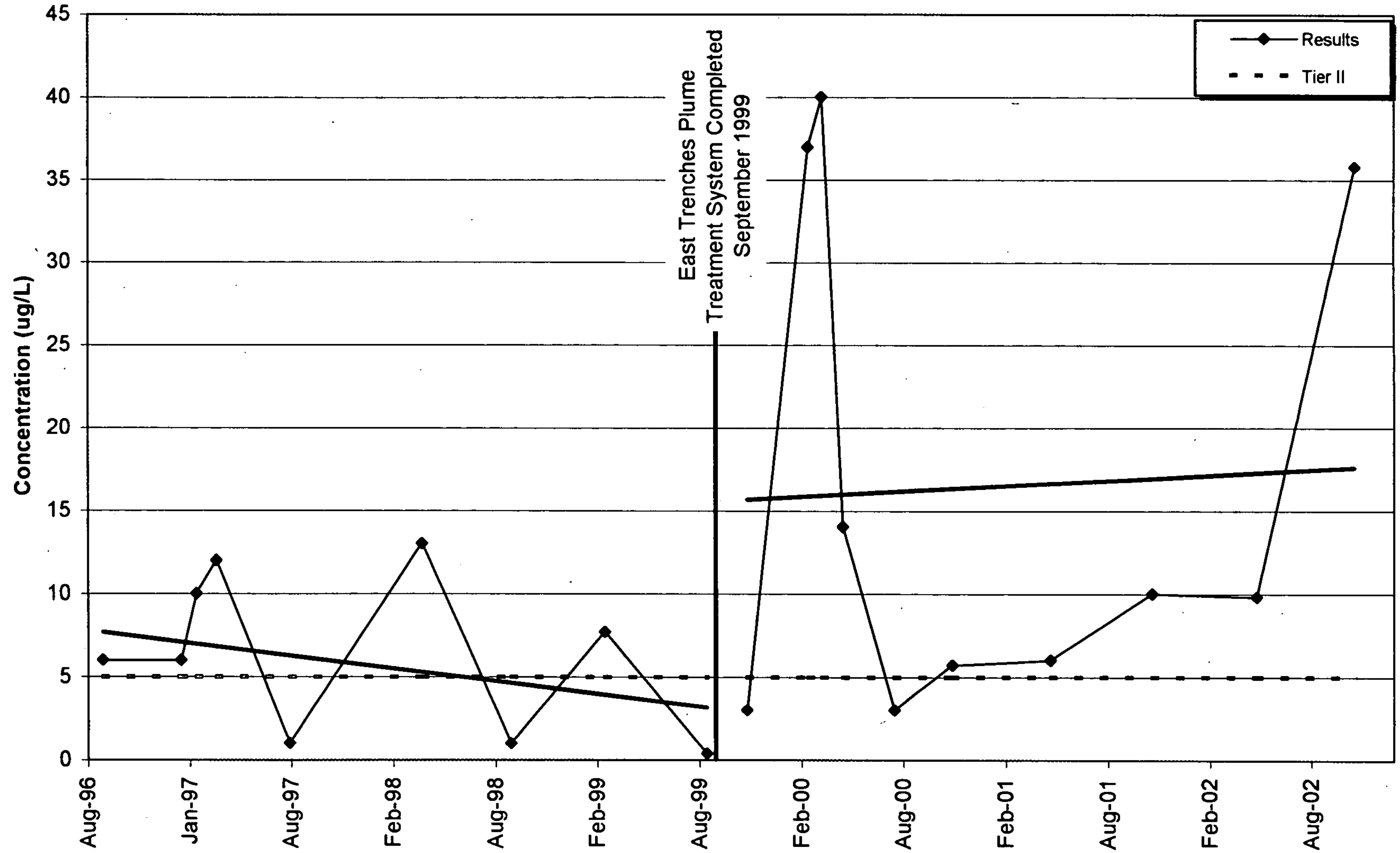

Figure 4-12
23296 cis-1,2-Dichloroethene

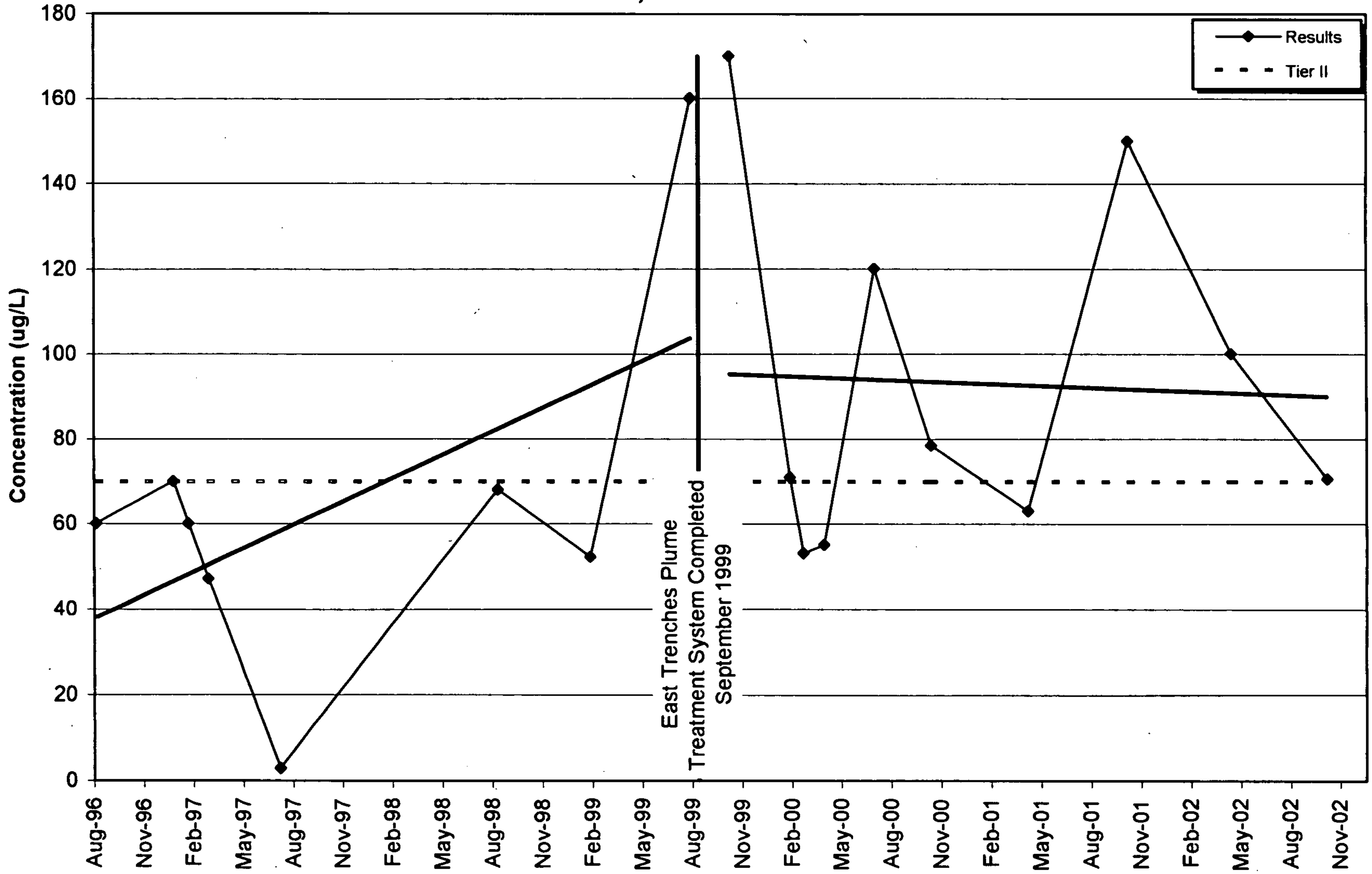

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Figure 4-13
23296 Tetrachloroethene

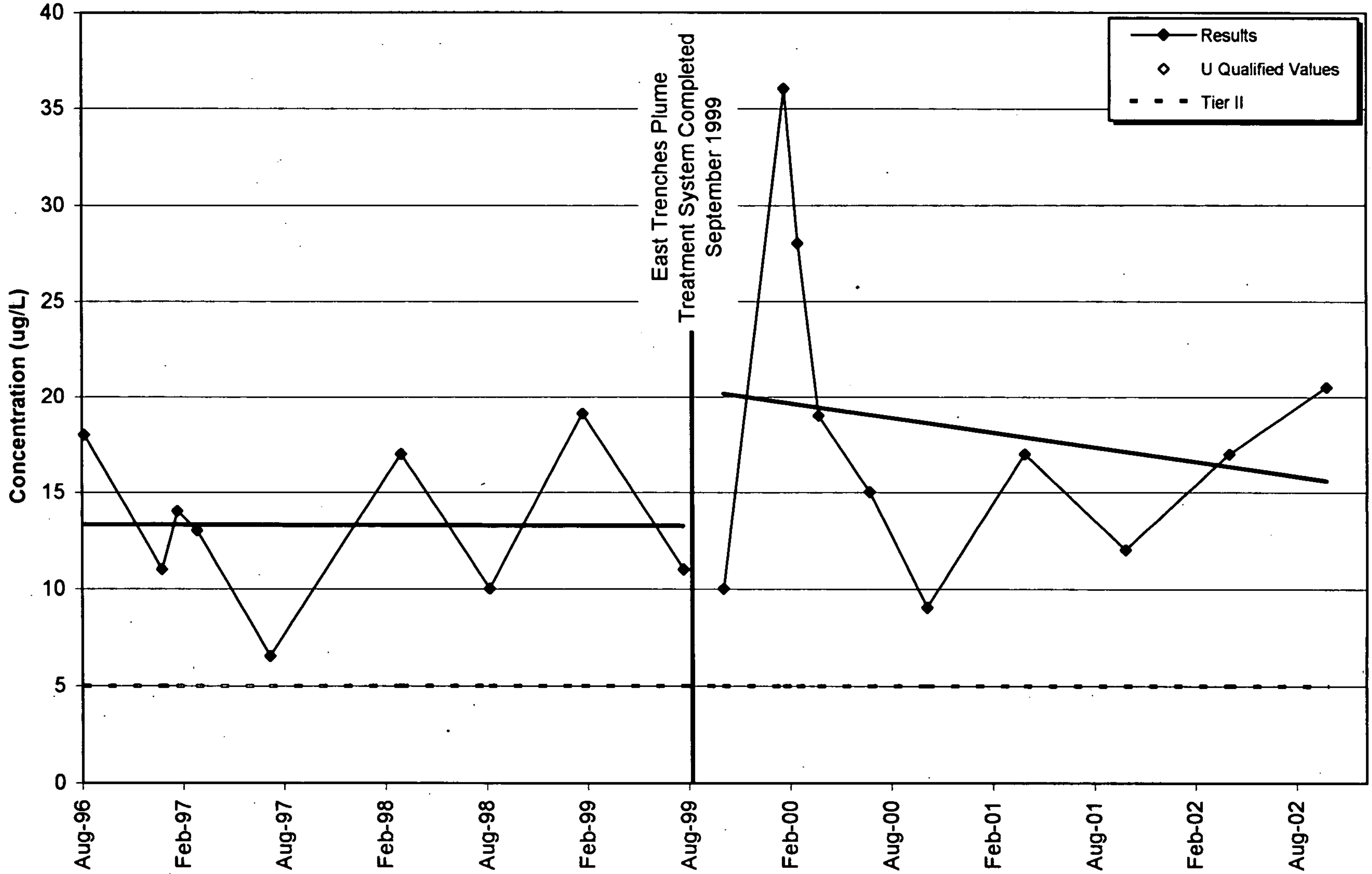

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Figure 4-14
23296 Trichloroethene

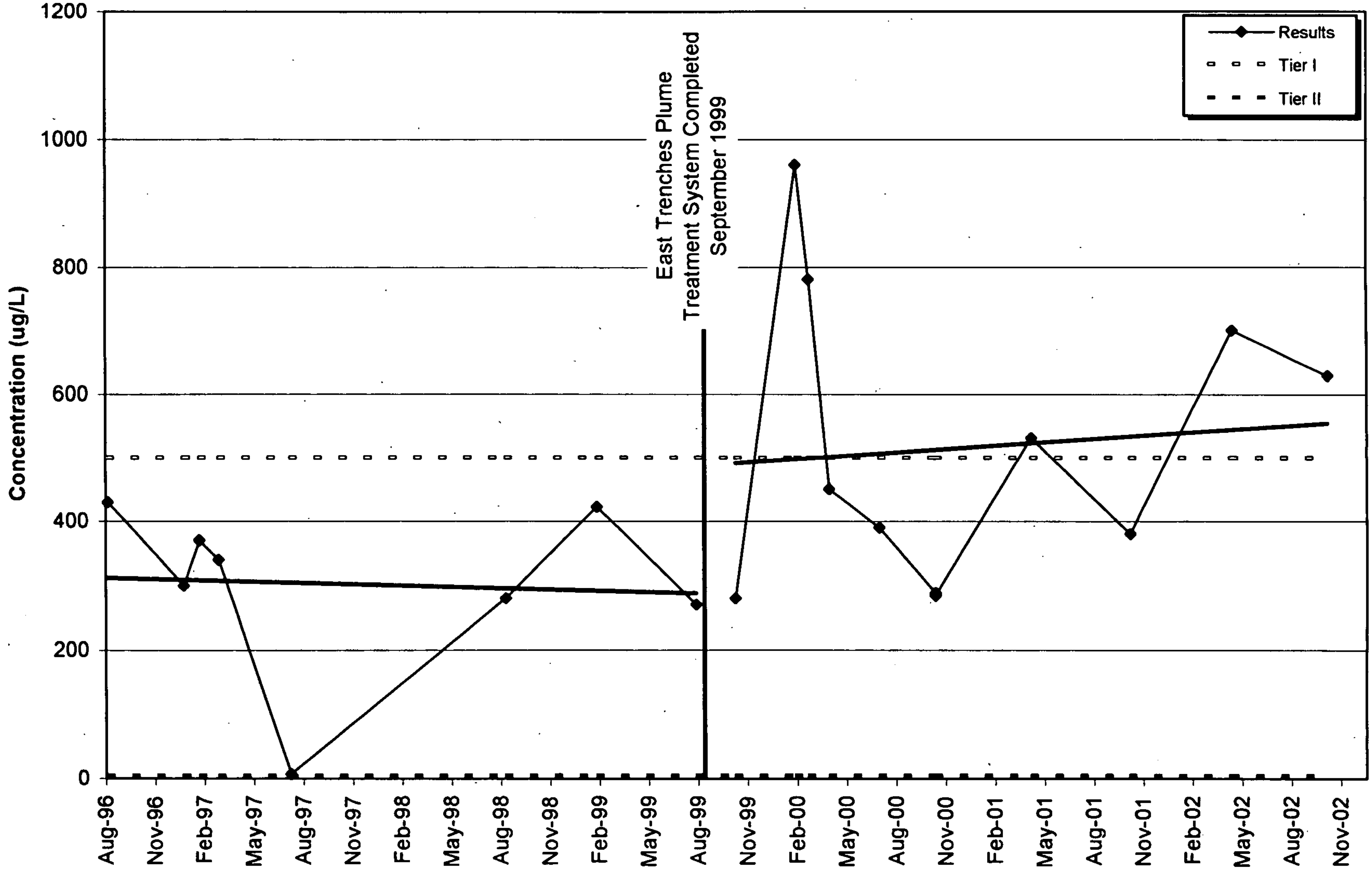

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Figure 4-15
23296 Cadmium

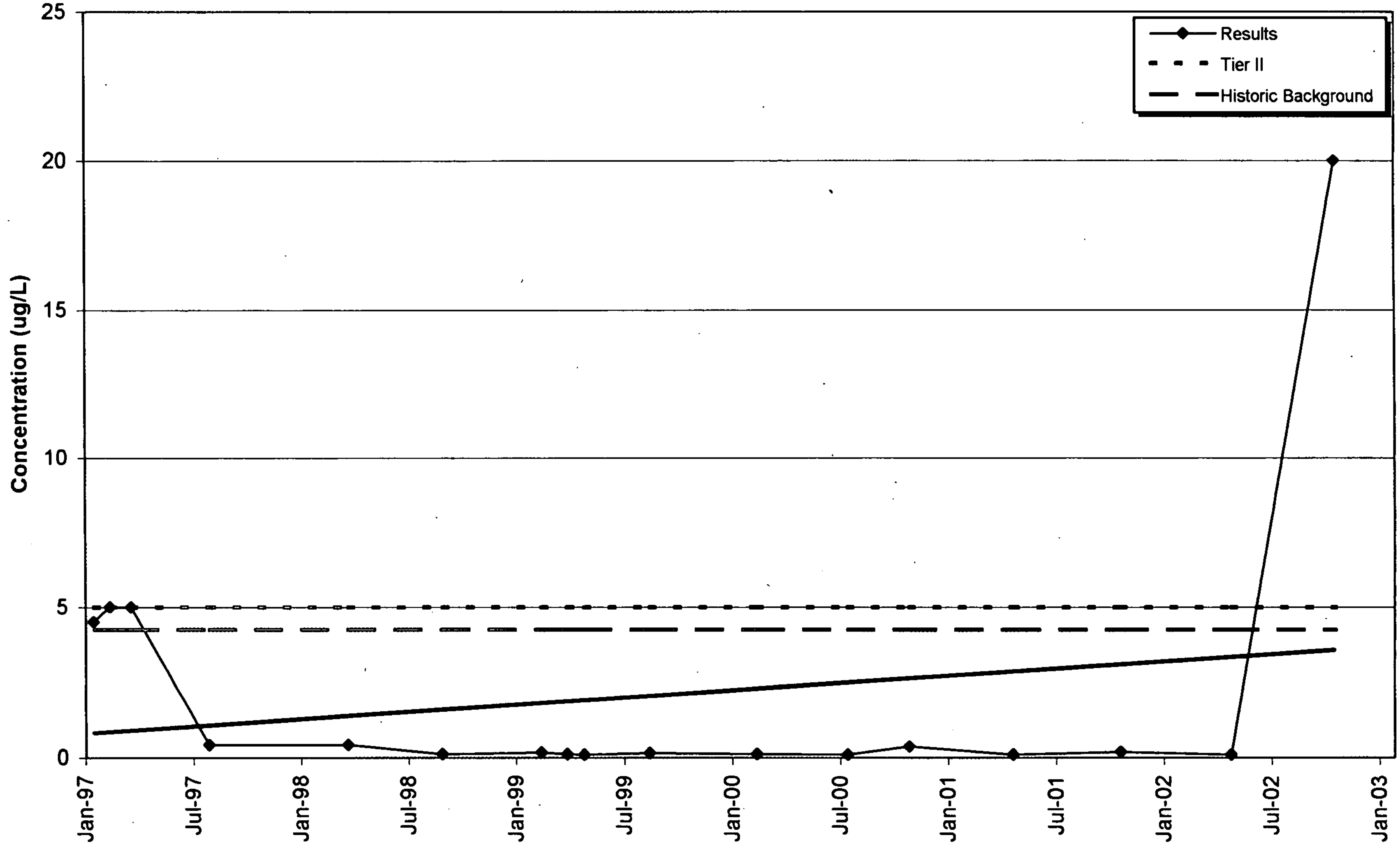

Figure 4-16
23296 Nickel

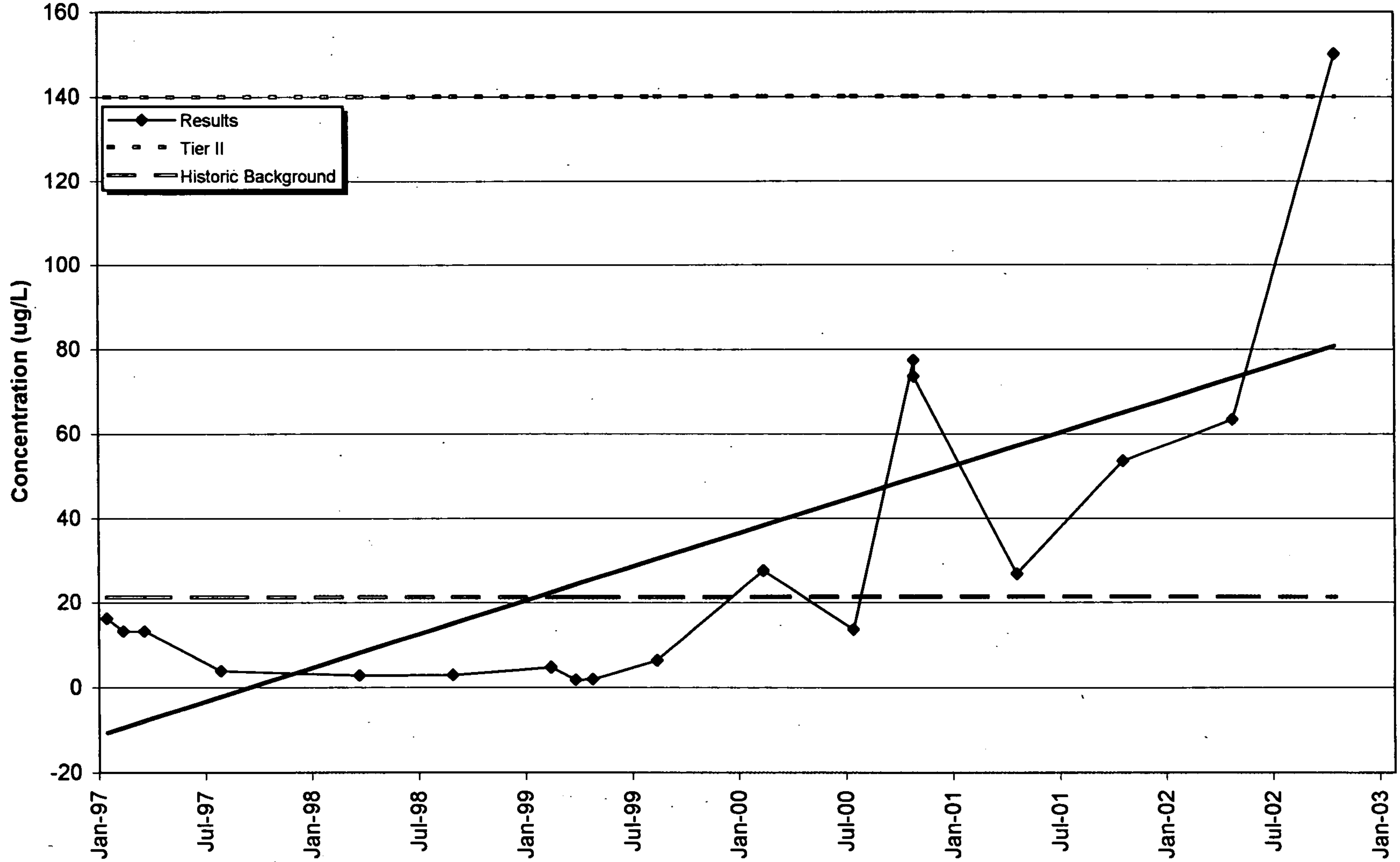

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Figure 4-17
3687 Tetrachloroethene

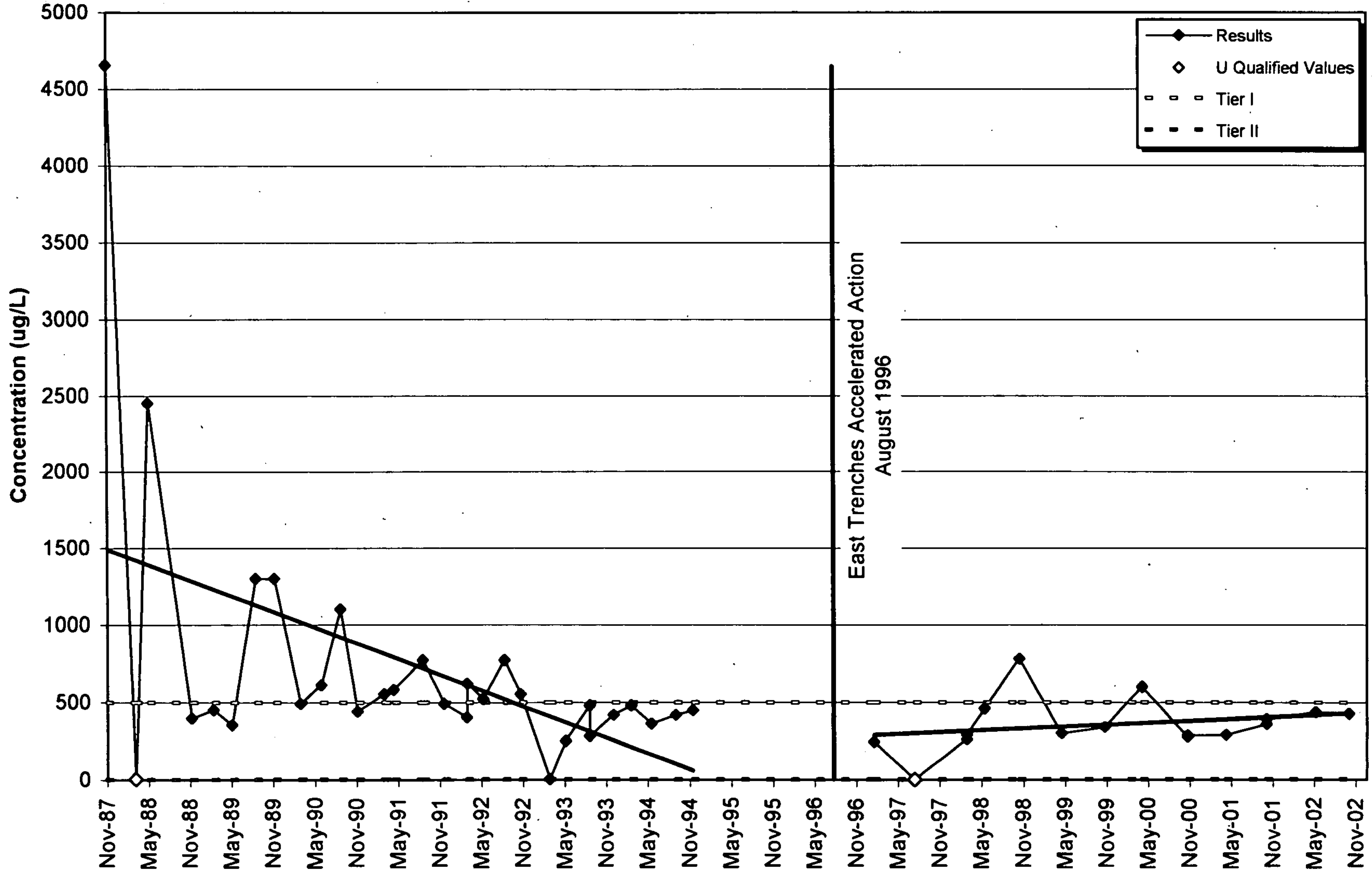

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Figure 4-18
3687 Trichloroethene

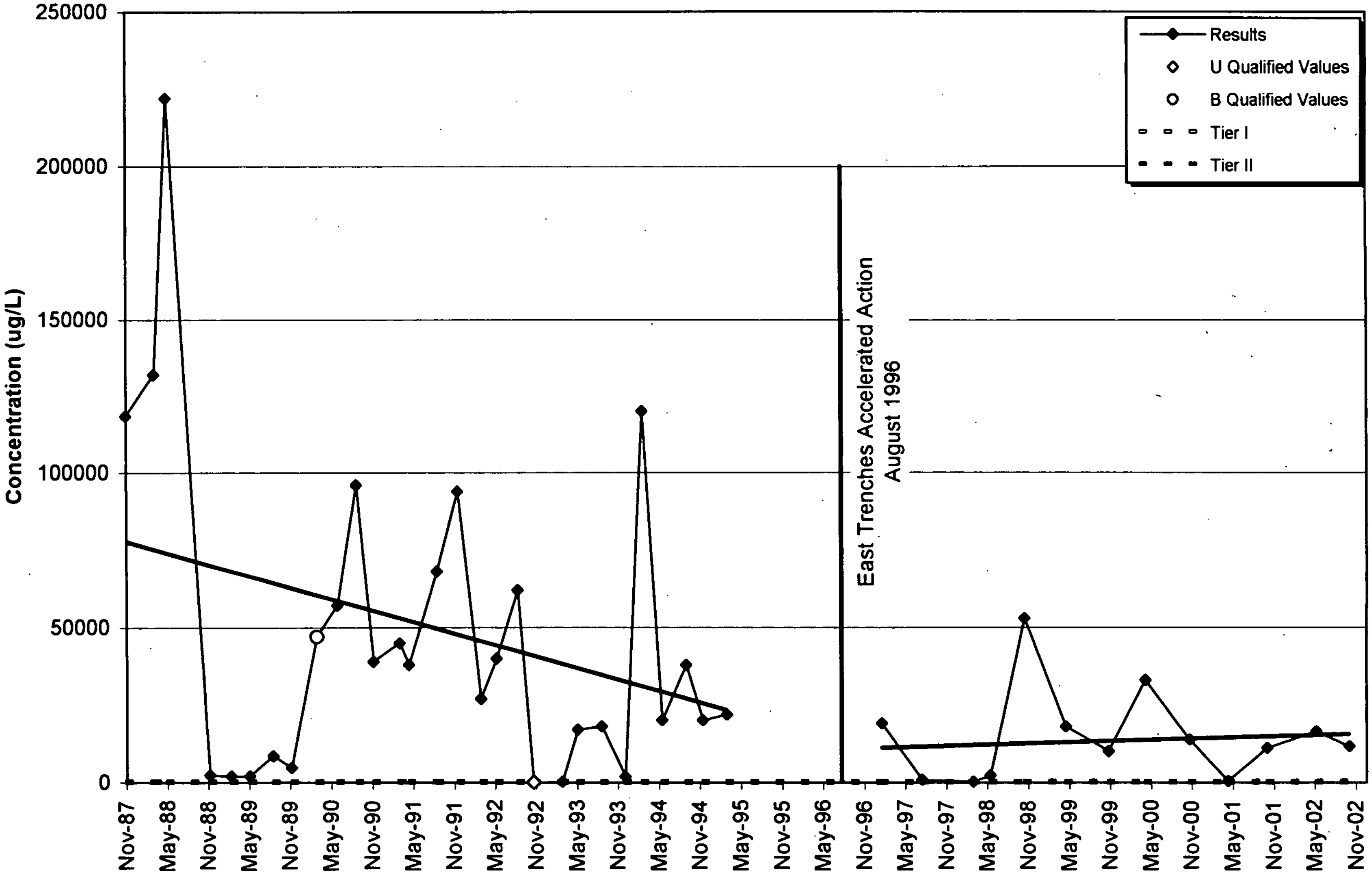

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Figure 4-19
3687 Chloroform

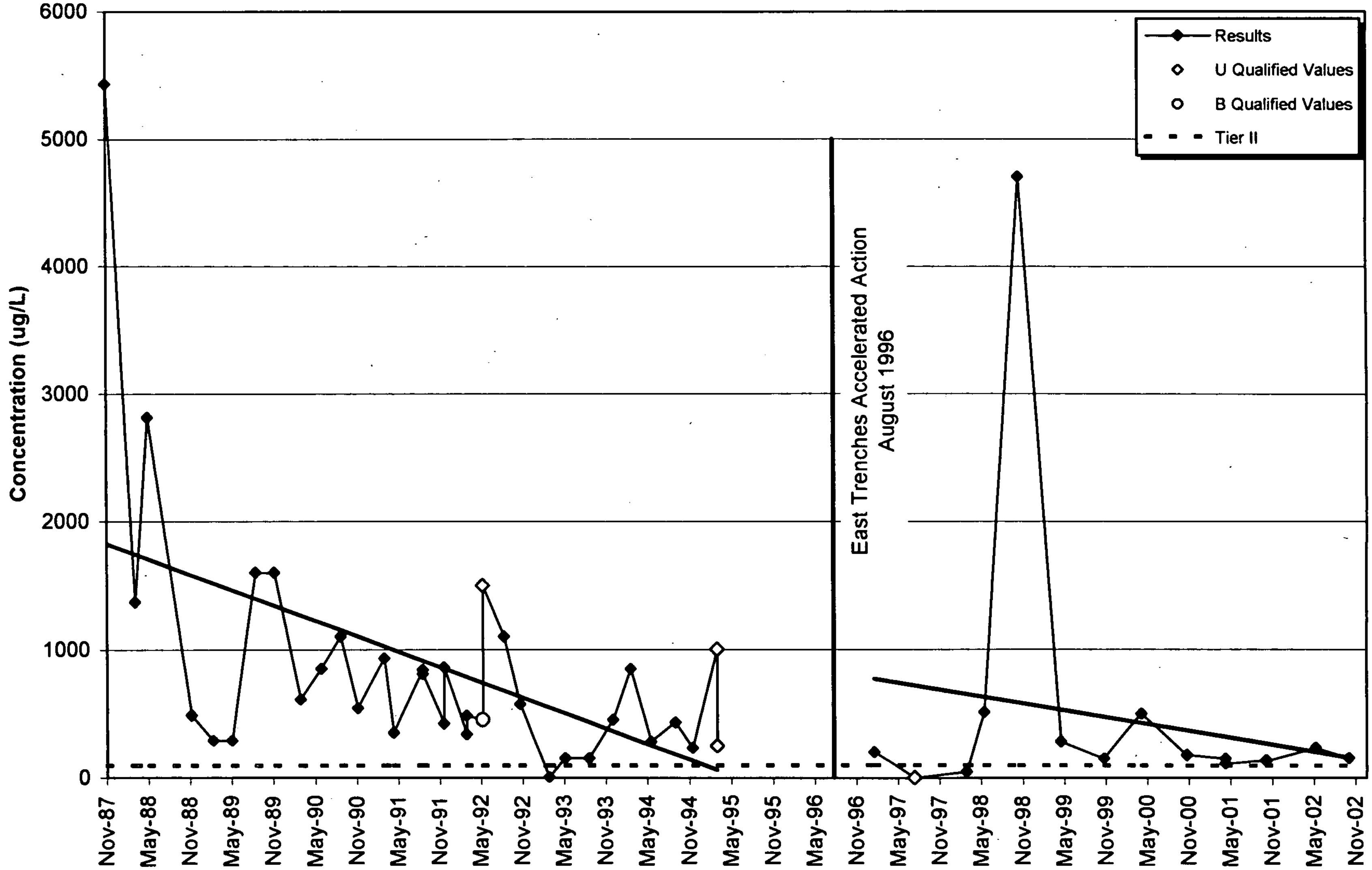

Figure 4-20
3687 Carbon Tetrachloride

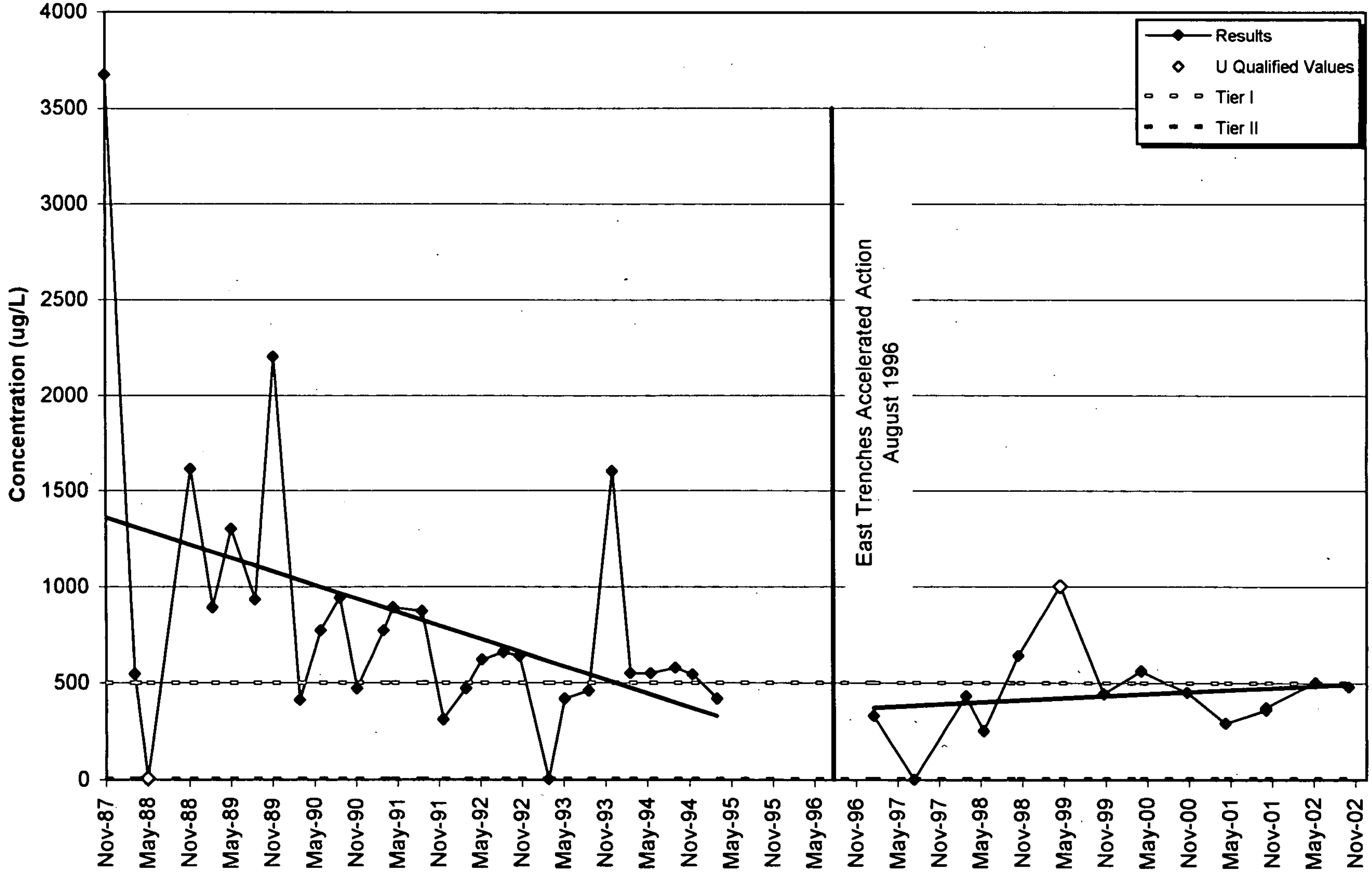

Figure 4-21
05691 Tetrachloroethene

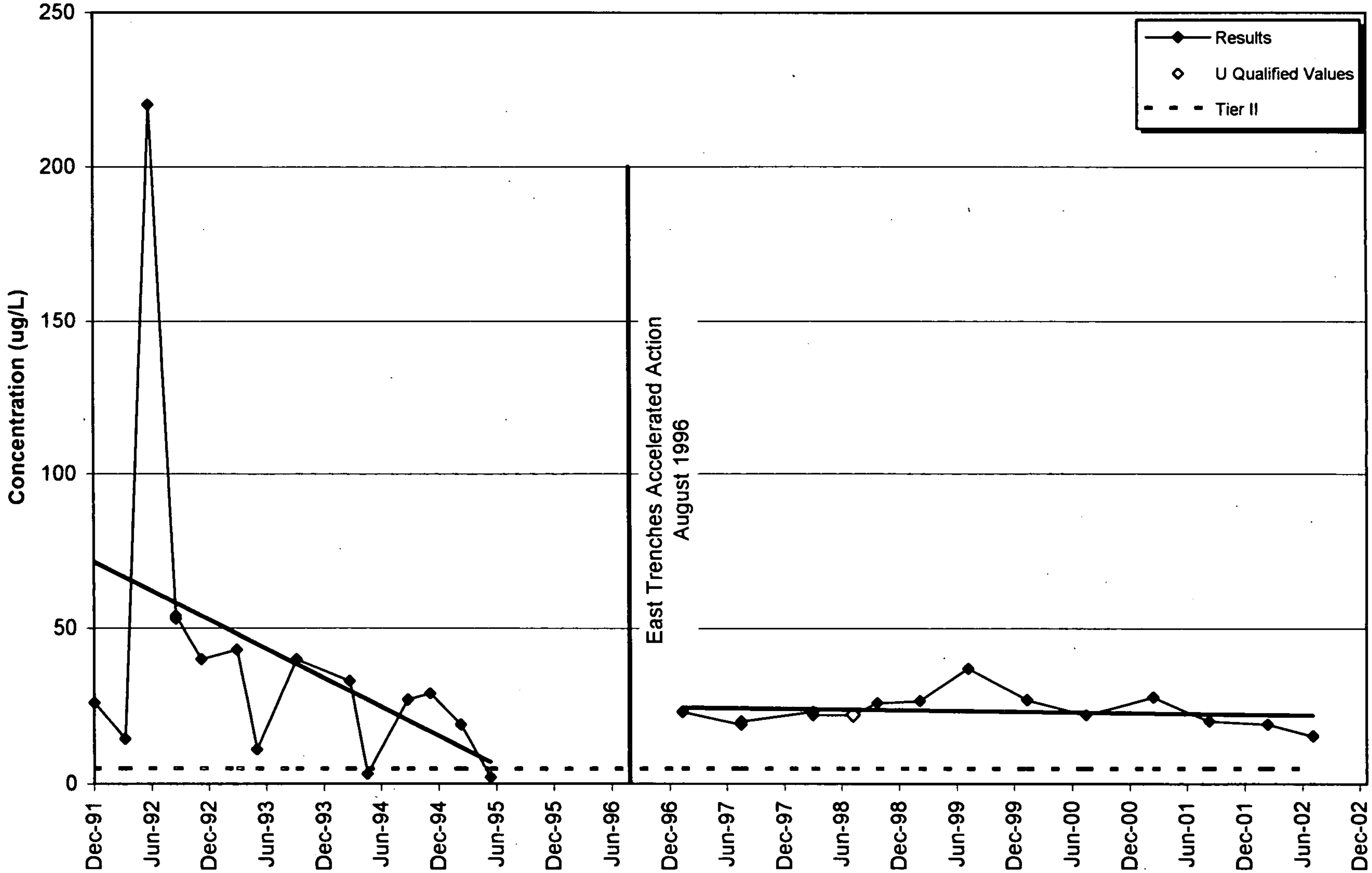

Figure 4-22
05691 Trichloroethene

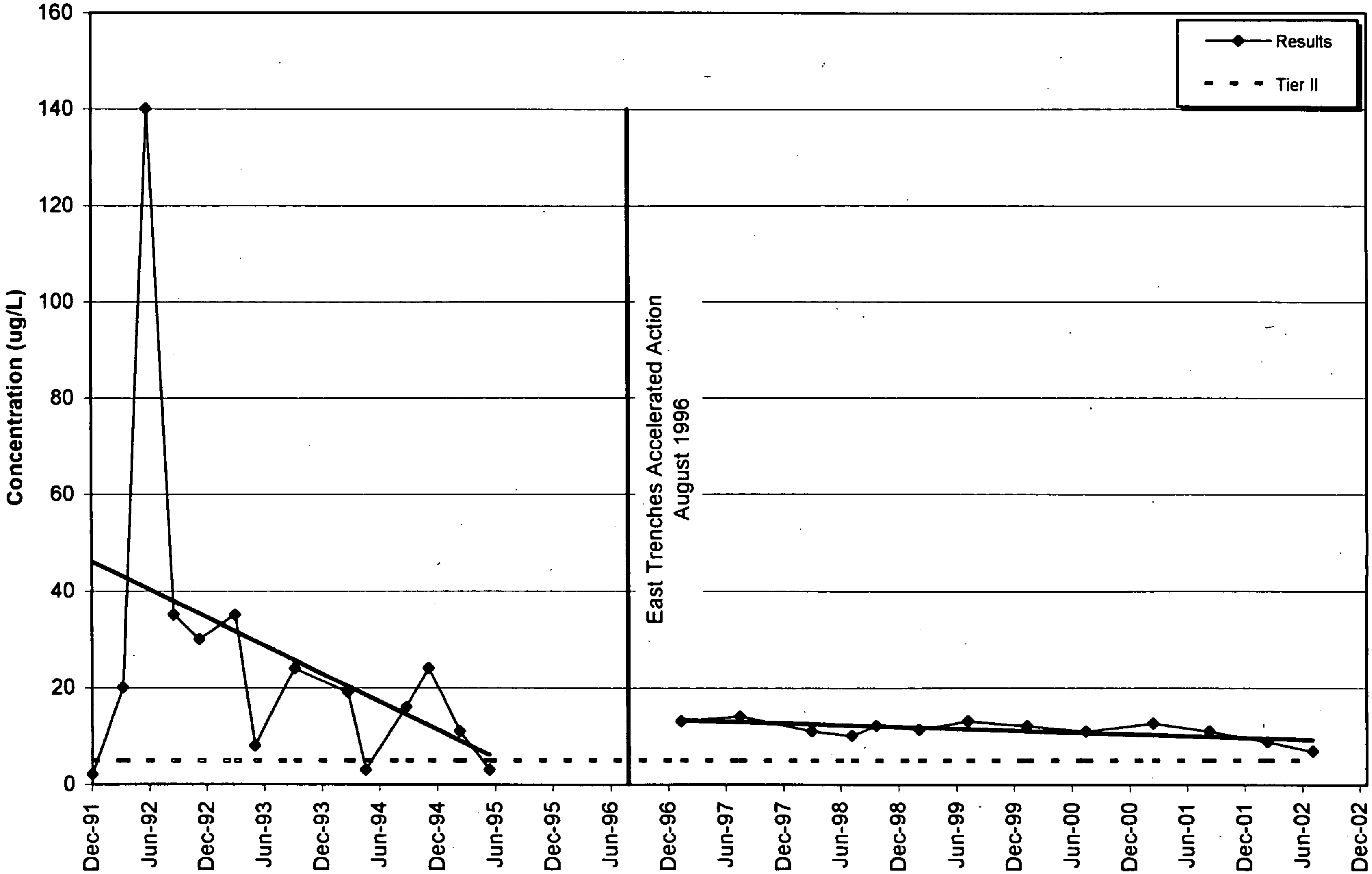

Figure 4-23
05691 Carbon Tetrachloride

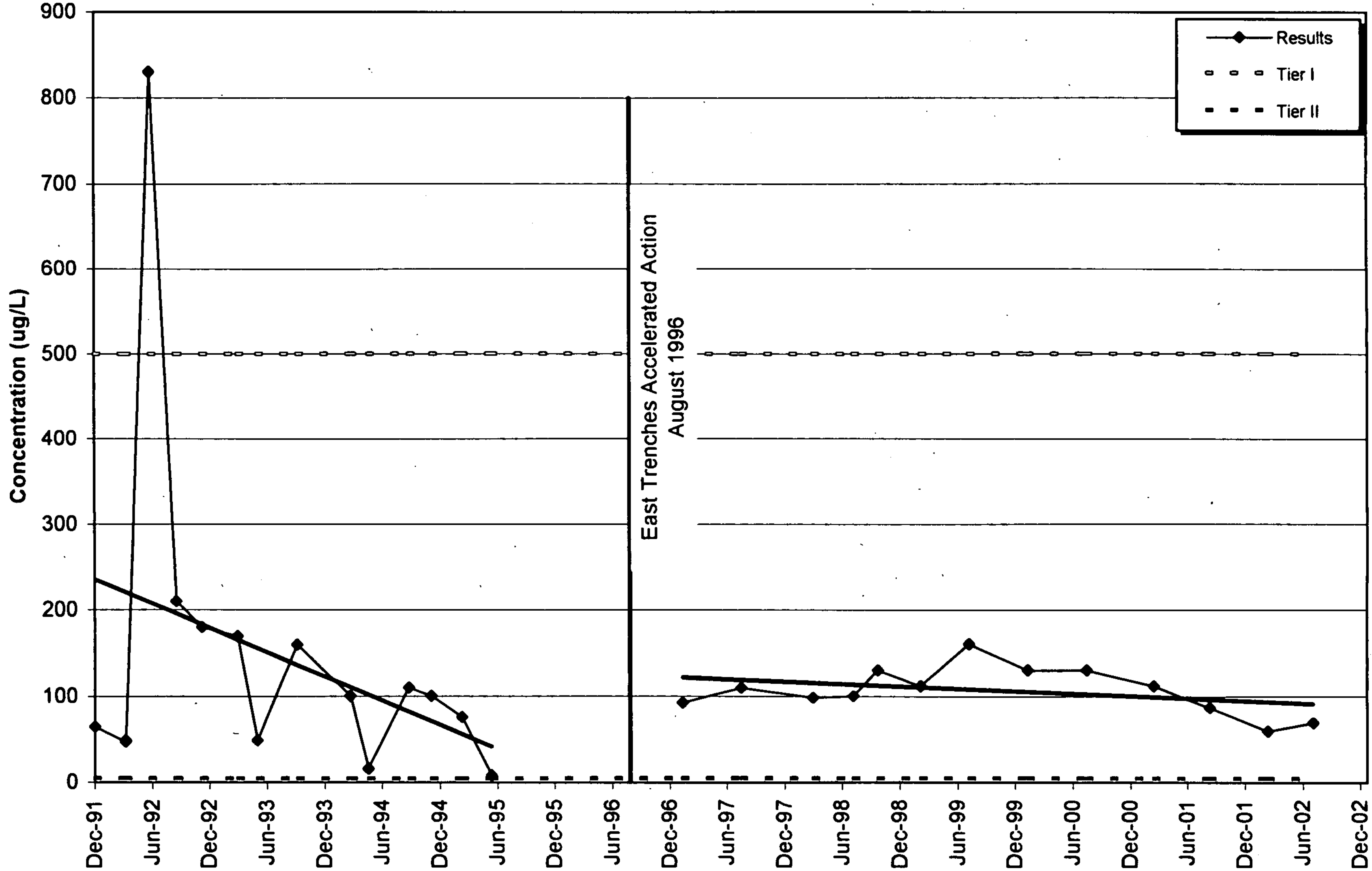

Figure 4-24
11891 Tetrachloroethene

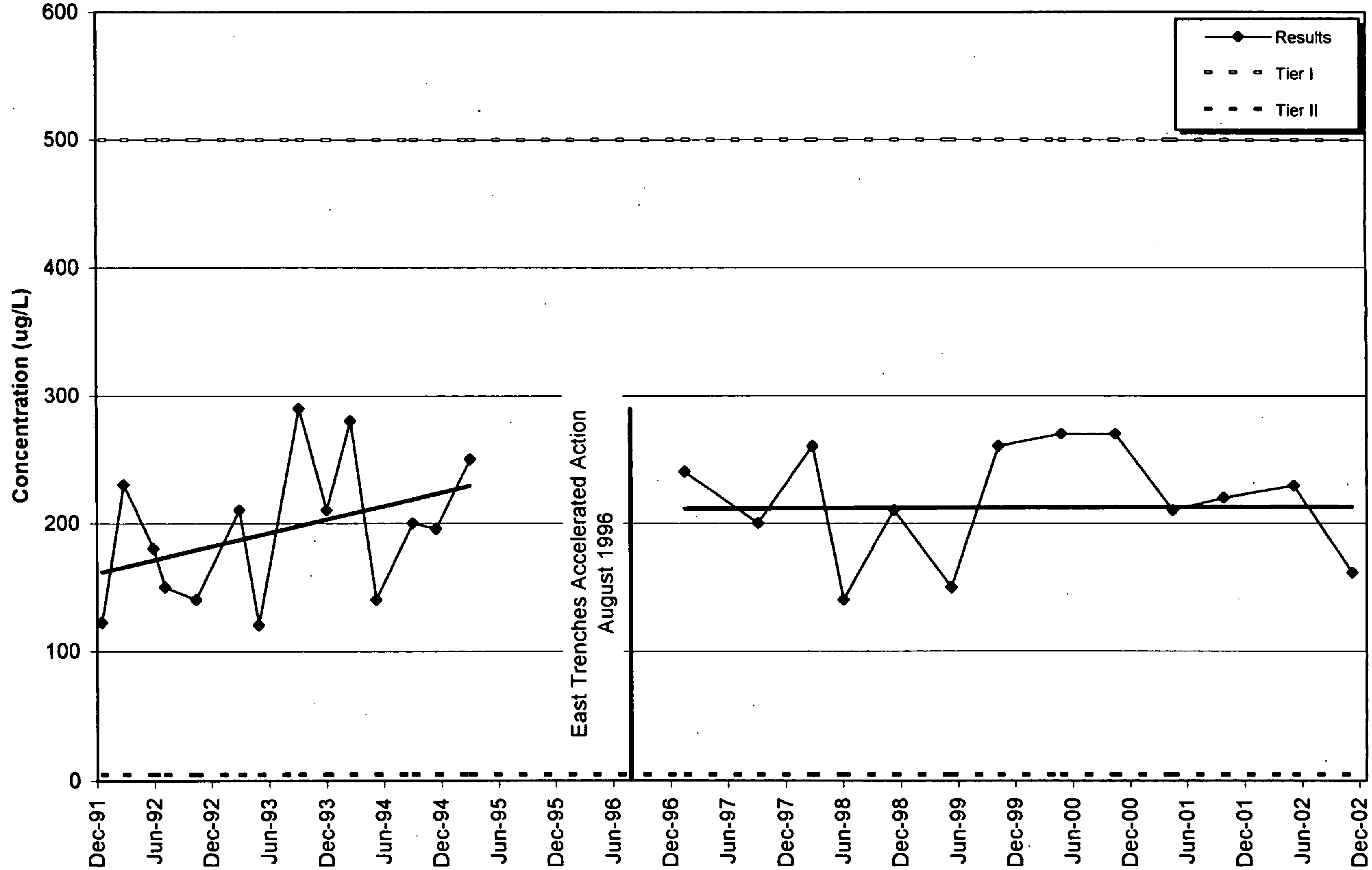

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Figure 4-25
11891 Trichloroethene

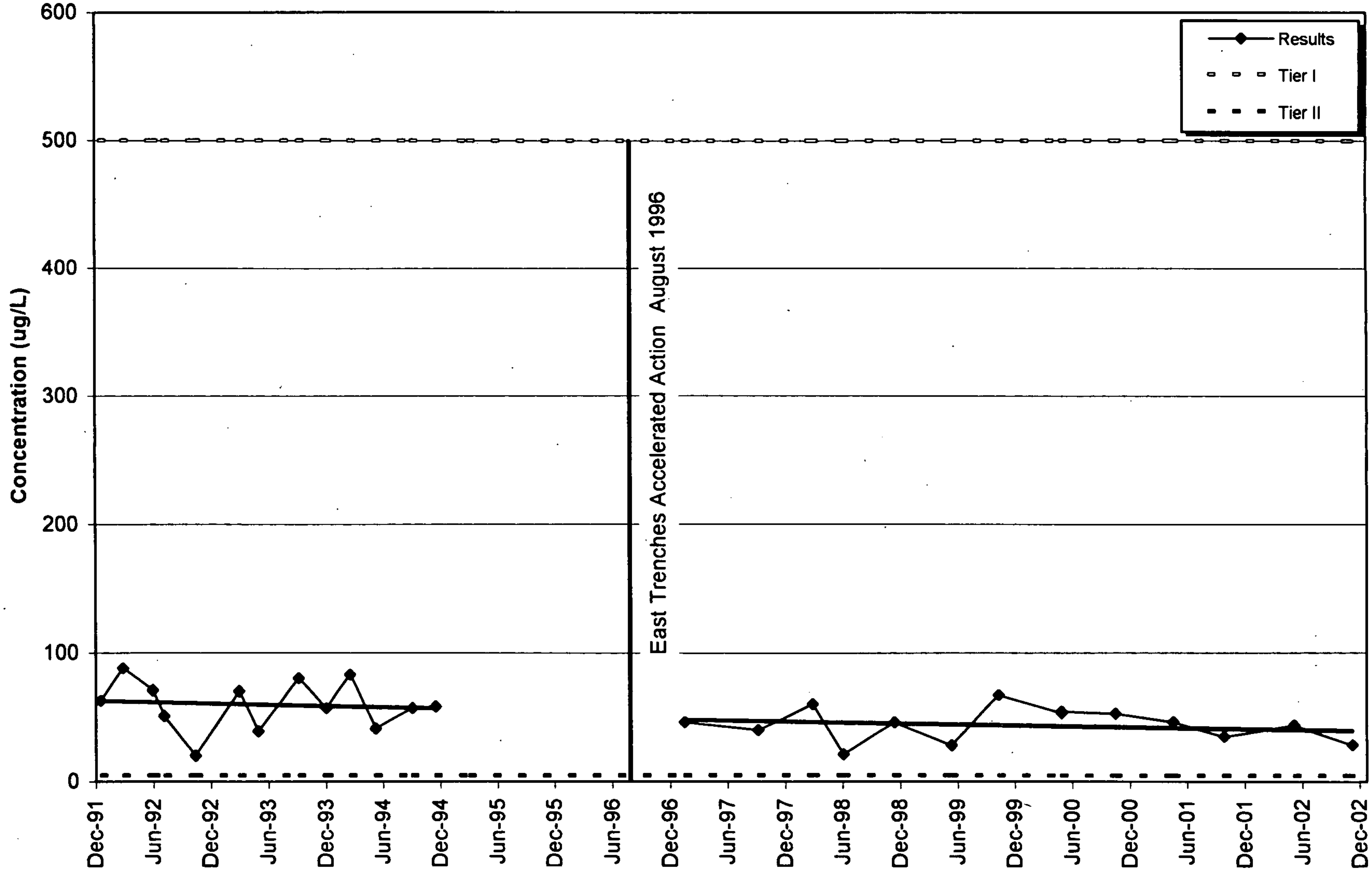

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Figure 4-26
11891 Carbon Tetrachloride

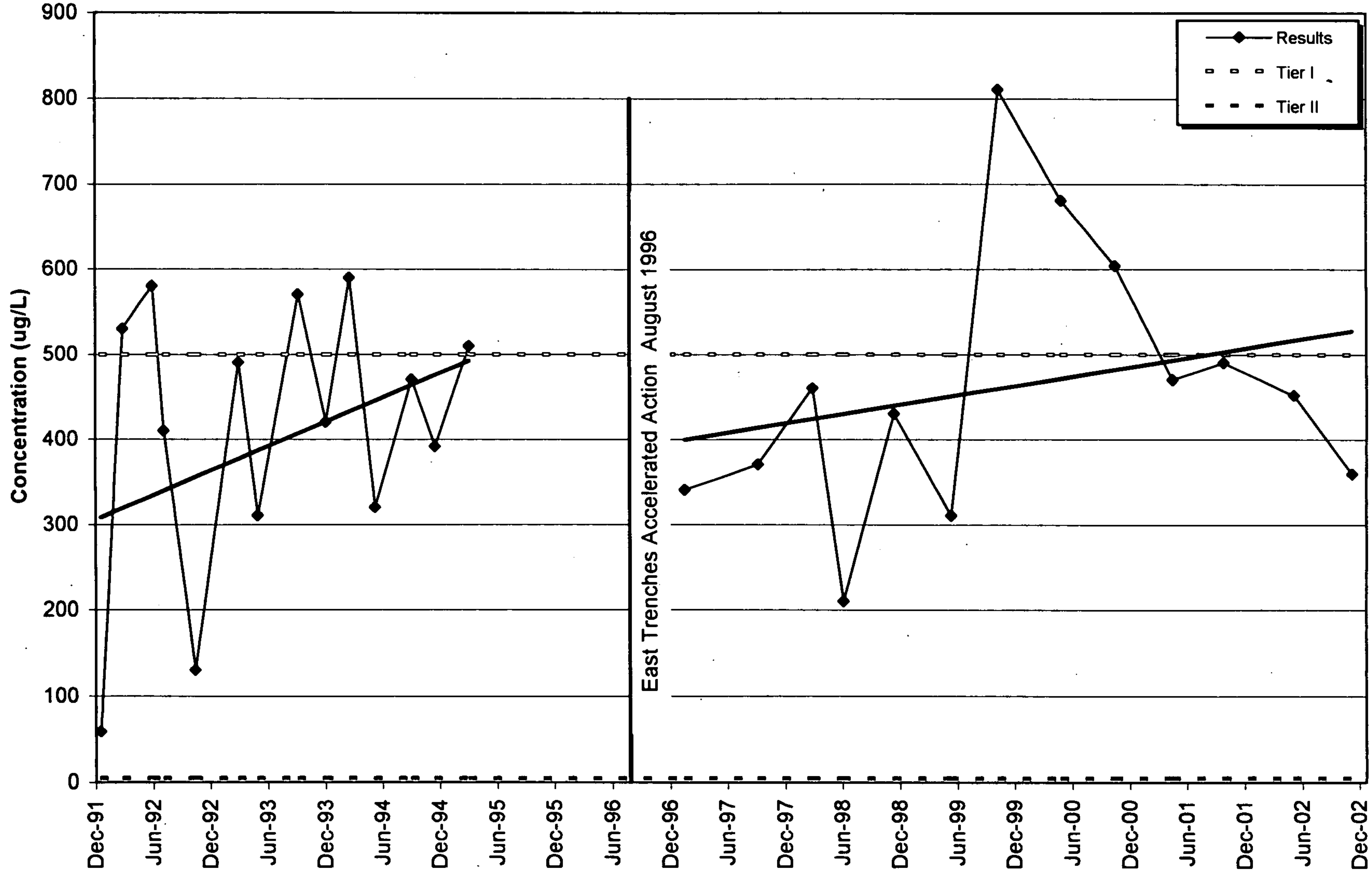

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Figure 4-27
12691 Tetrachloroethene

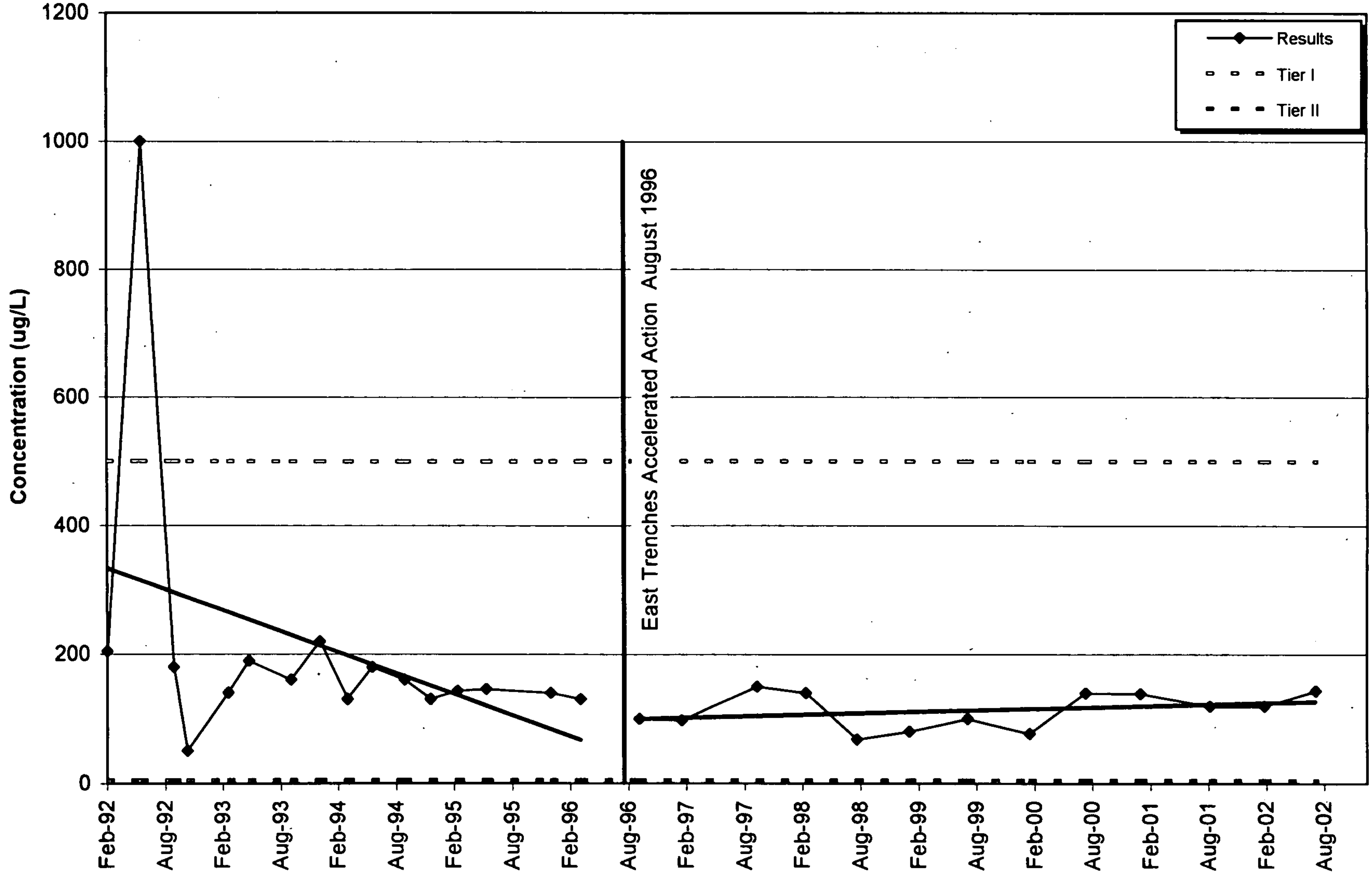

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Figure 4-28
12691 Trichloroethene

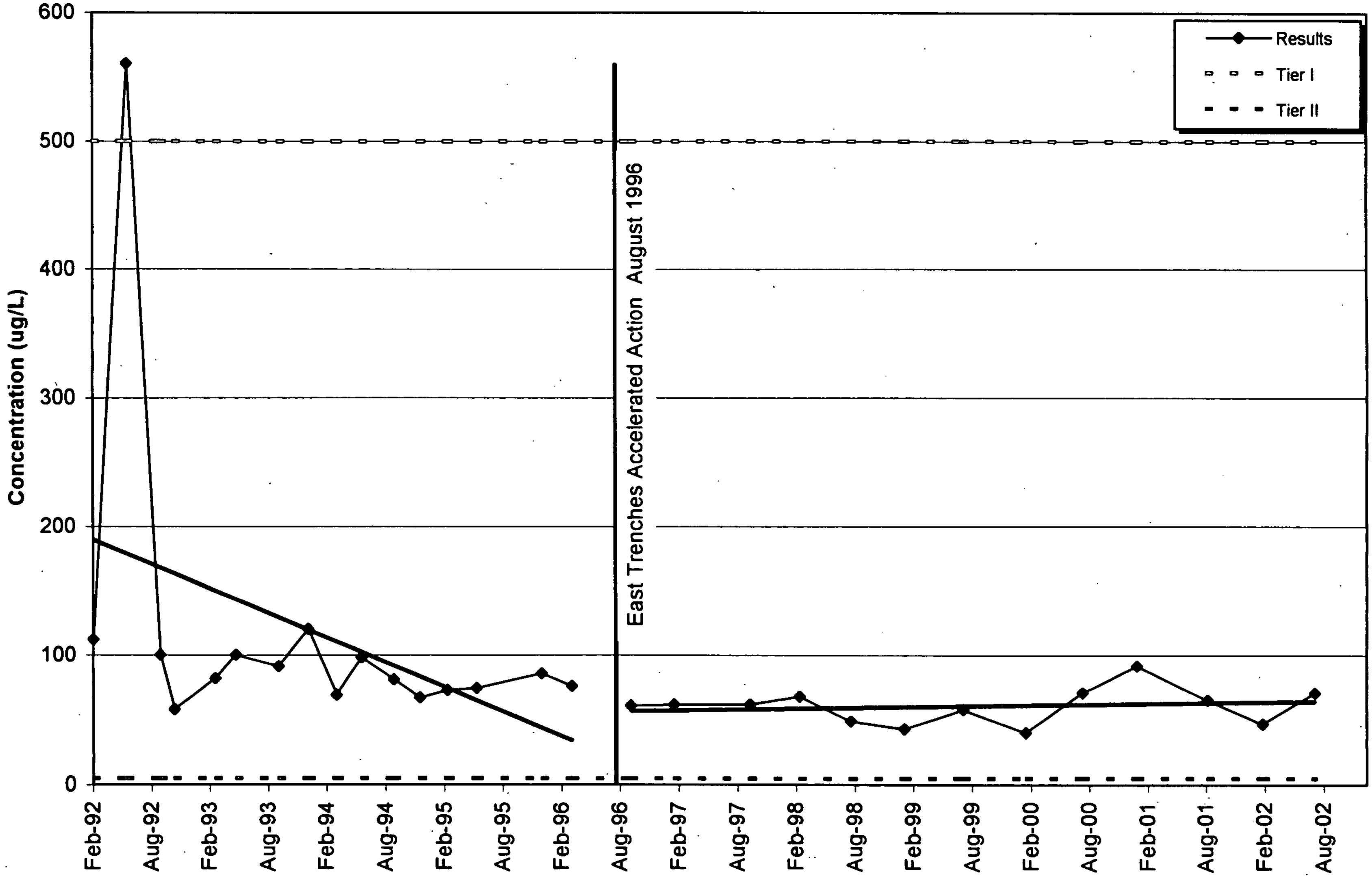

Figure 4-30
12191 Tetrachloroethene

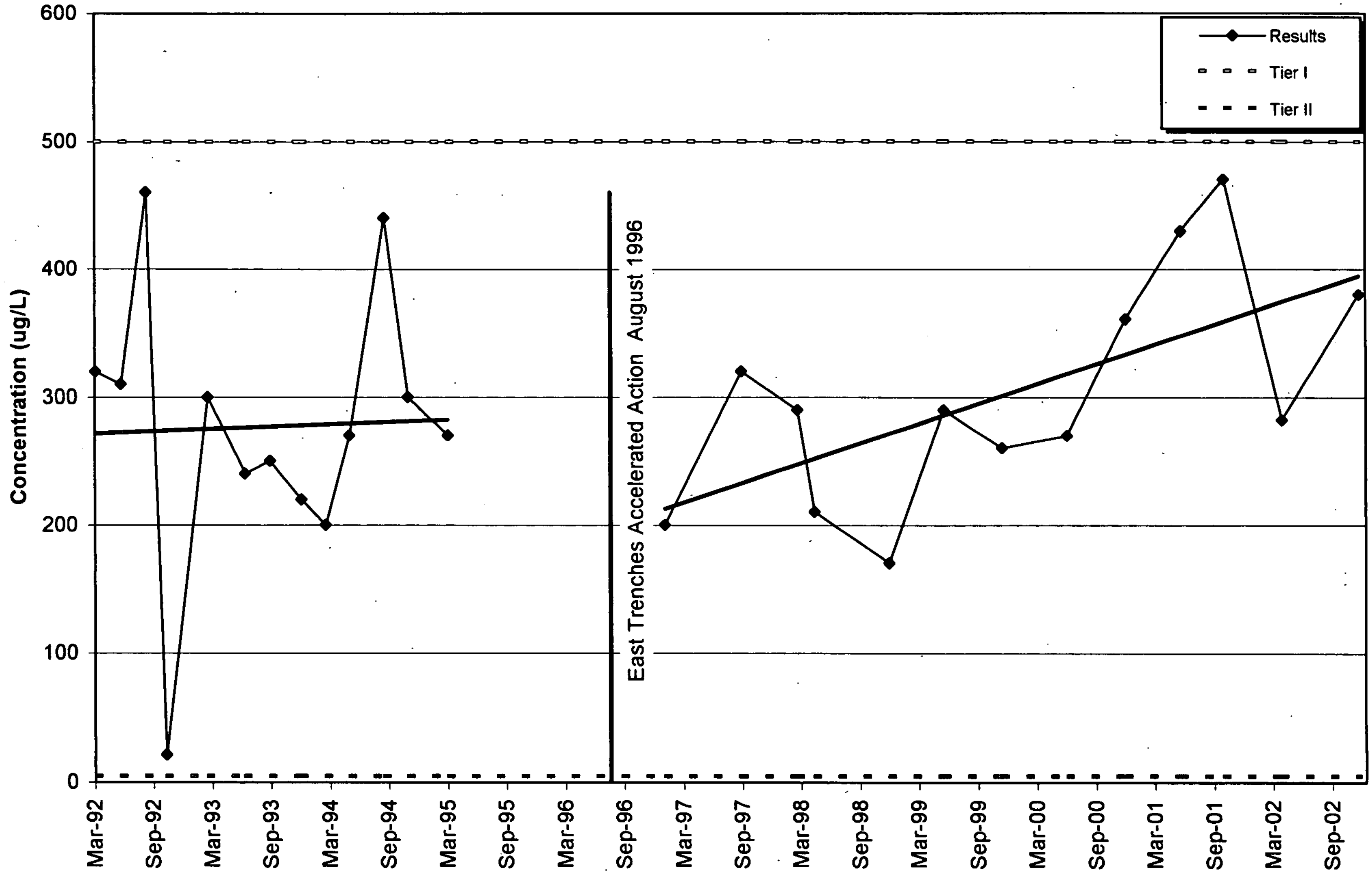

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Figure 4-31
12191 Trichloroethene

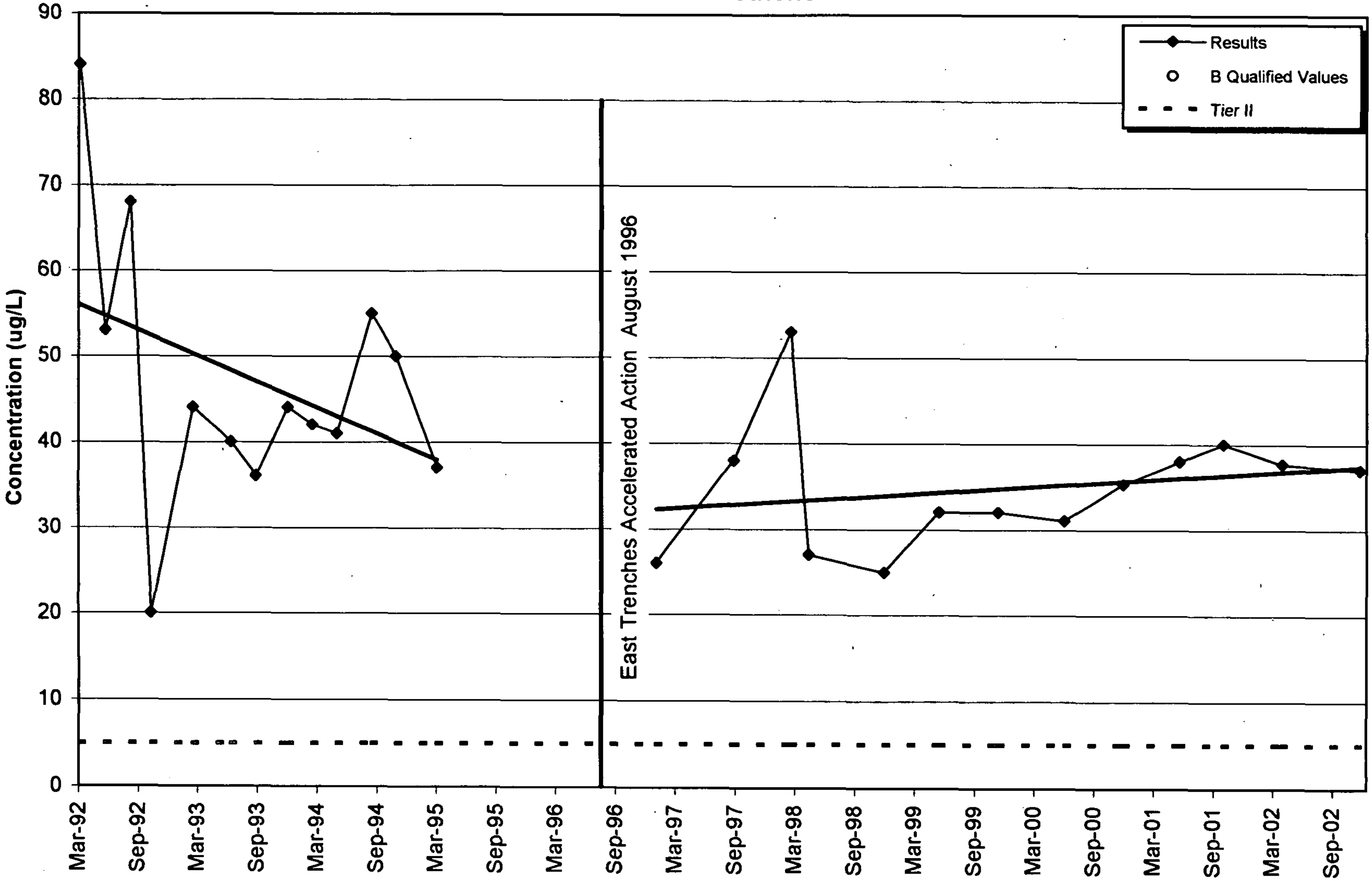


Figure 4-32
12191 Carbon Tetrachloride

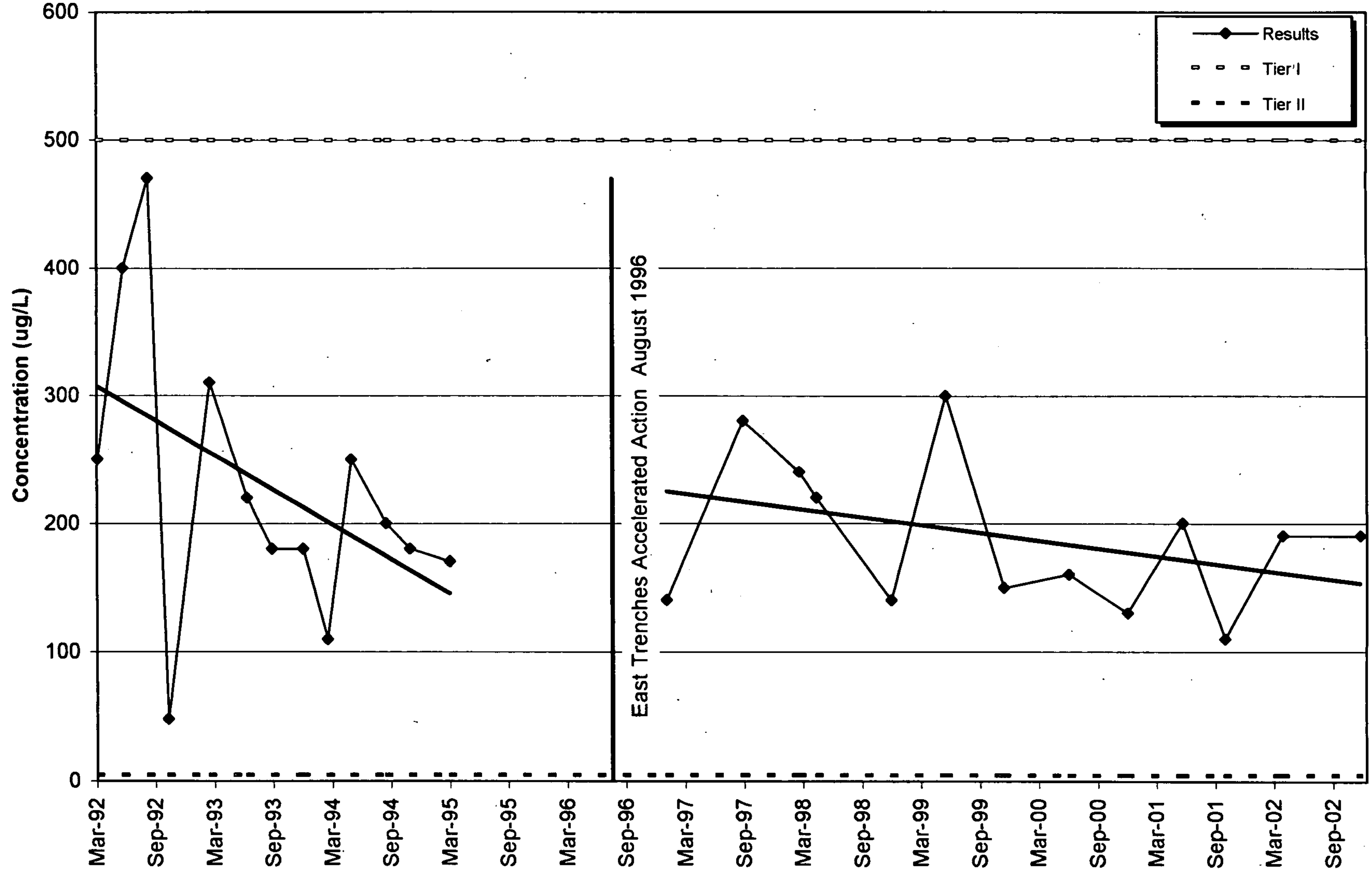
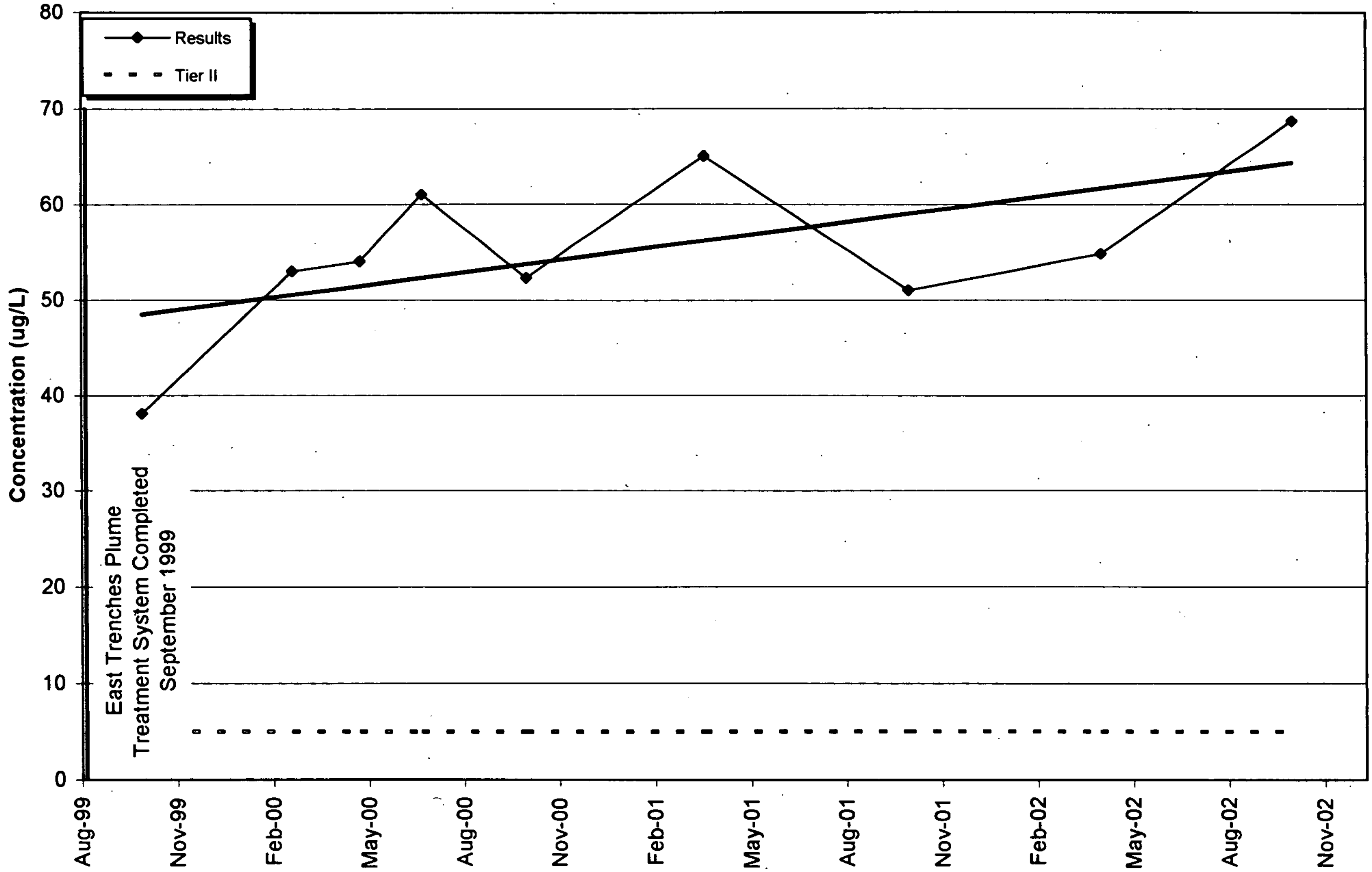


Figure 4-33
95199 Trichloroethene



129

Figure 4-35
3586 Manganese

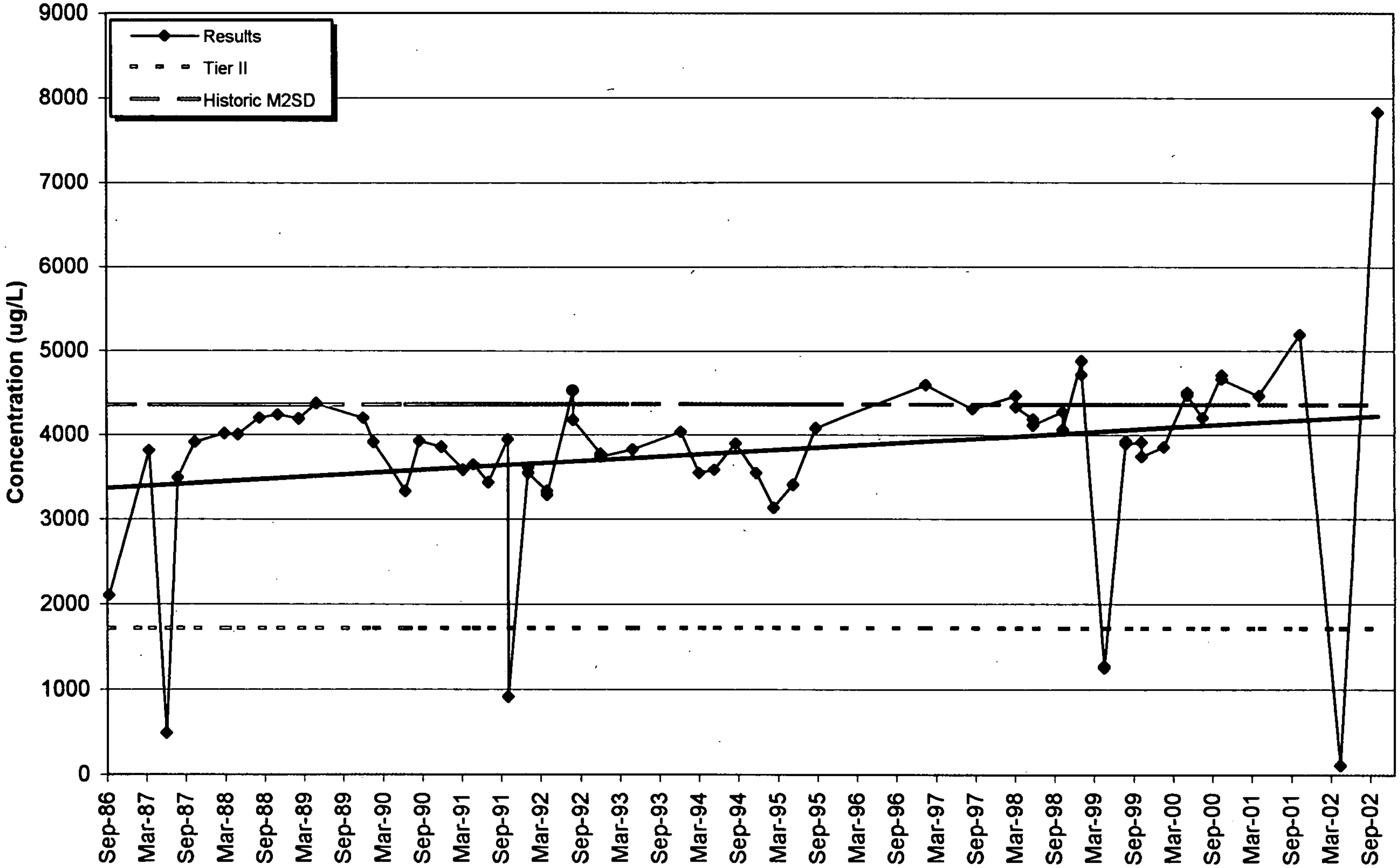


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Figure 4-36
00897 Tetrachloroethene

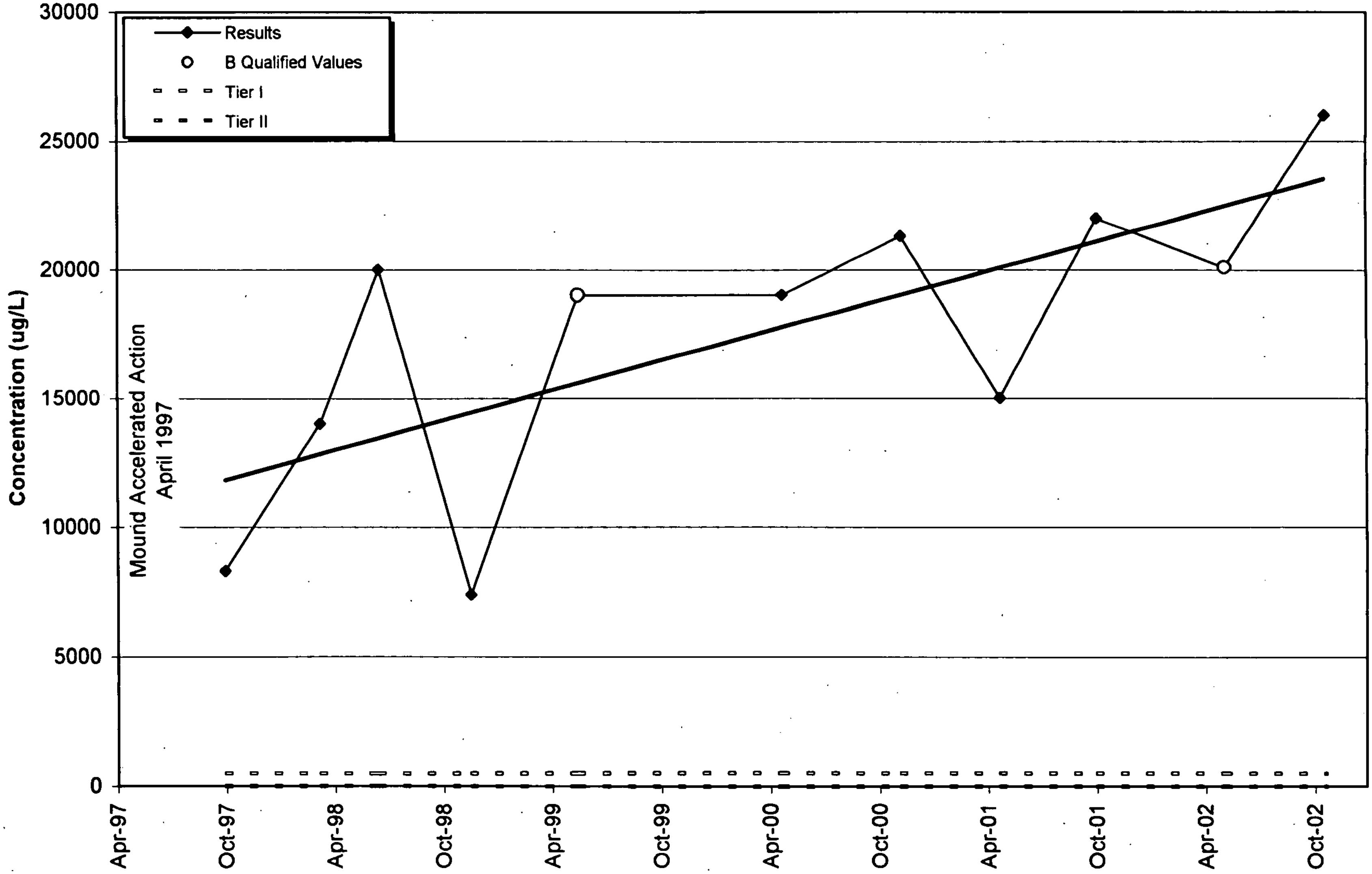

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Figure 4-37
00897 Trichloroethene

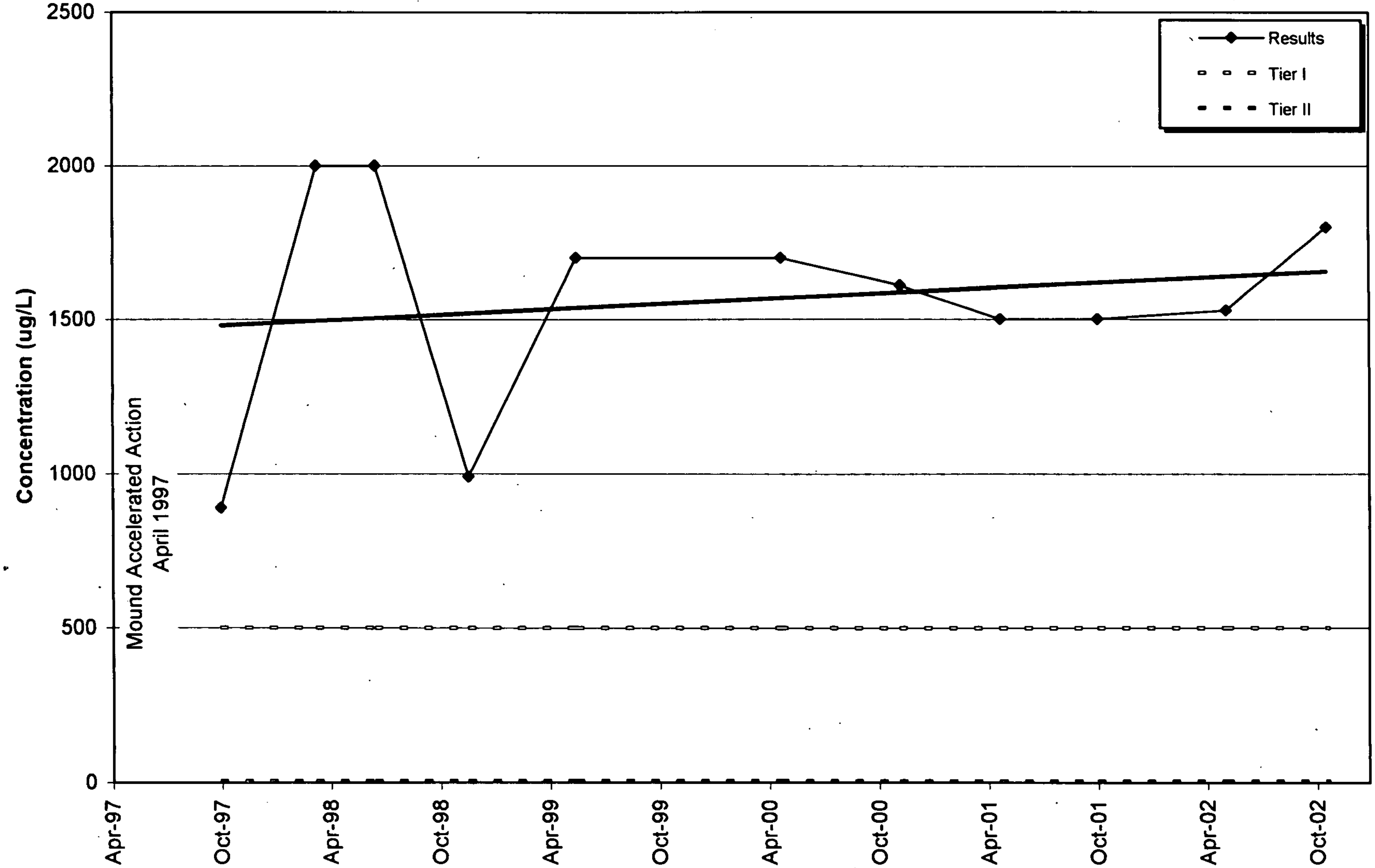

Figure 4-38
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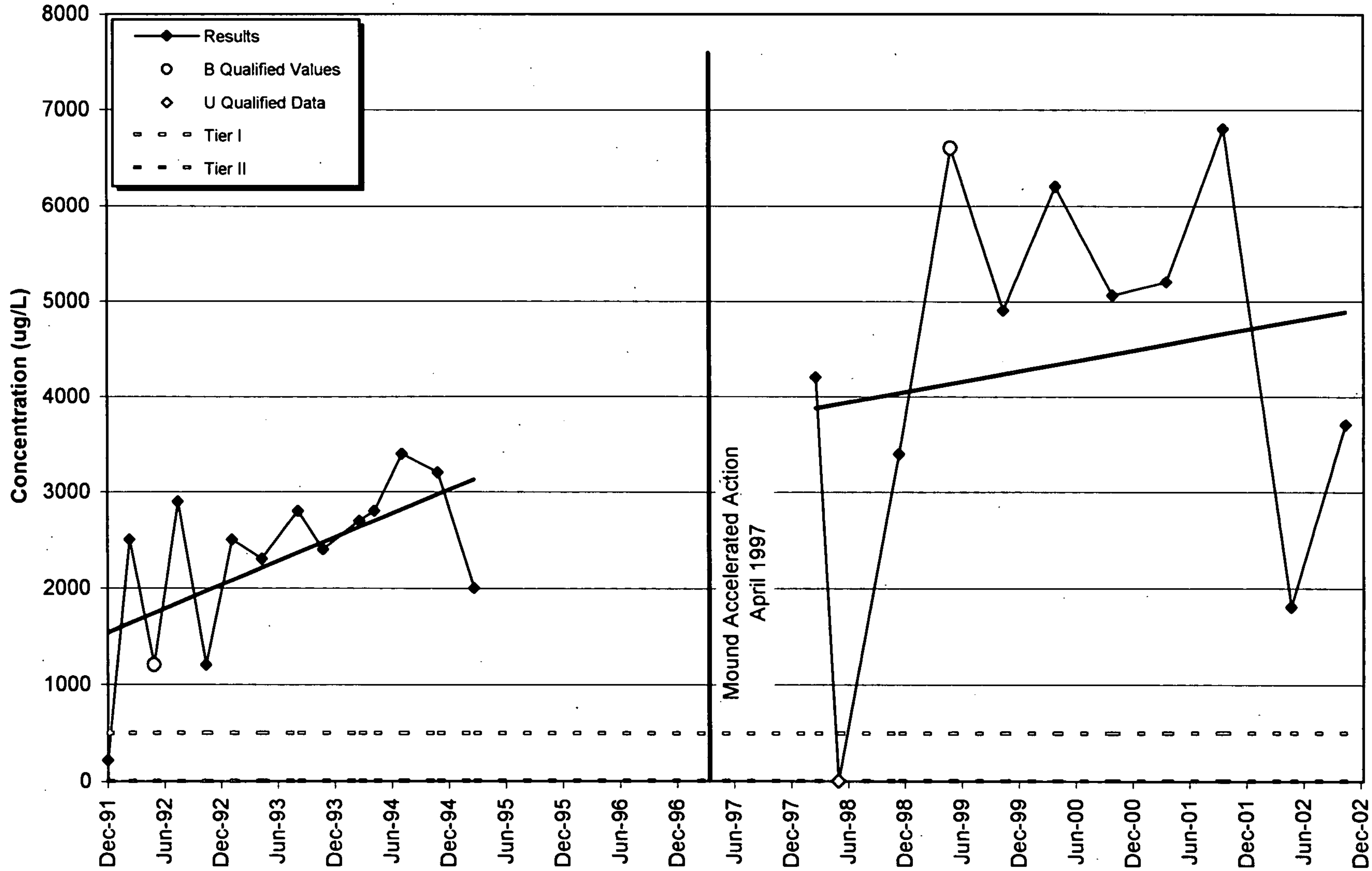

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Figure 4-39
02291 Trichloroethene

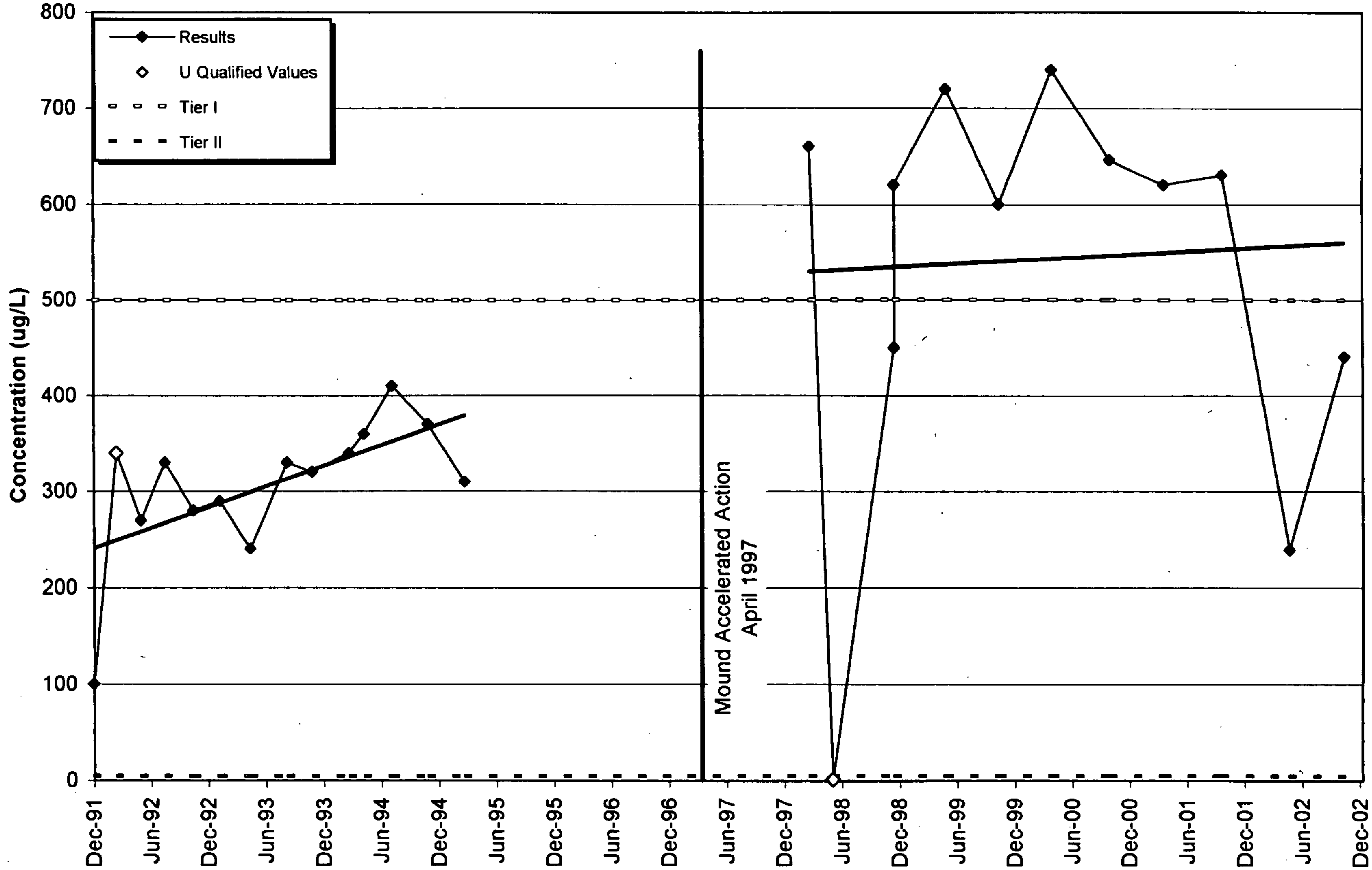

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Figure 4-40
3586 Vinyl Chloride

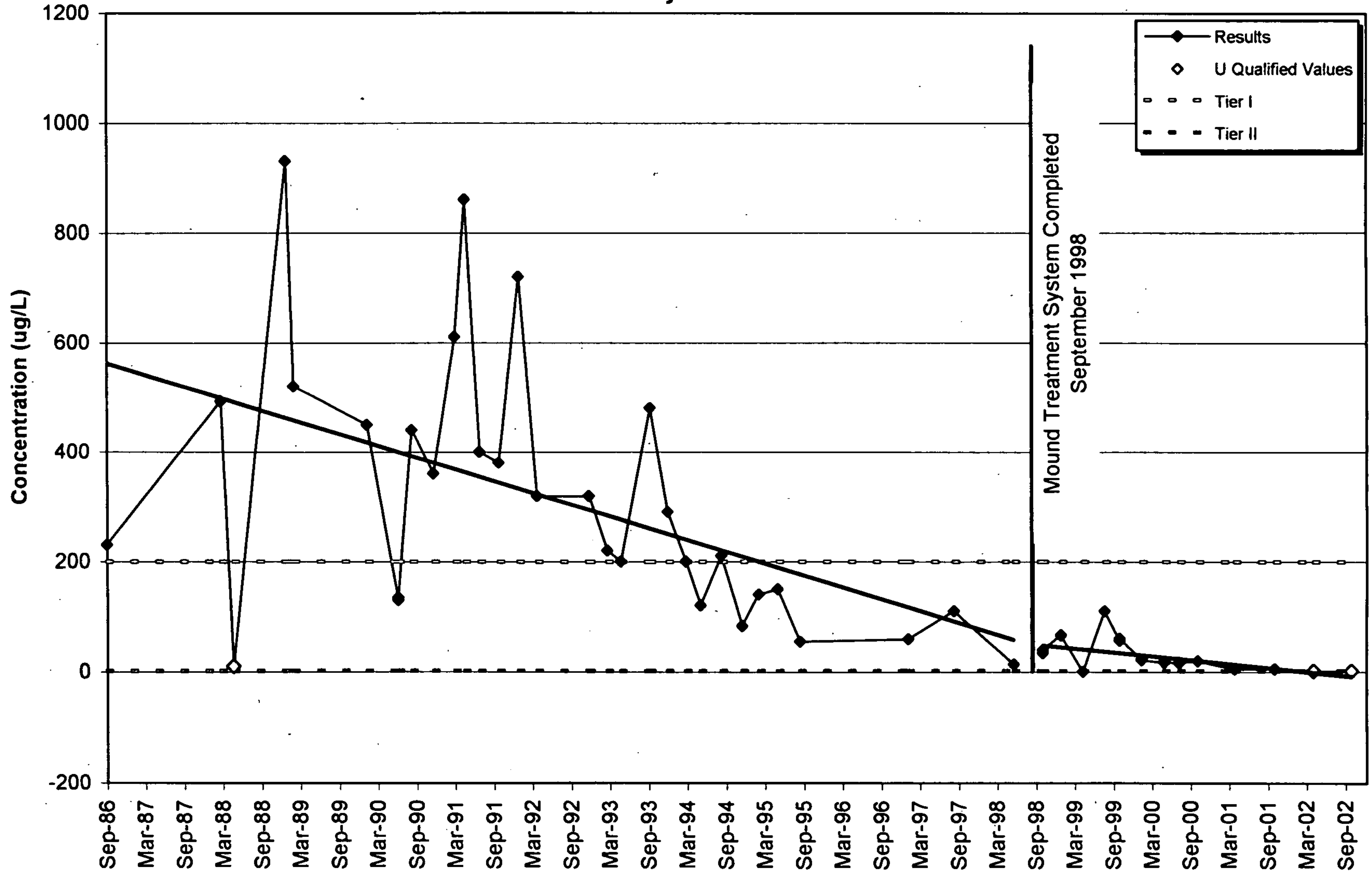

Figure 4-41
15699 Tetrachloroethene

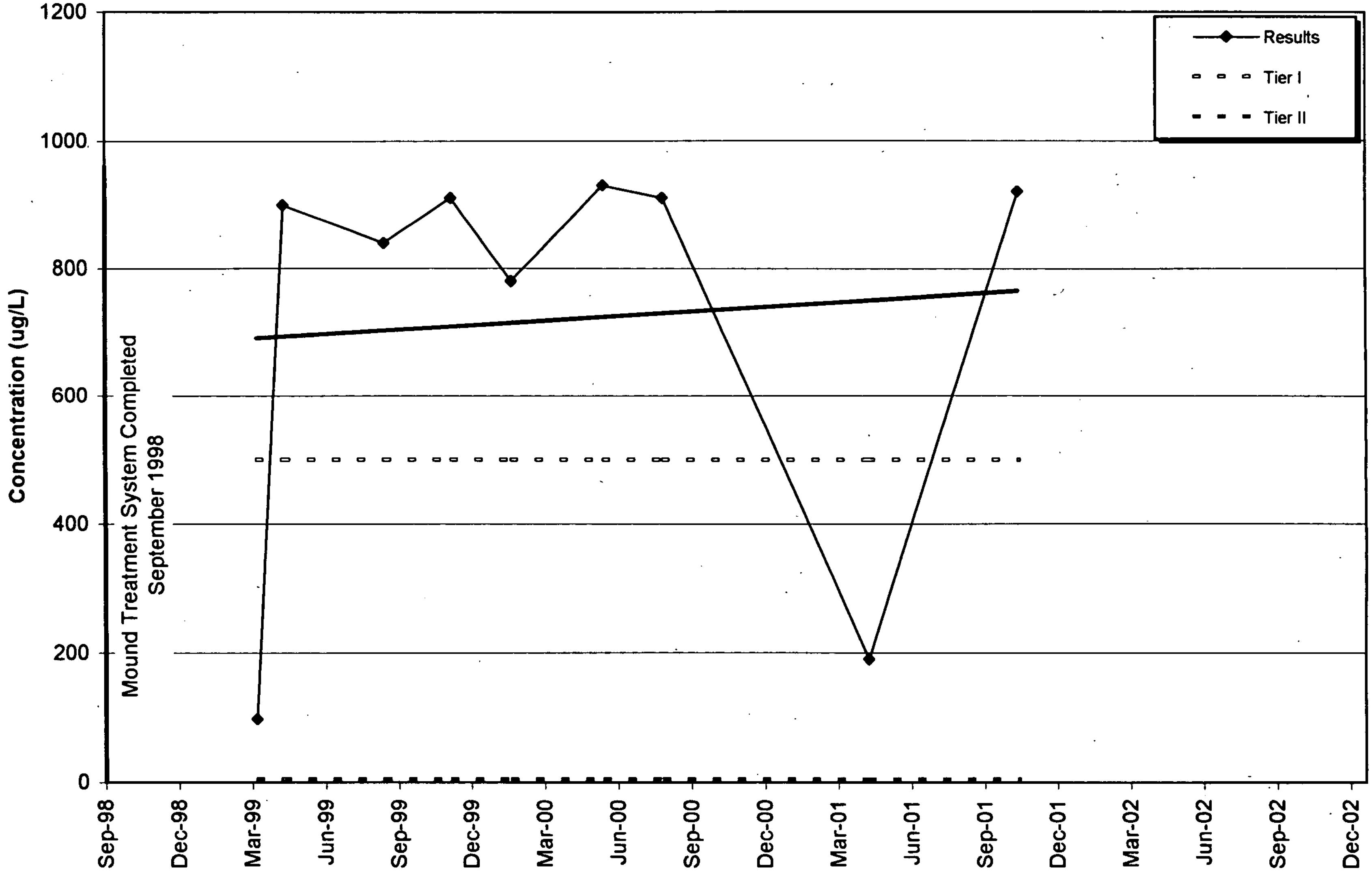

Figure 4-42
15699 Trichloroethene

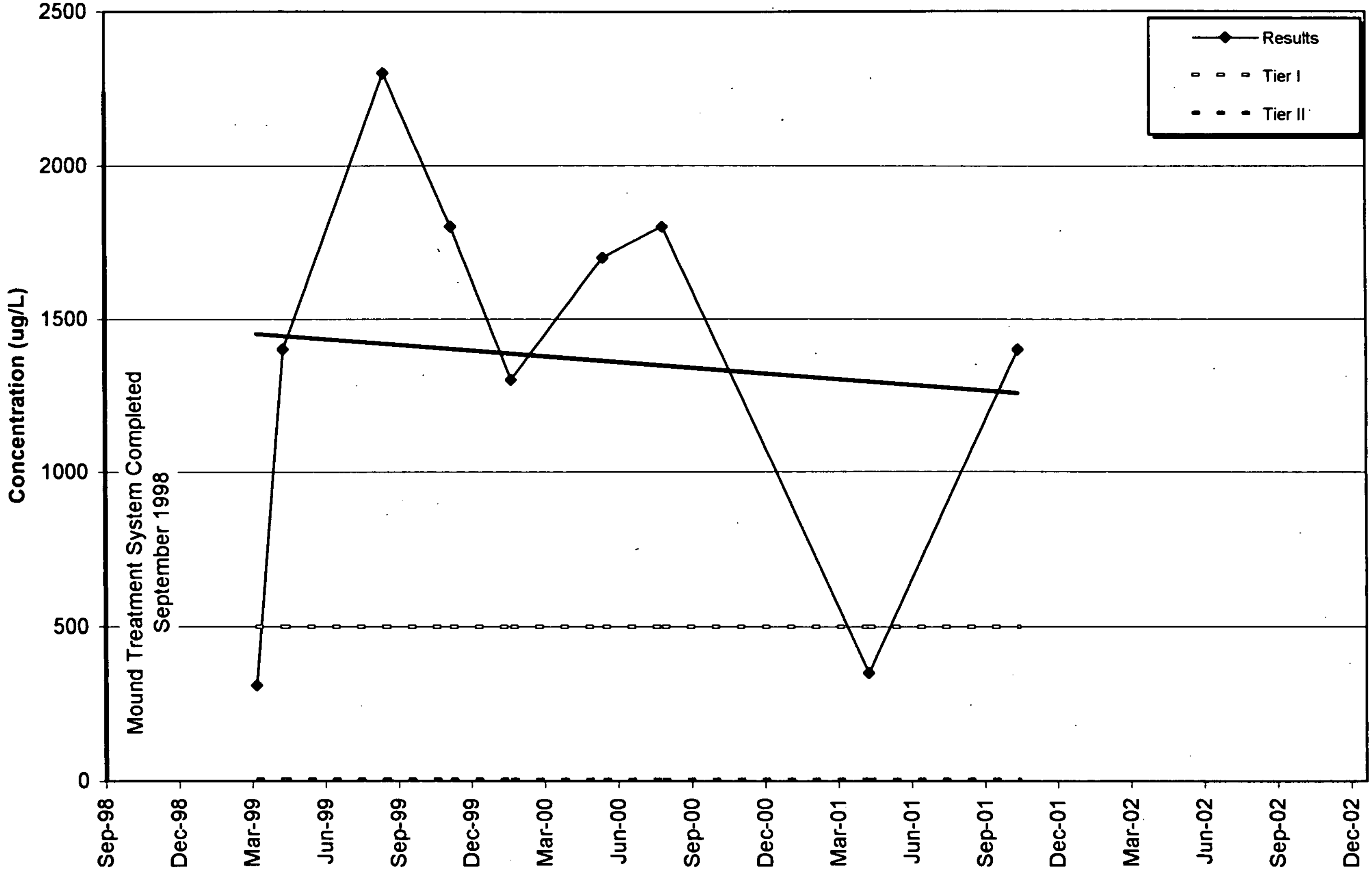

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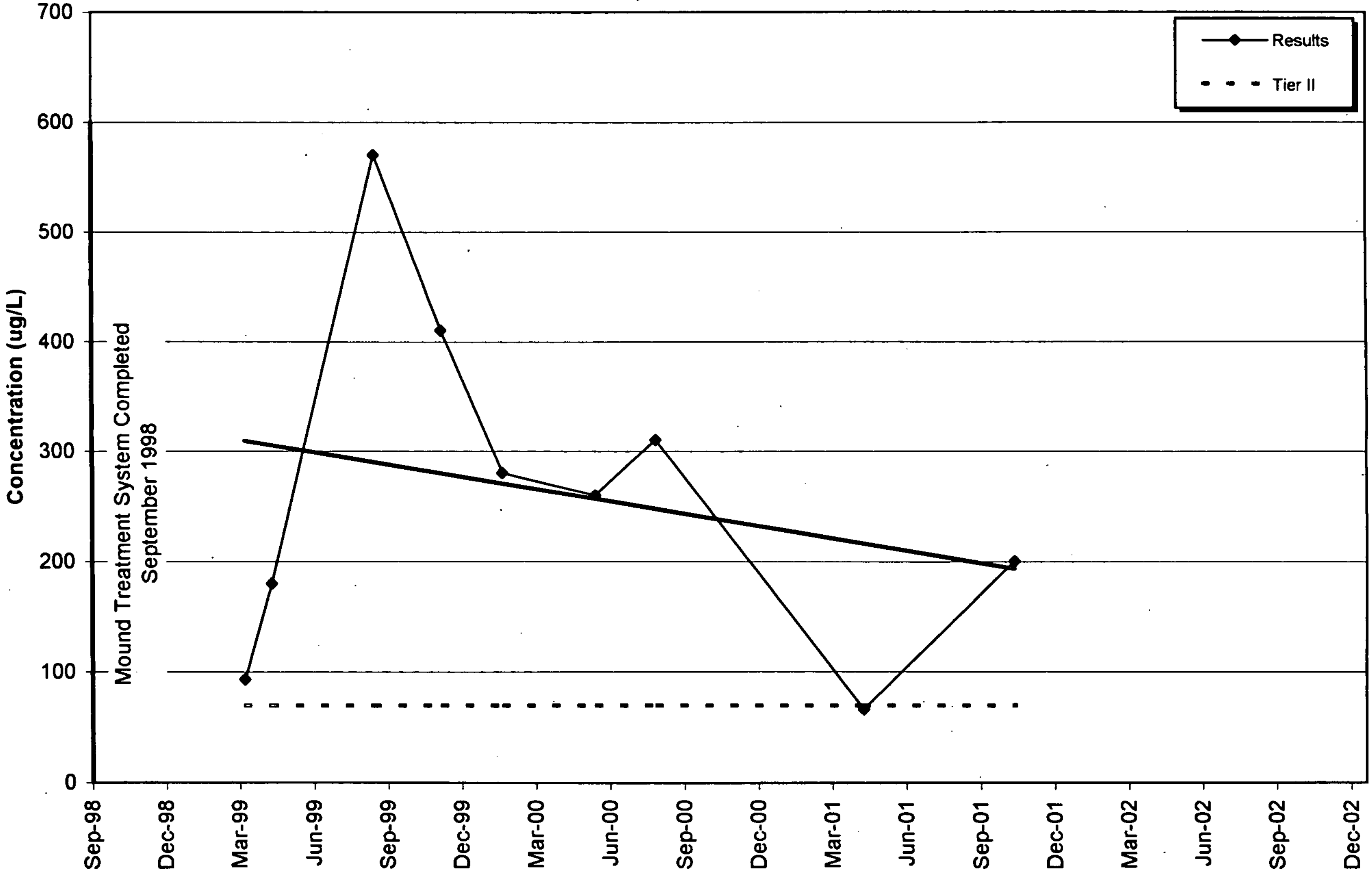
Figure 4-43
15699 cis-1,2-Dichloroethene



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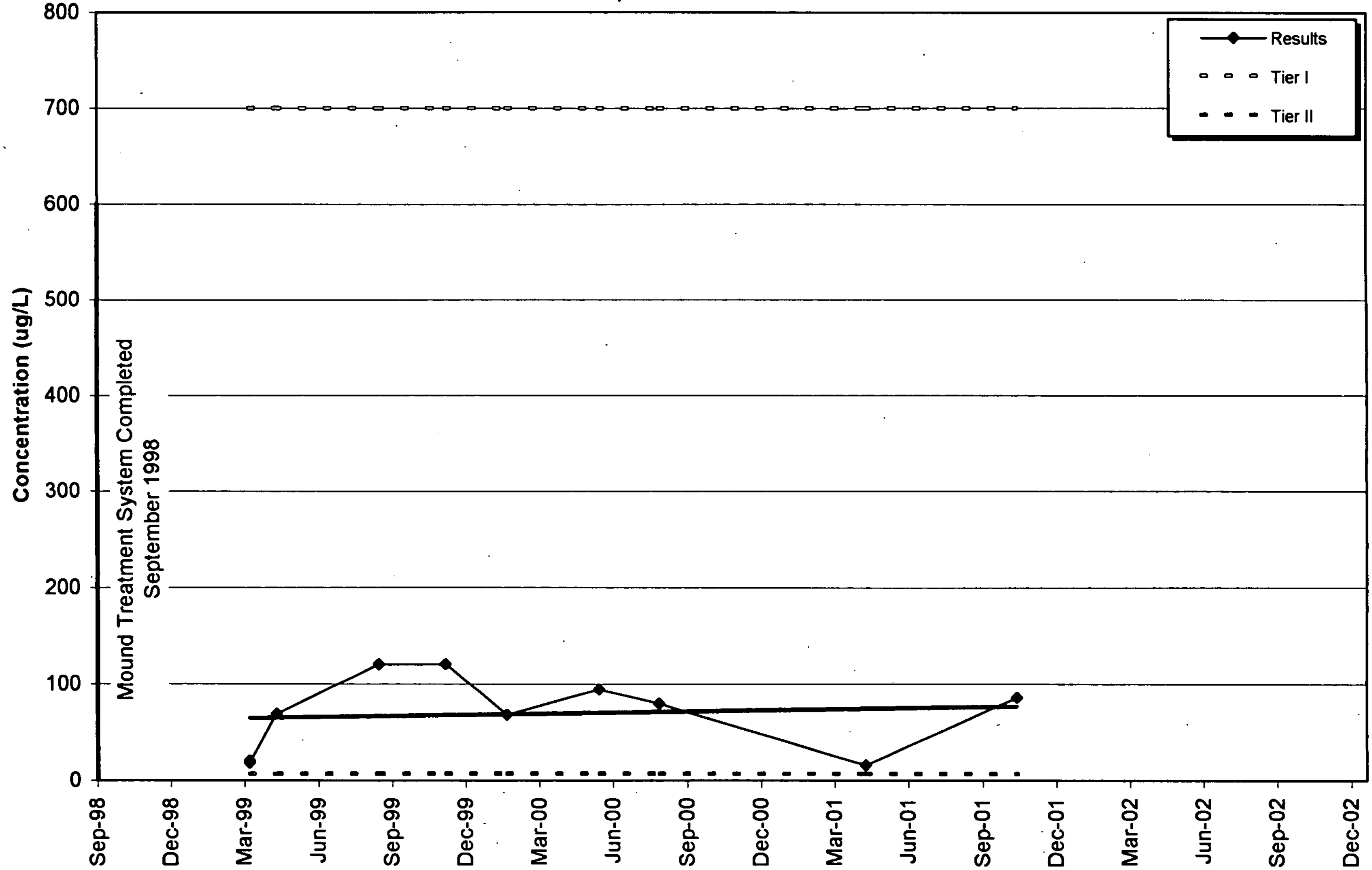

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Figure 4-45
15699 1,2-Dichloroethane

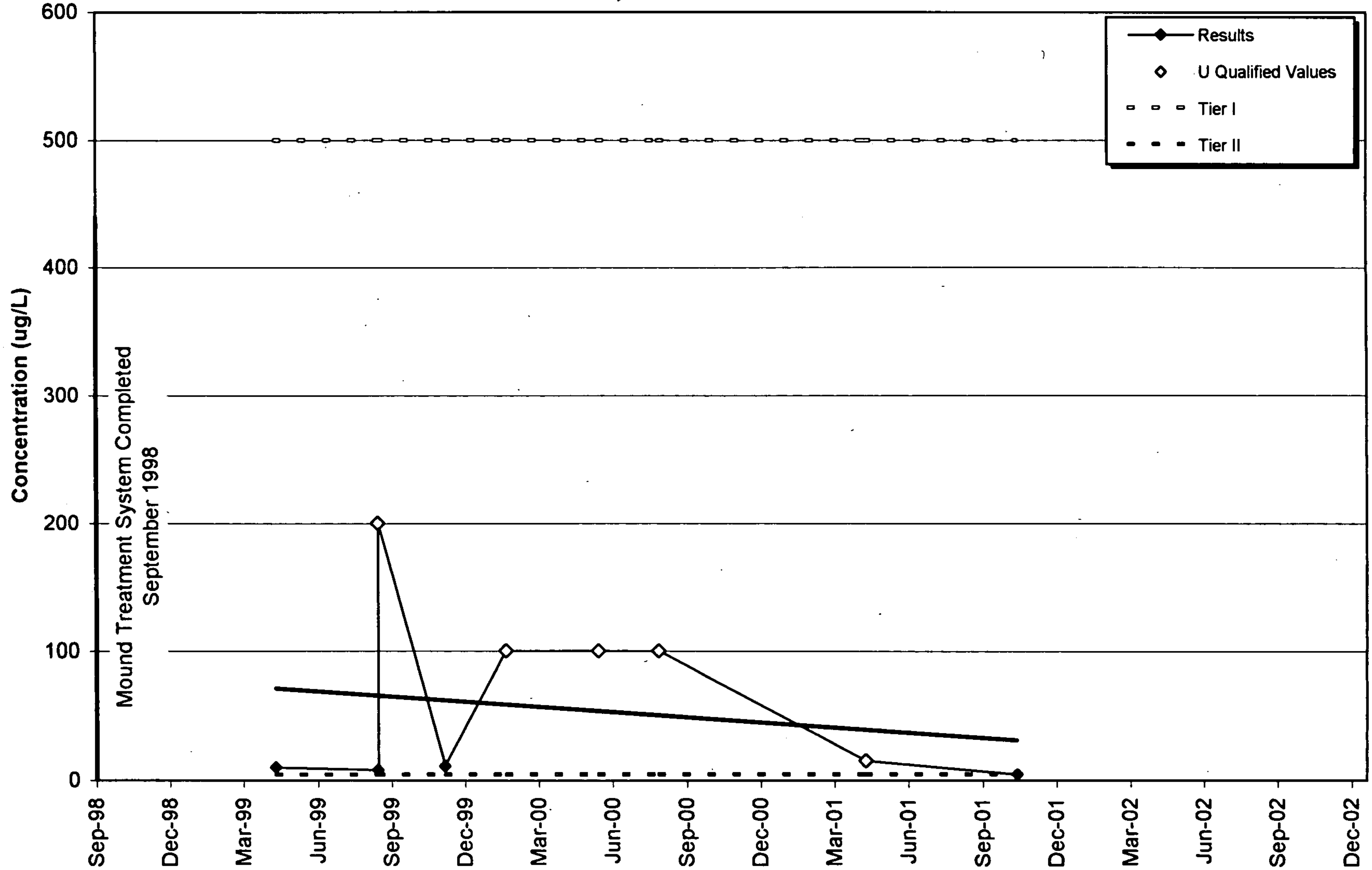

Figure 4-47
5387 Nickel

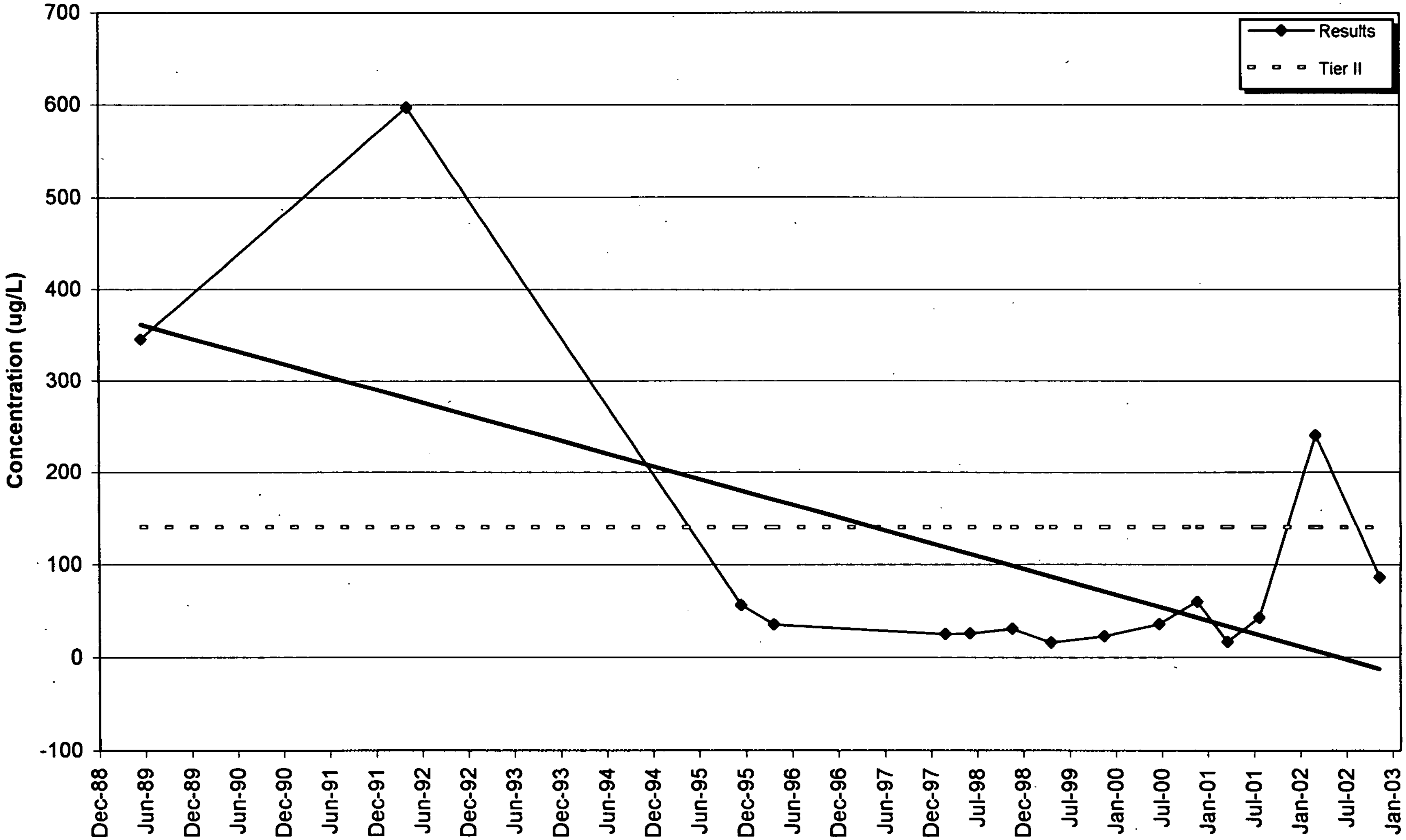

Figure 4-48
10992 Nitrate

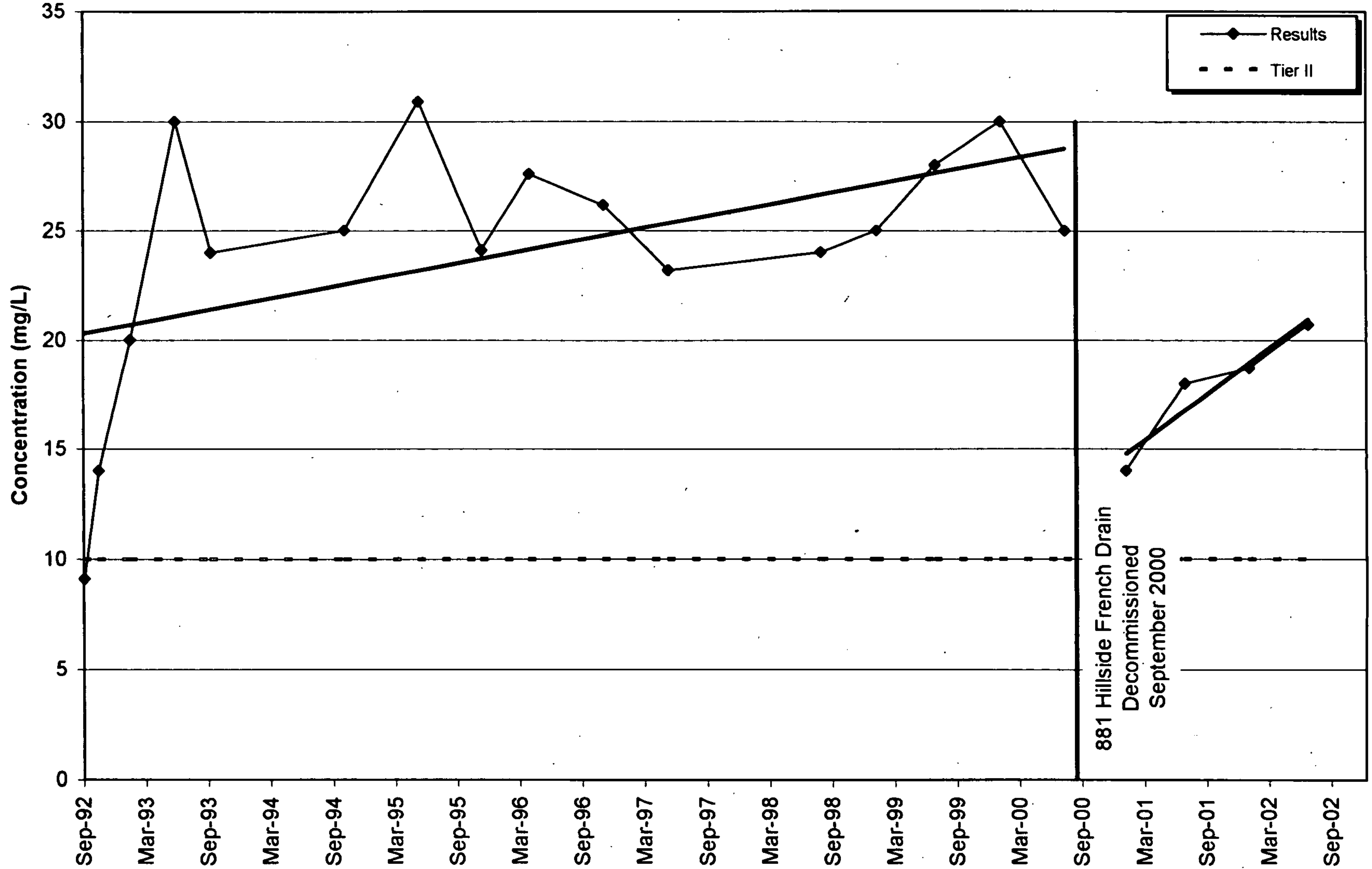

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Figure 4-49
10992 Selenium

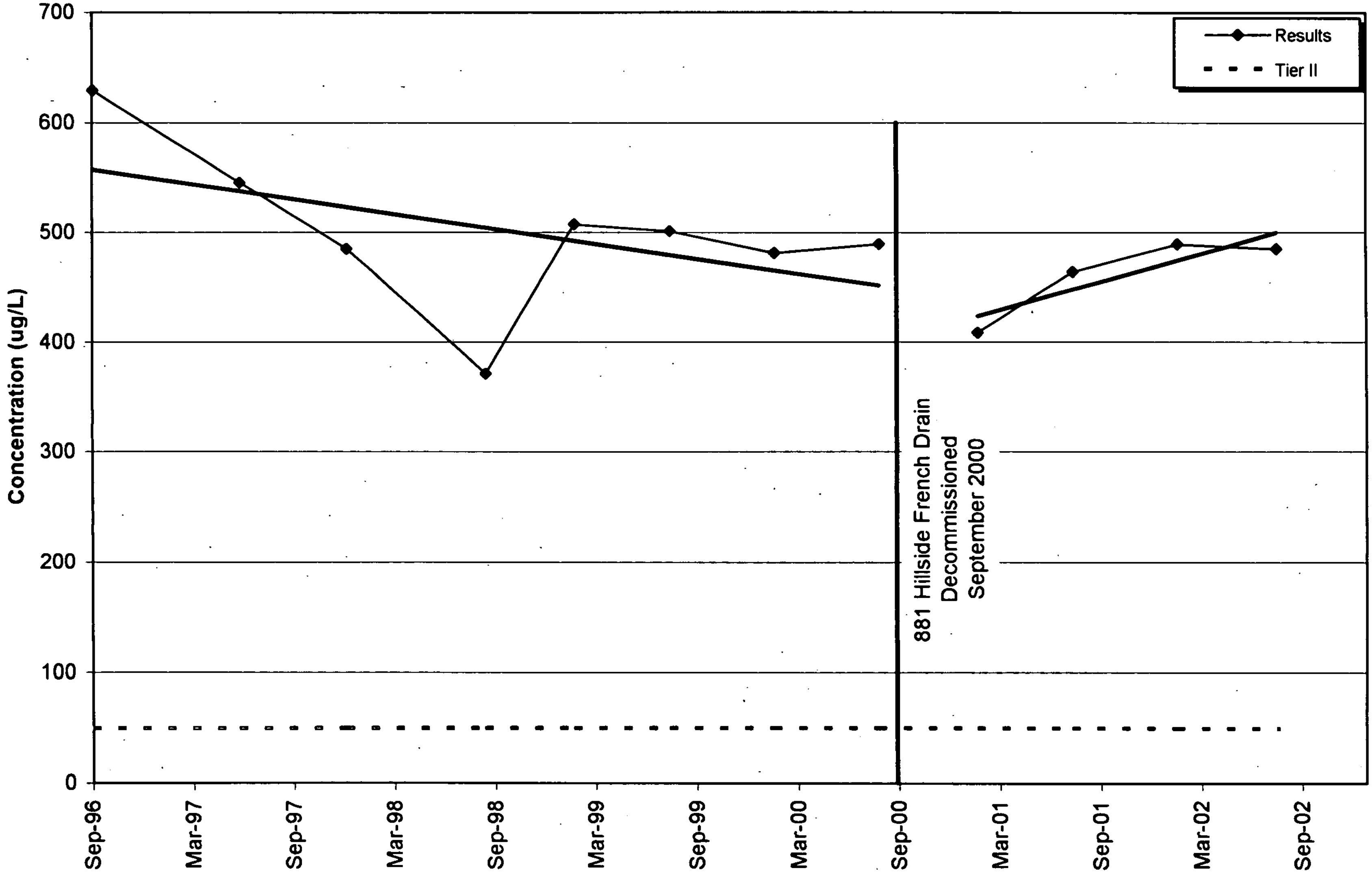

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Figure 4-50
891COLWEL Trichloroethene

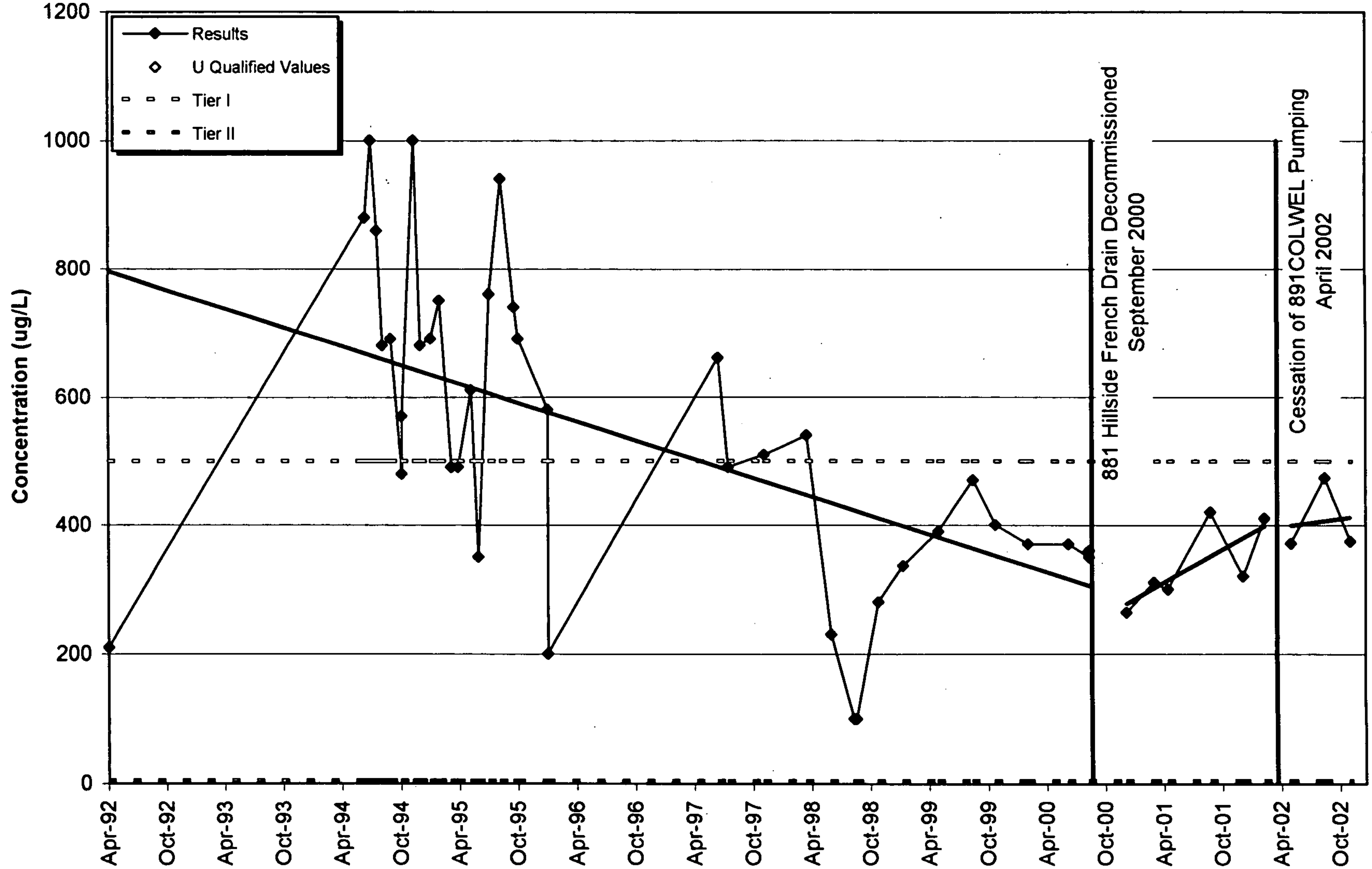
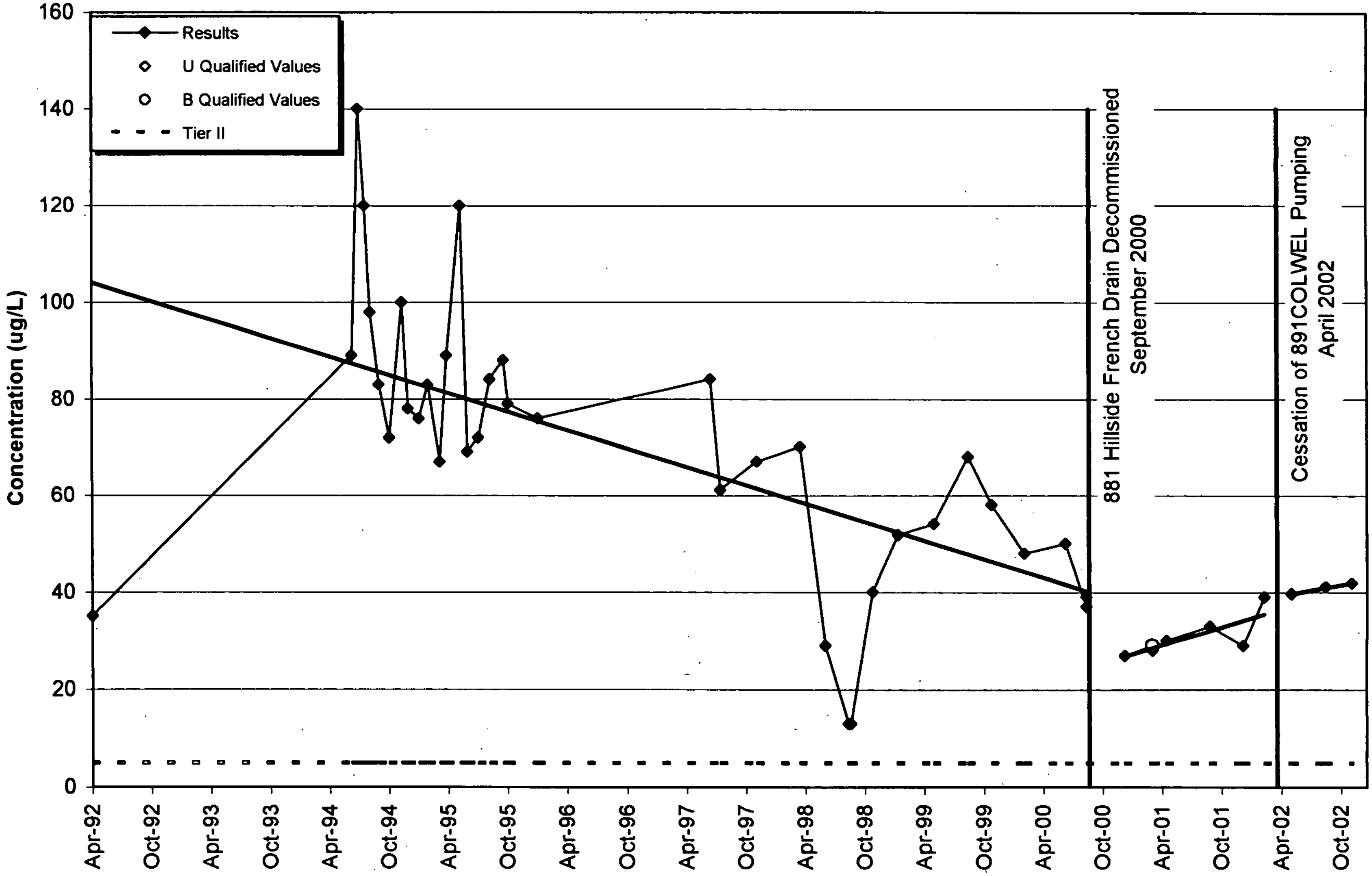


Figure 4-51
891COLWEL Tetrachloroethene



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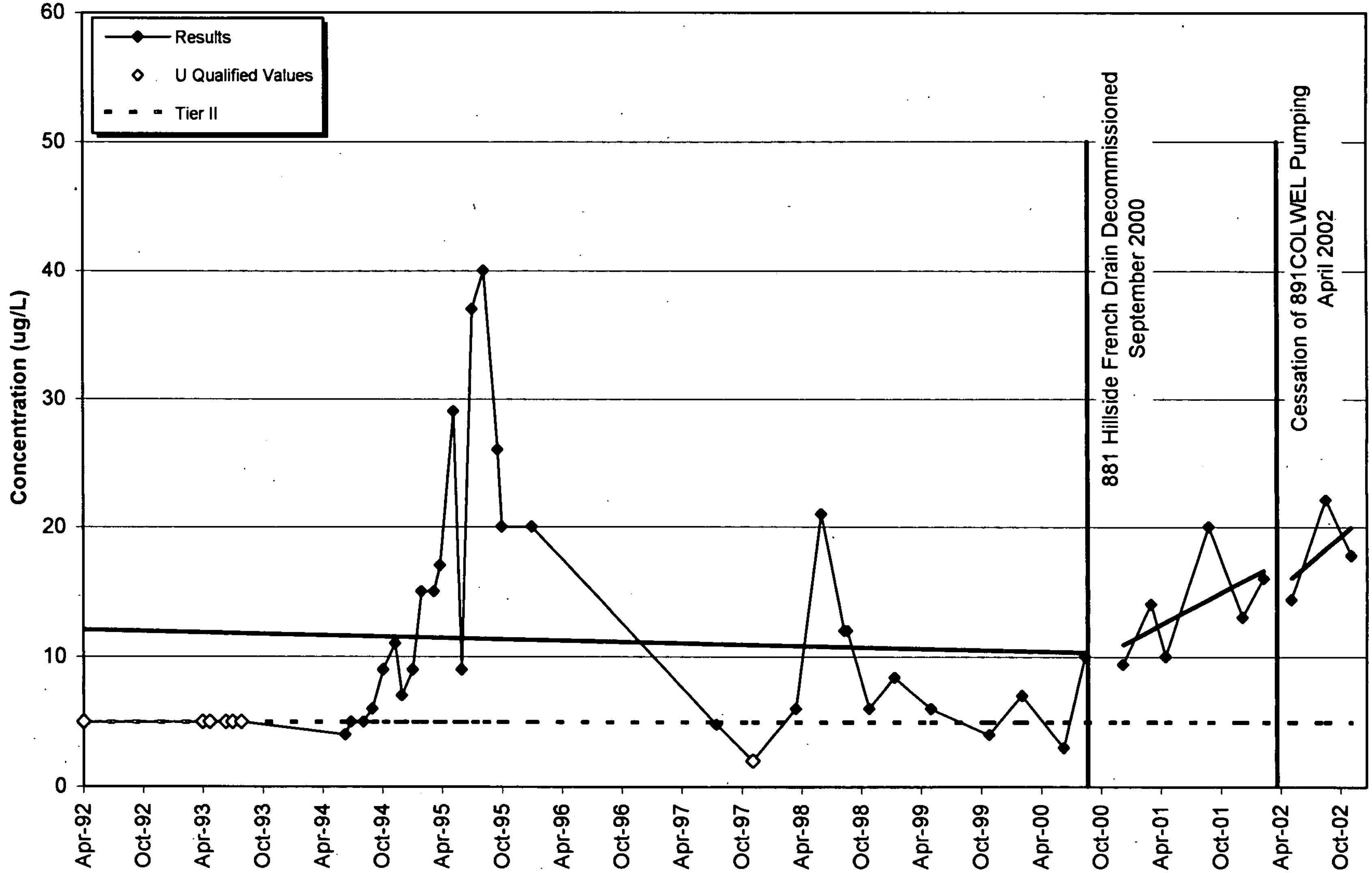

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Figure 4-53
891COLWEL 1,1-Dichloroethene

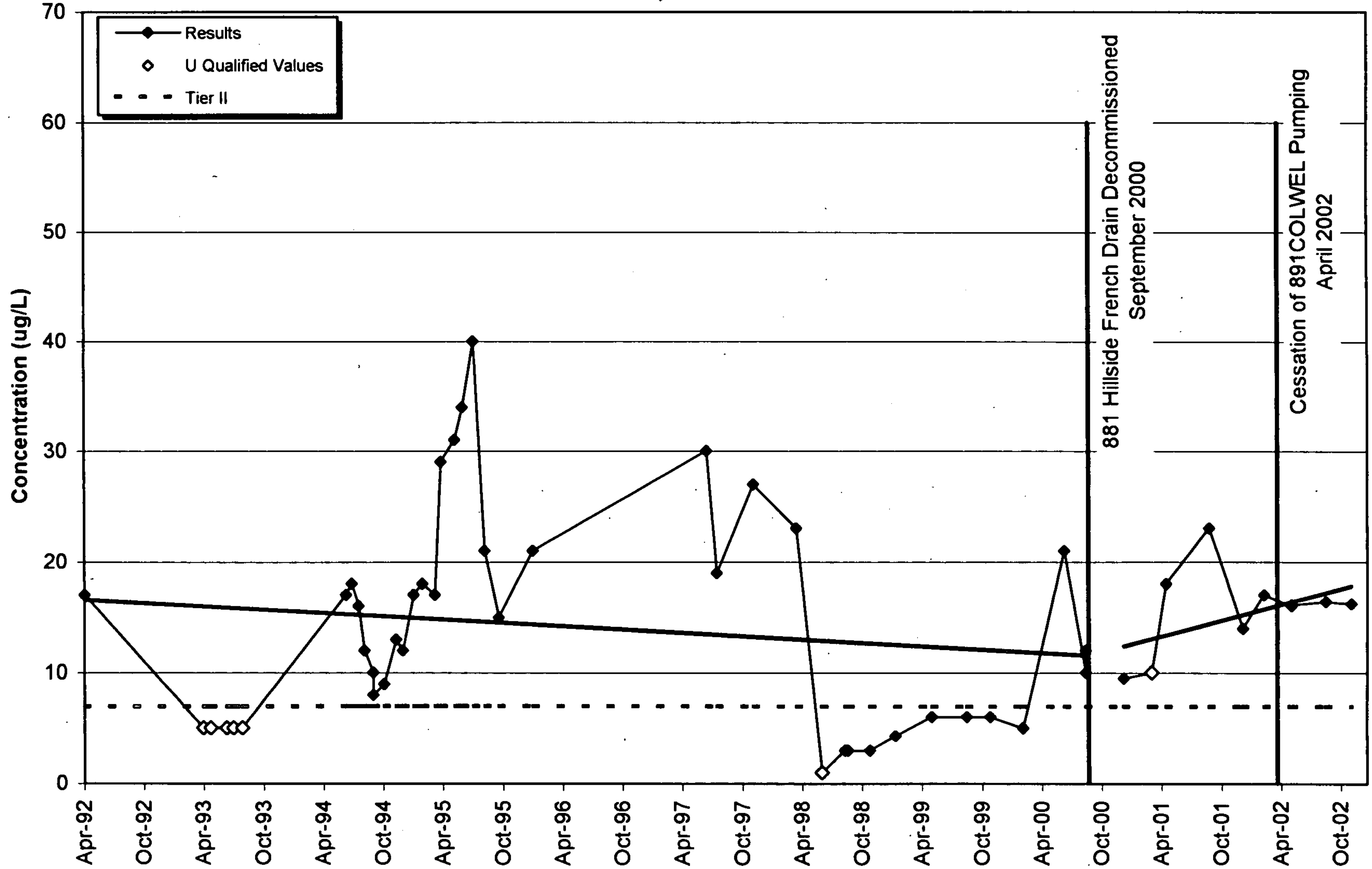

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Figure 4-54
891COLWEL Selenium

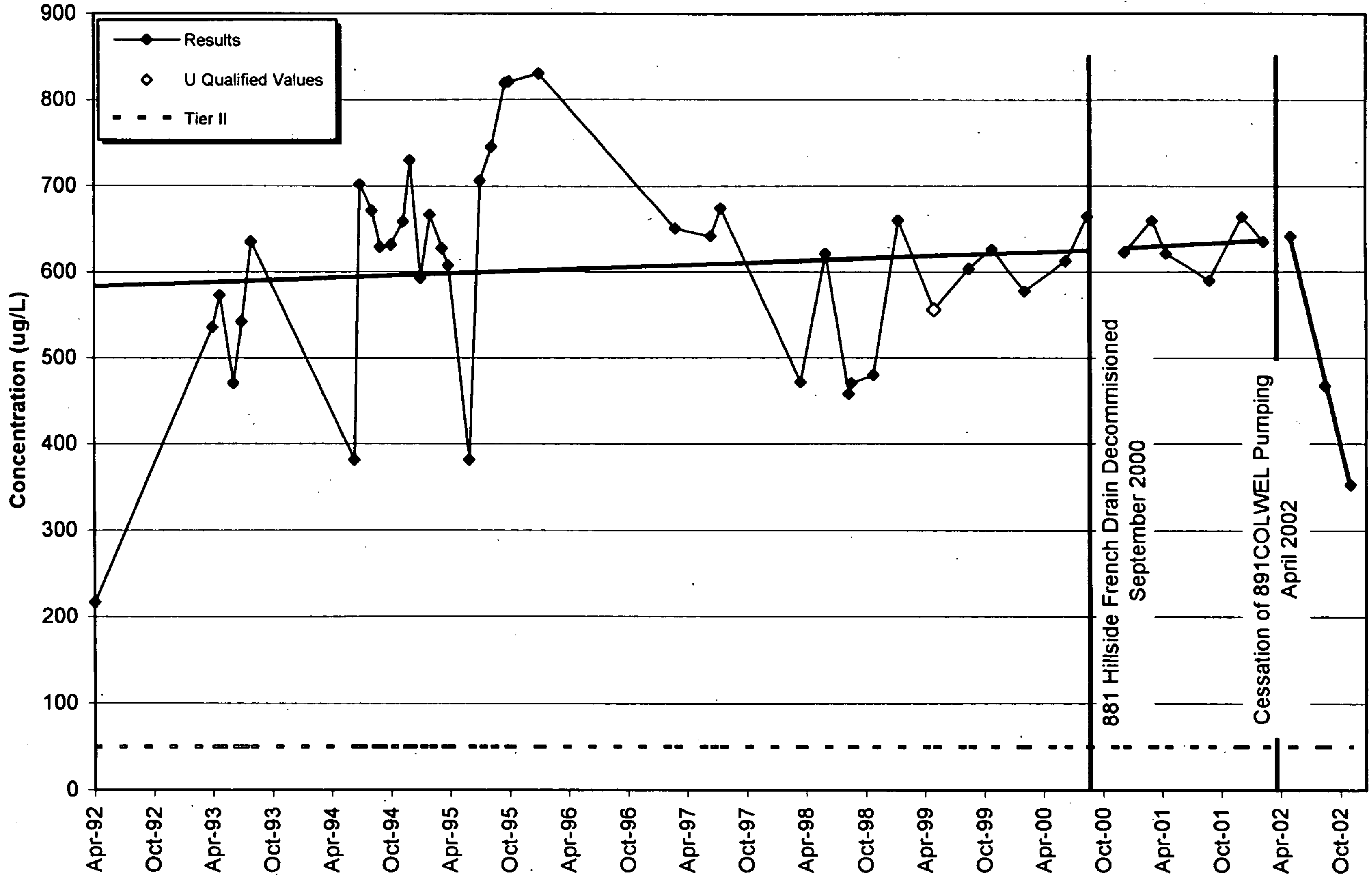

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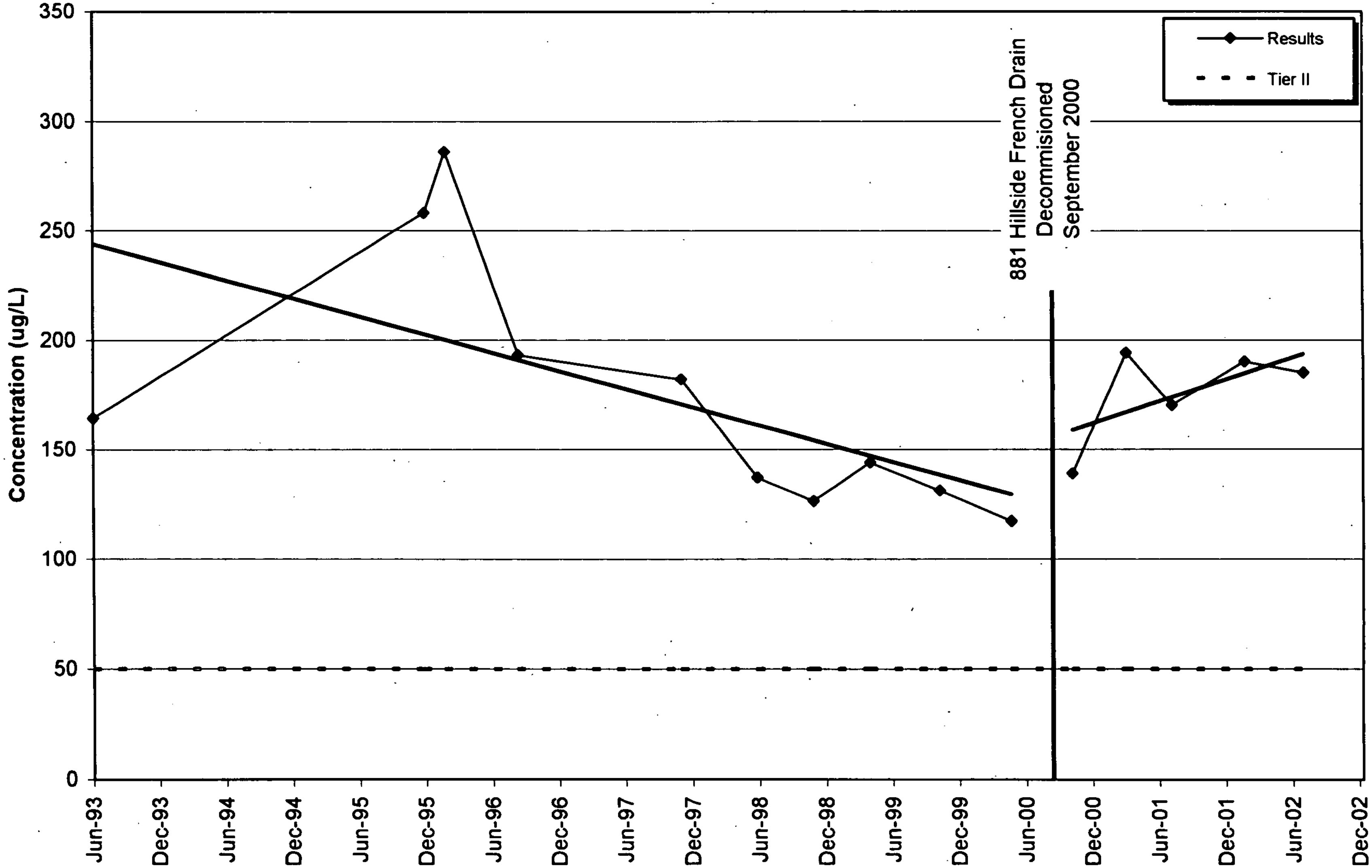
Figure 4-55
10592 Selenium



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10792 Selenium

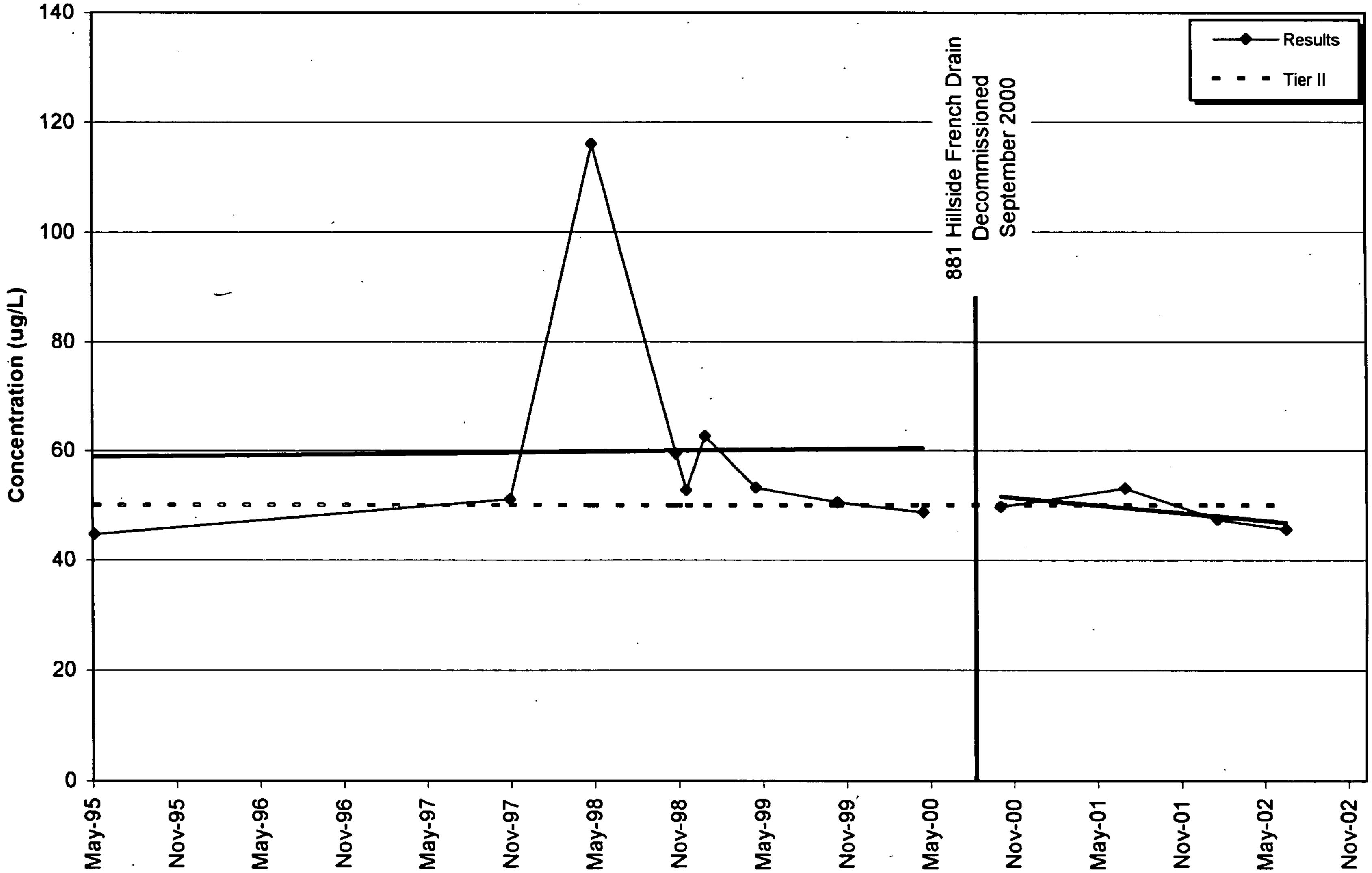

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Figure 4-57
10994 Nitrate

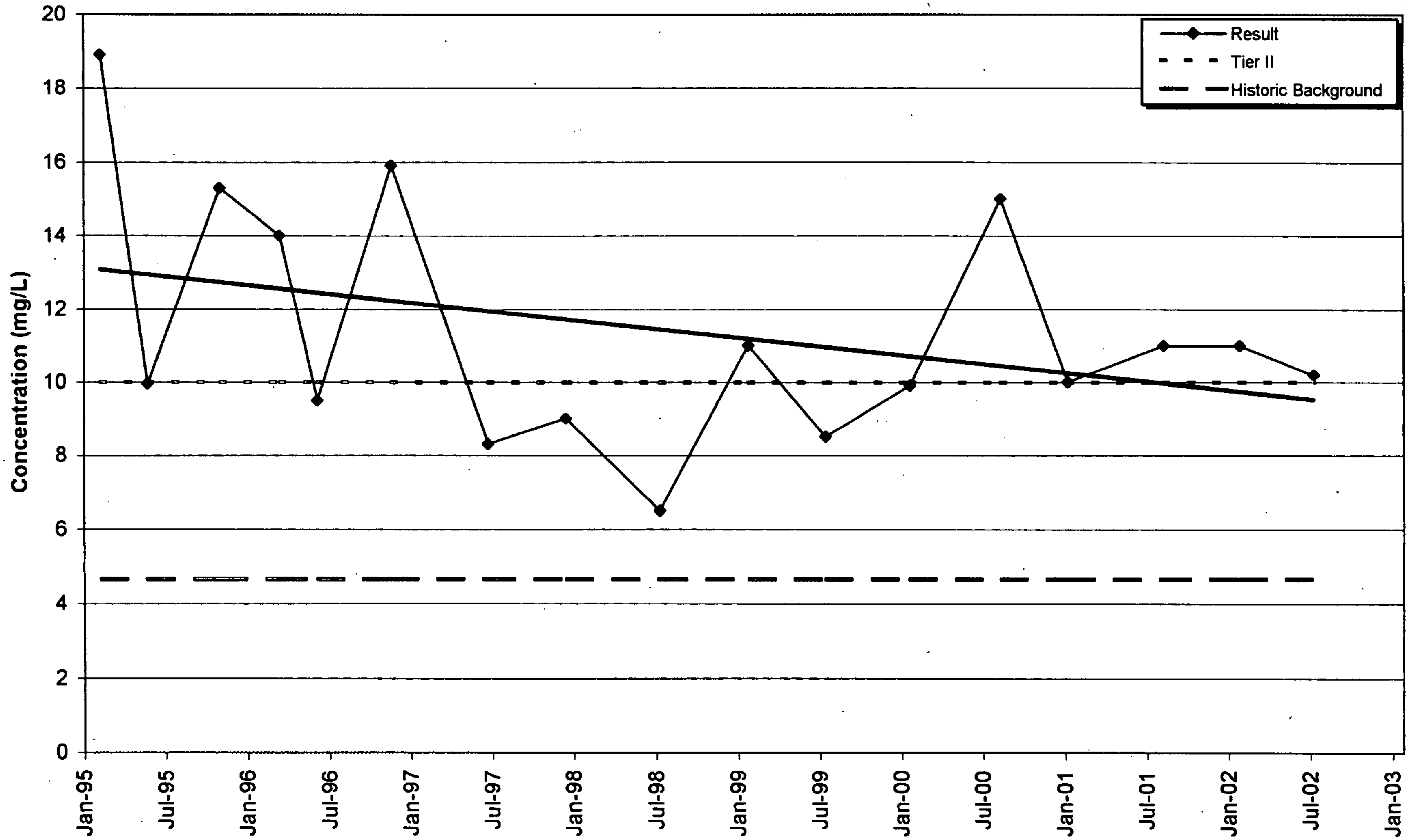

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Figure 4-58
10994 Selenium

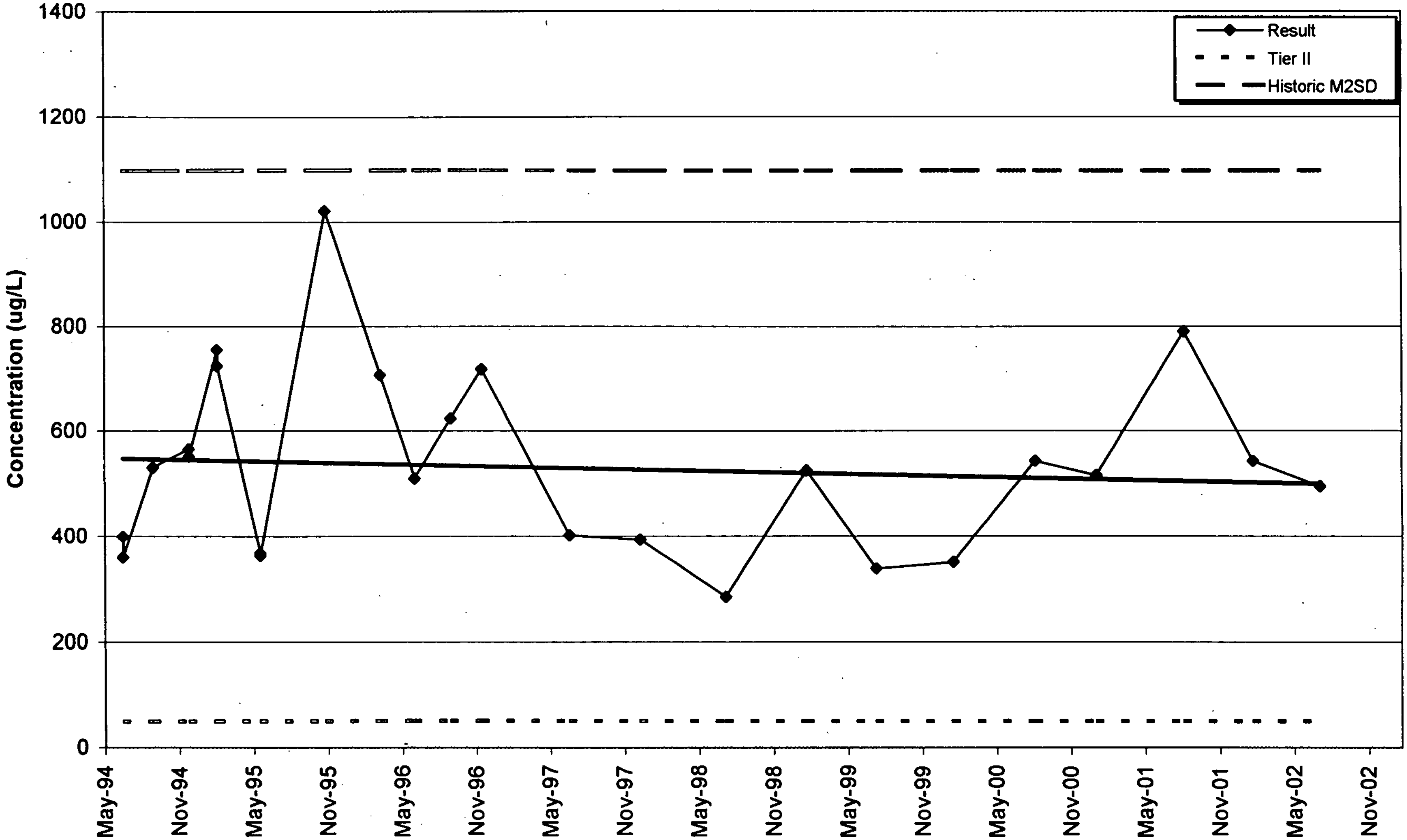

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Figure 4-59
1986 Manganese

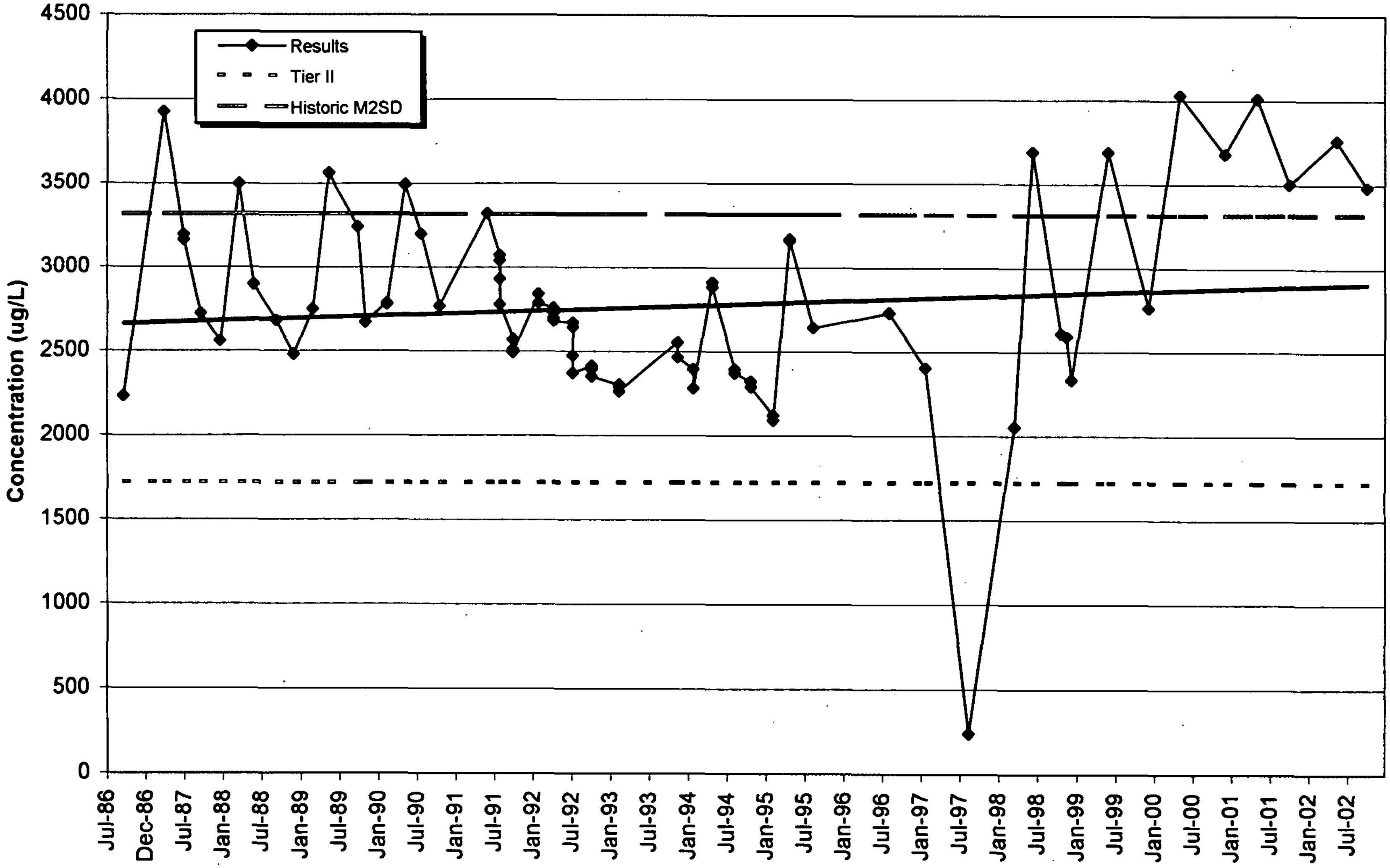

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Figure 4-60
21098/21002 Carbon Tetrachloride

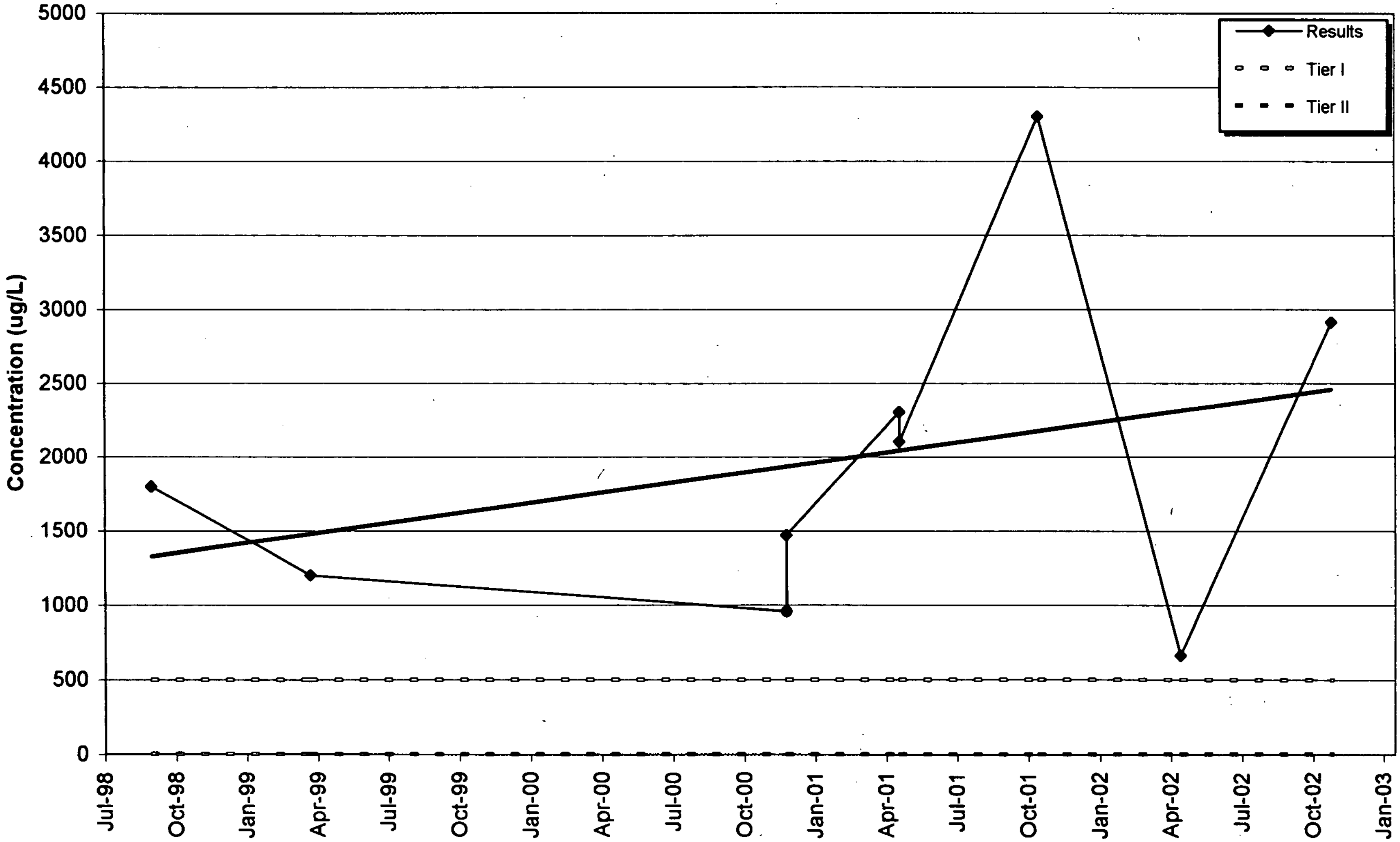

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Figure 4-61
21098/21002 Chloroform

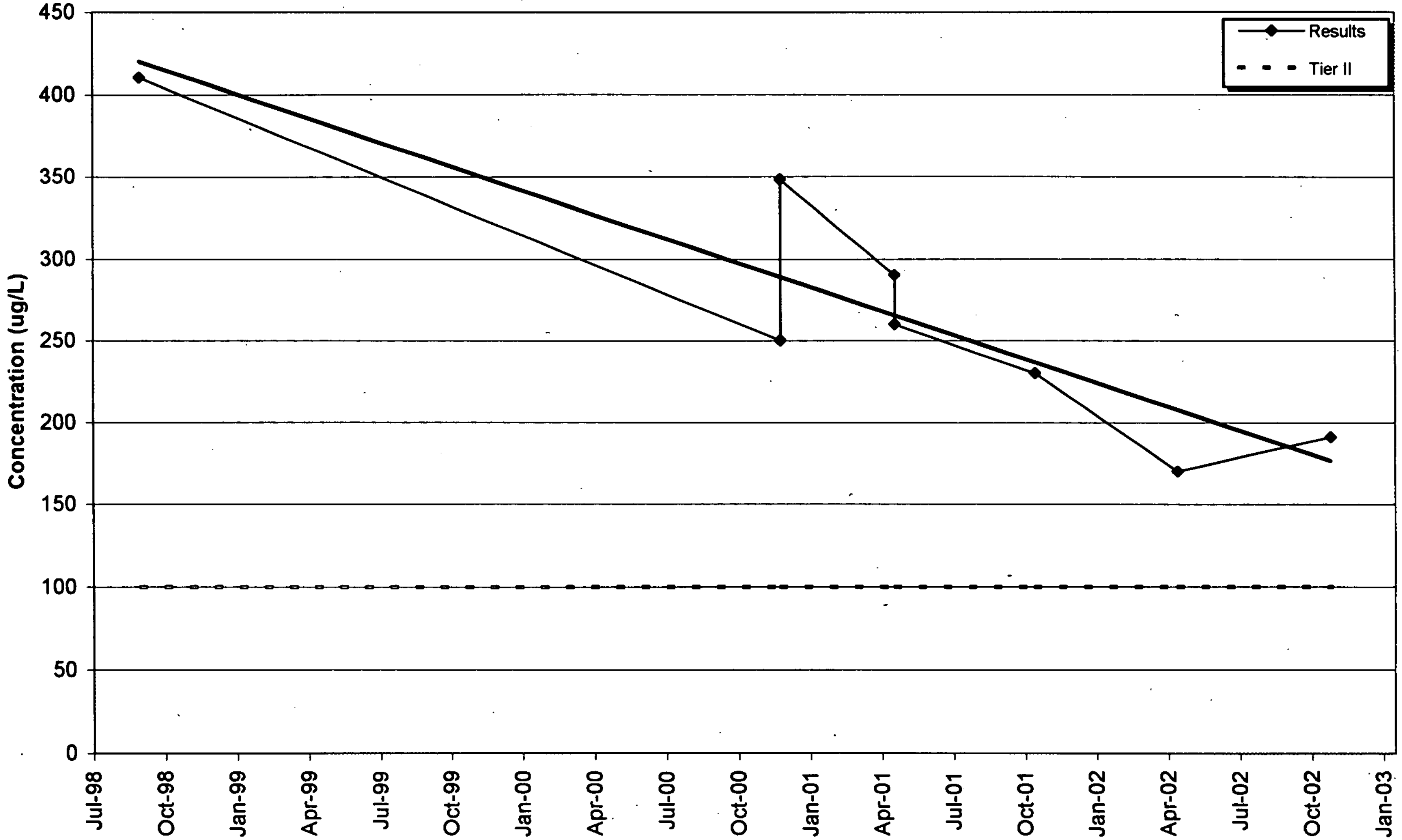

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Figure 4-62
22596 Thallium

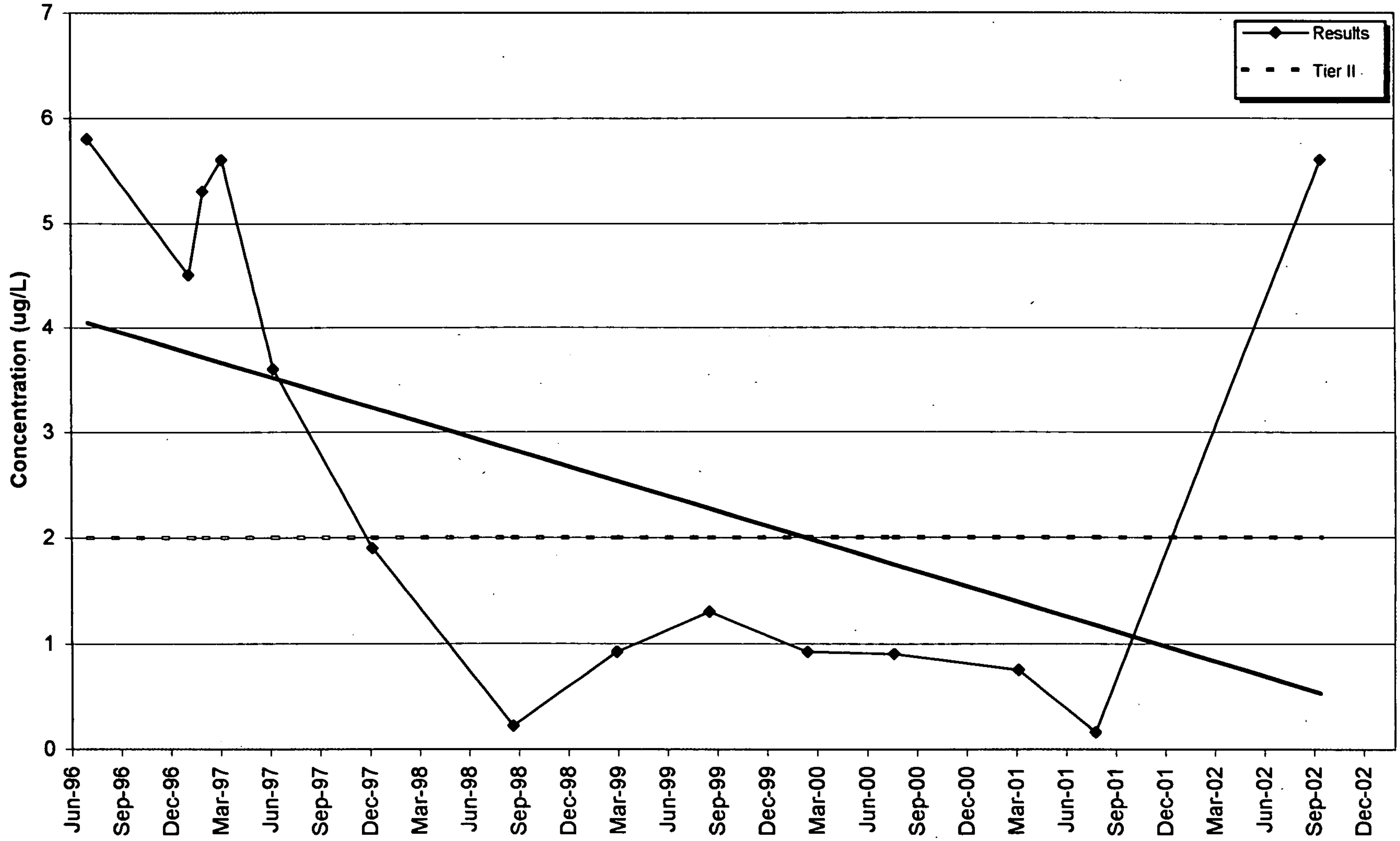

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Figure 4-63
6186 Nickel

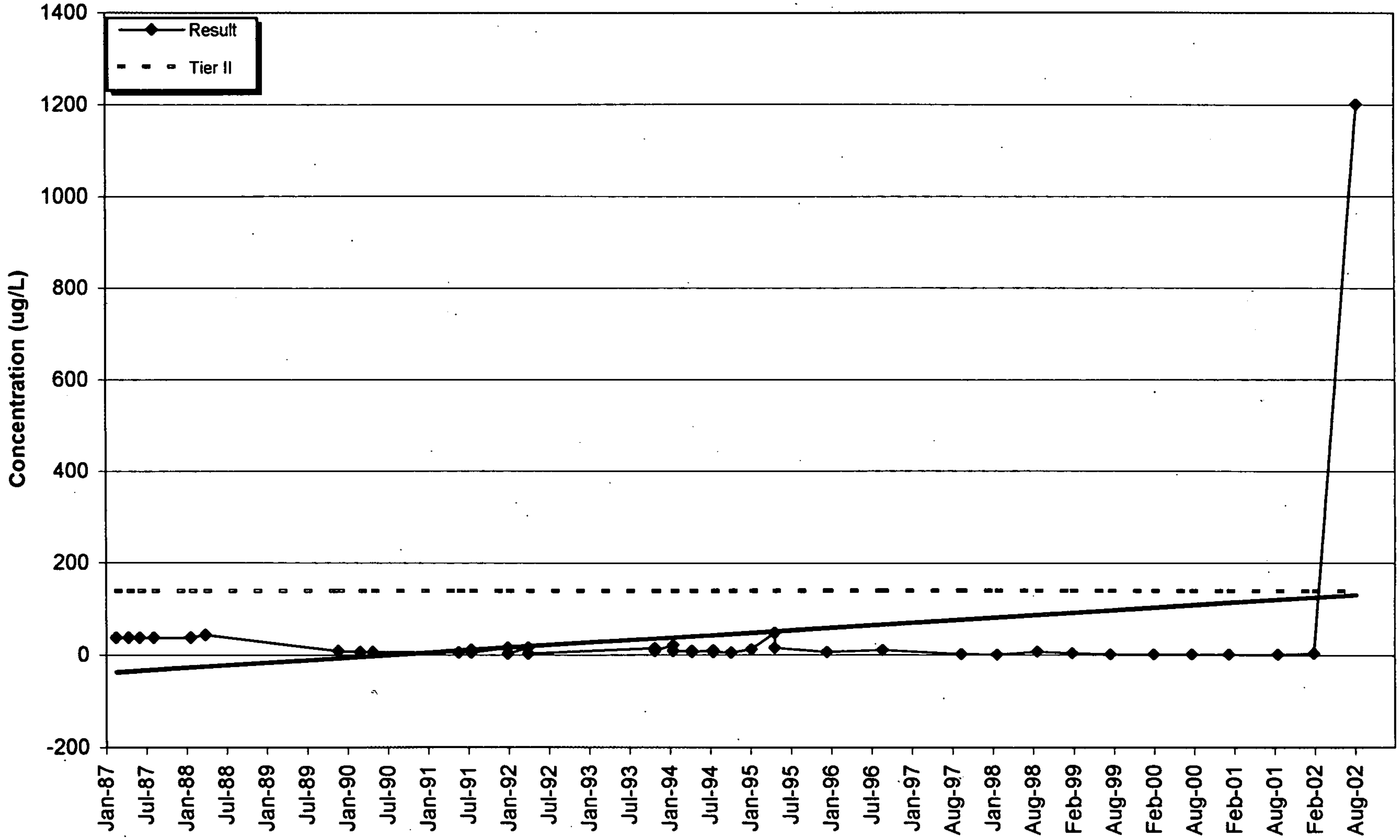

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Figure 4-64
P416689 Nickel

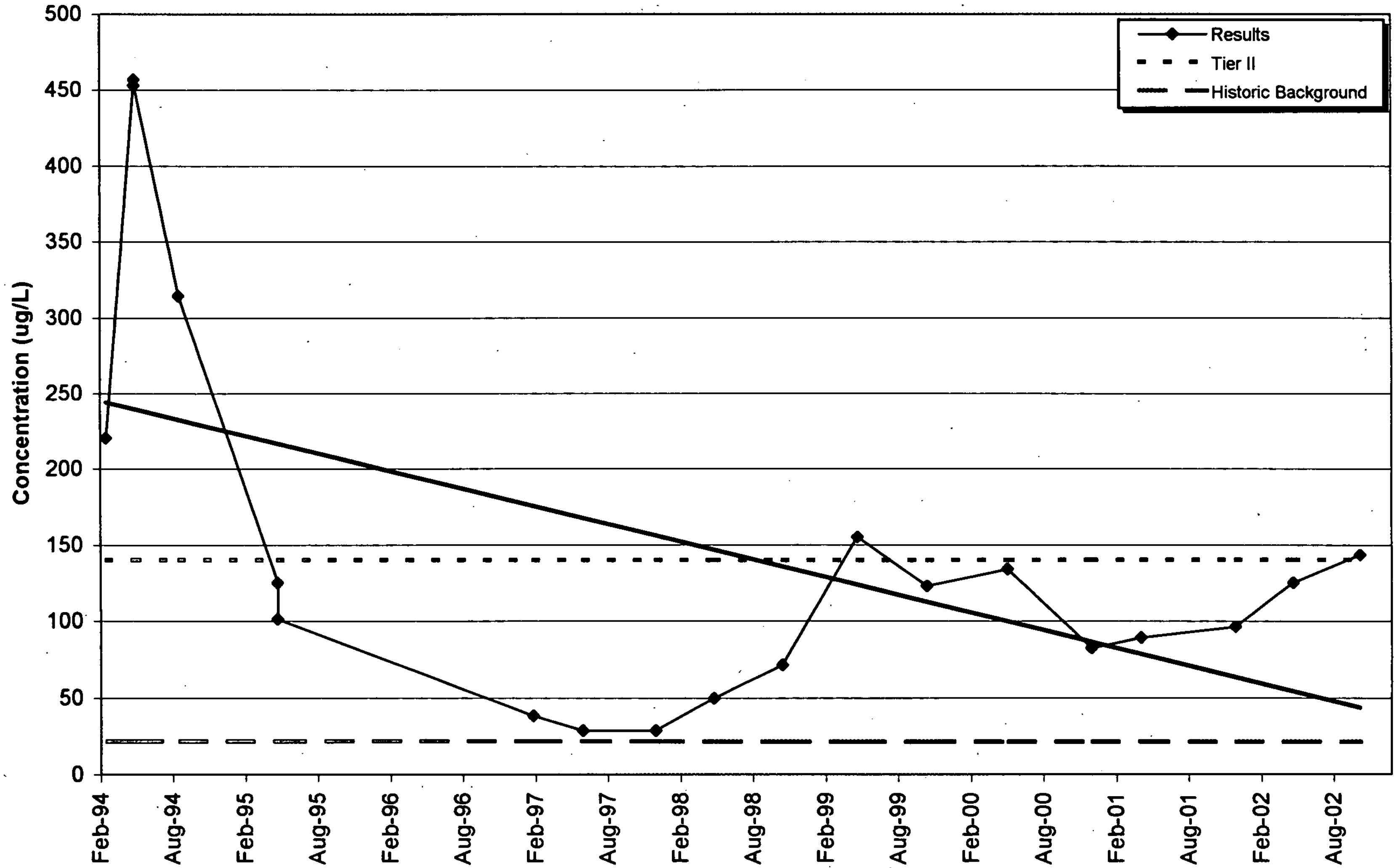

Figure 4-67
1786 Nitrate

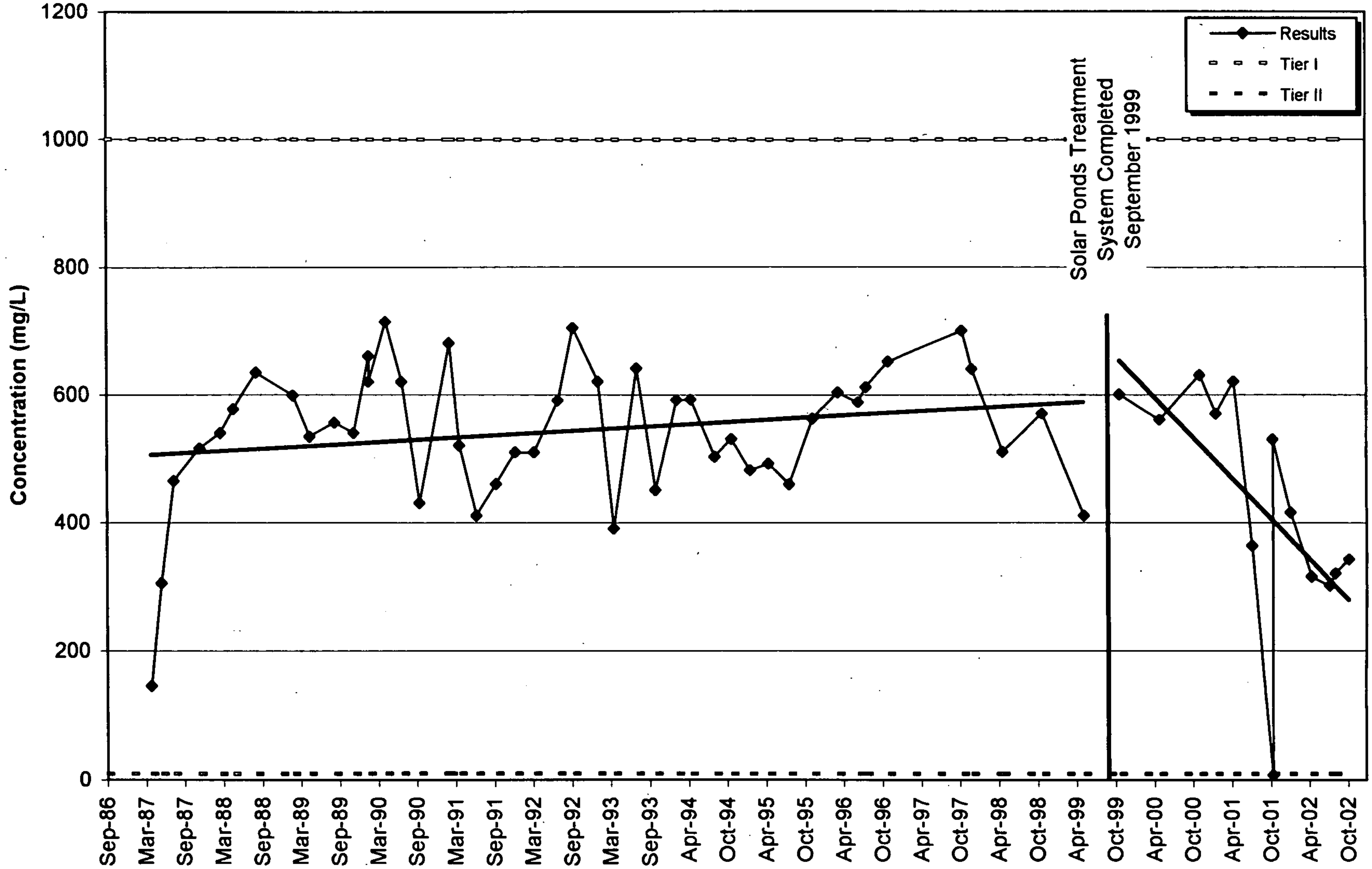

Figure 4-68
1786 Selenium

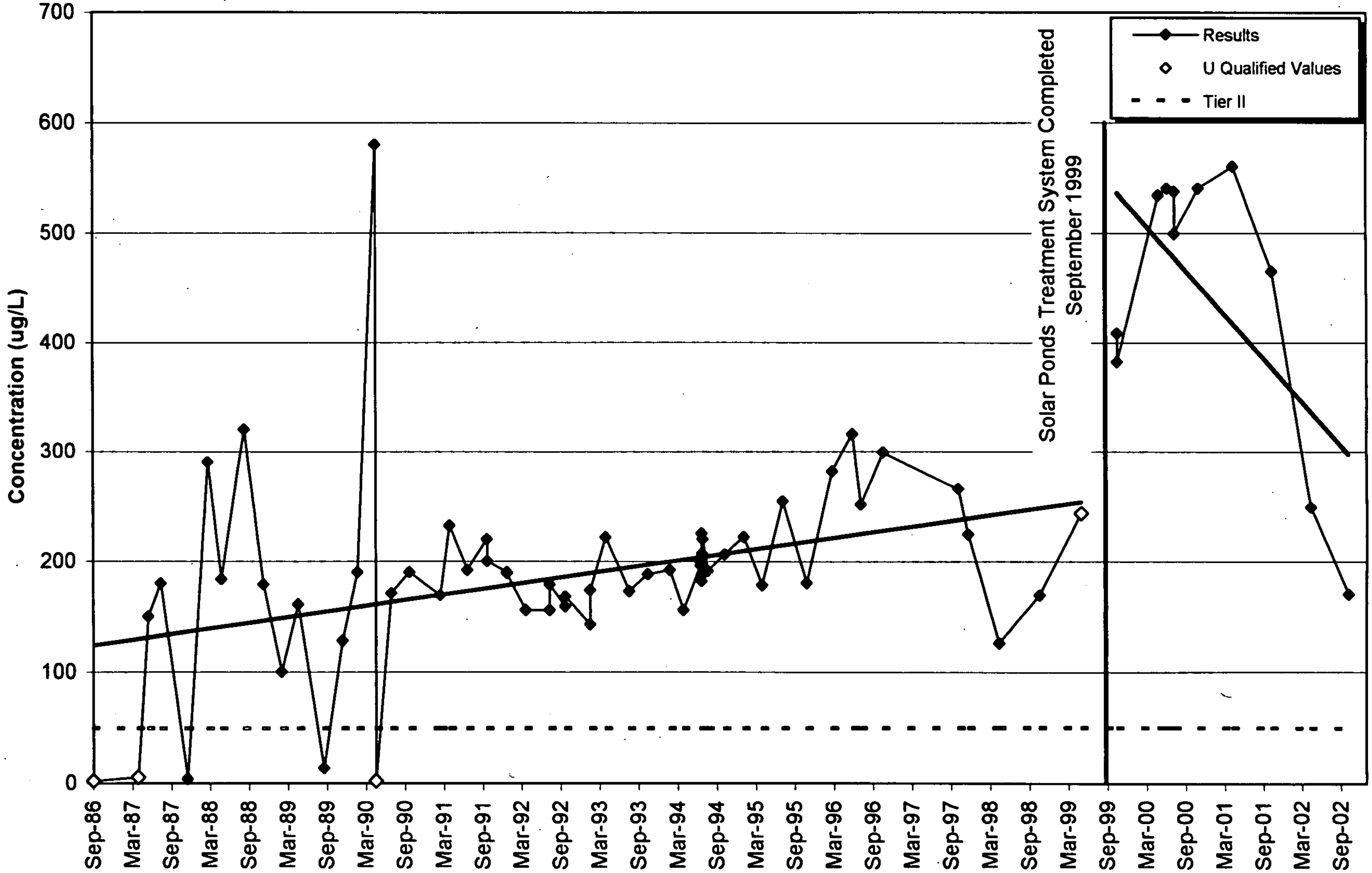

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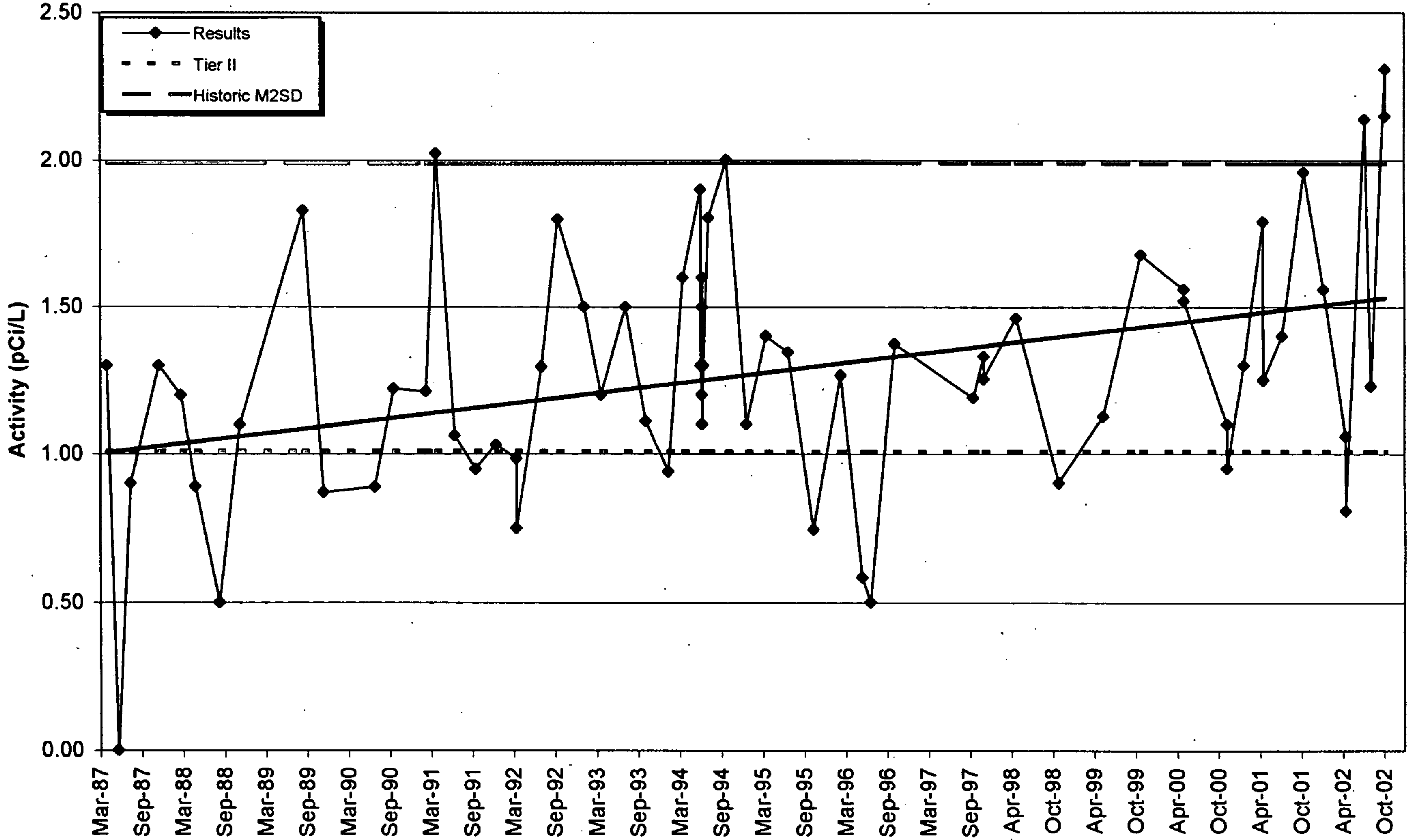
Figure 4-69
1786 Uranium-235



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1386 Nickel

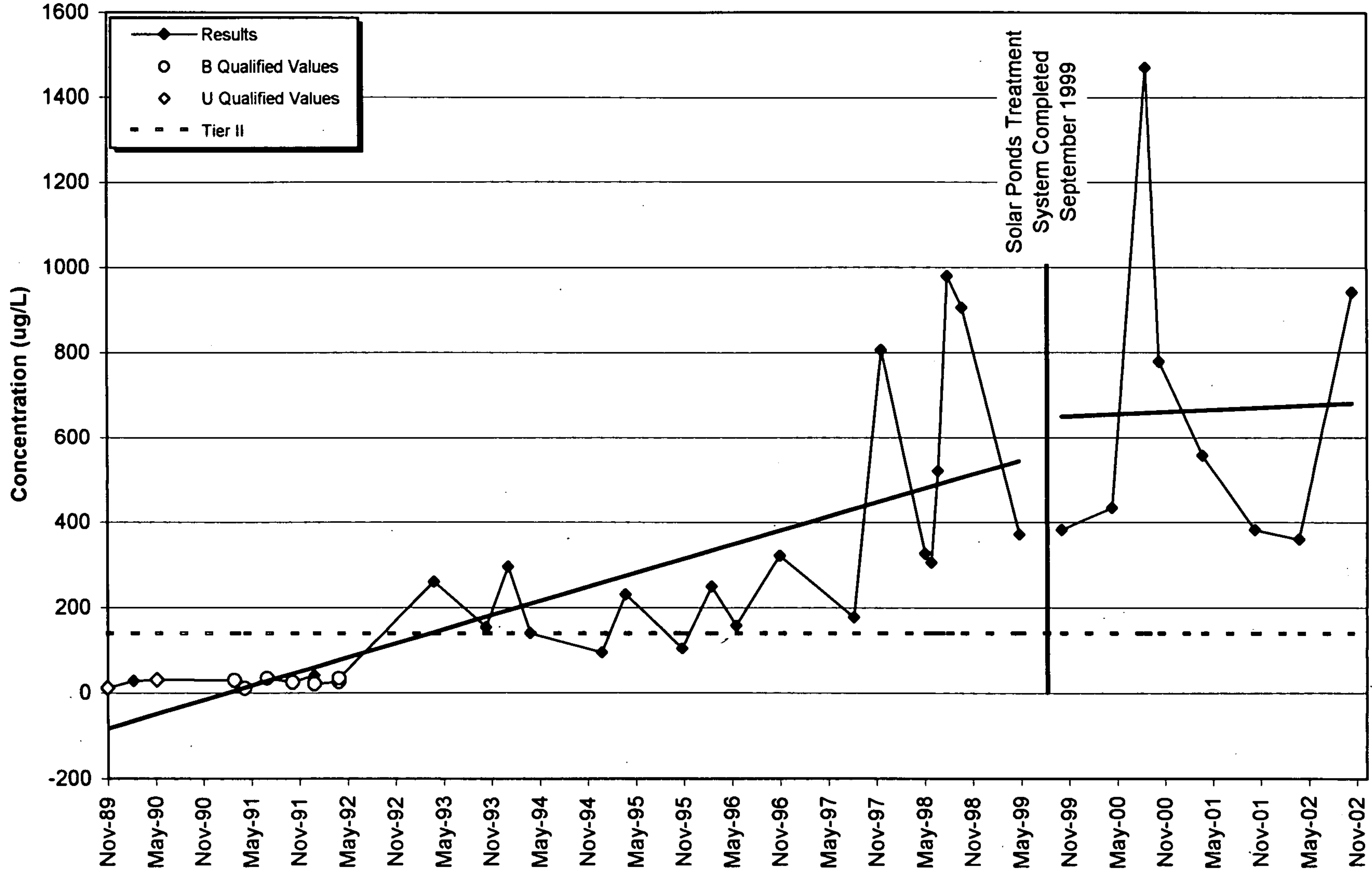

Figure 4-71
P219489 Nitrate

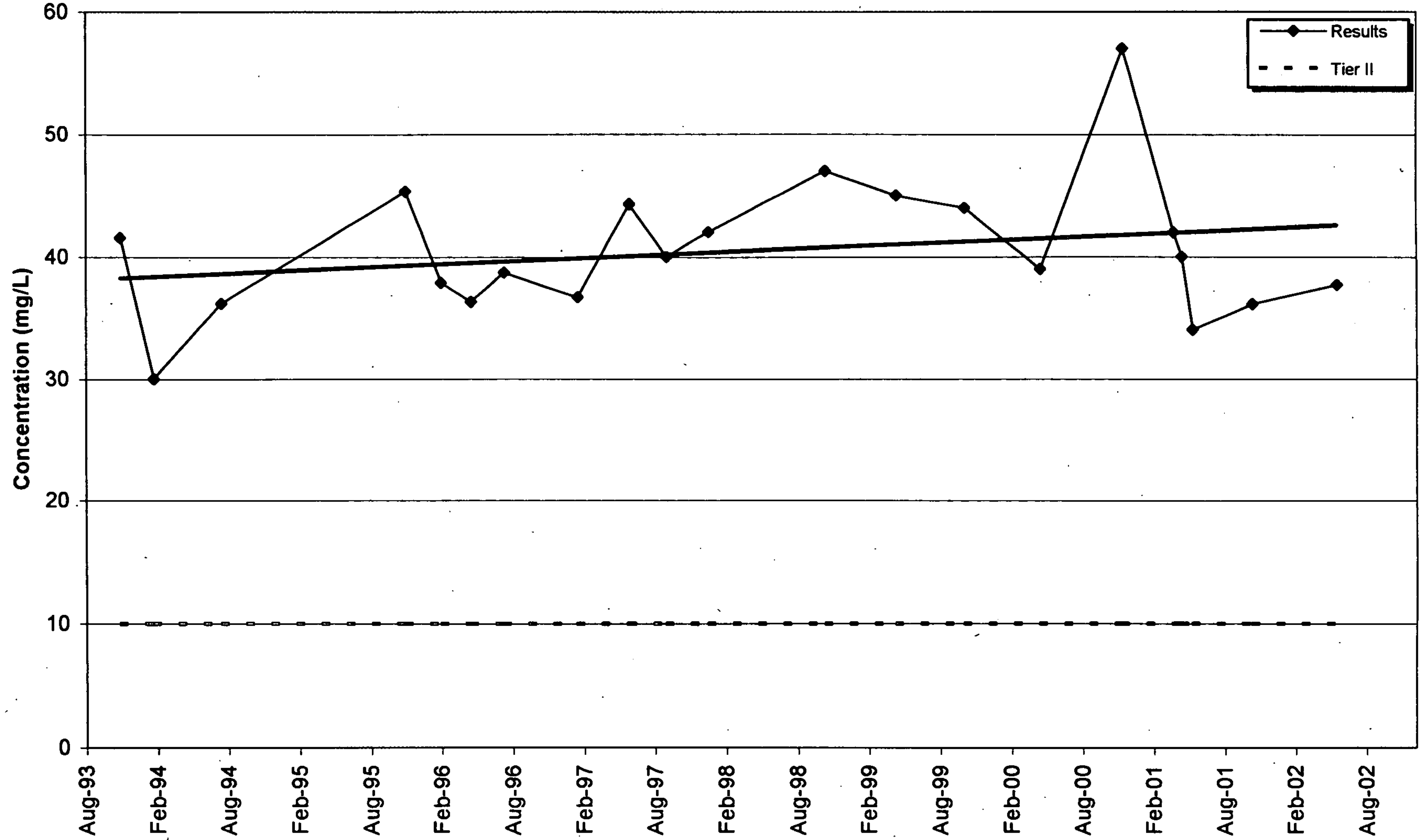

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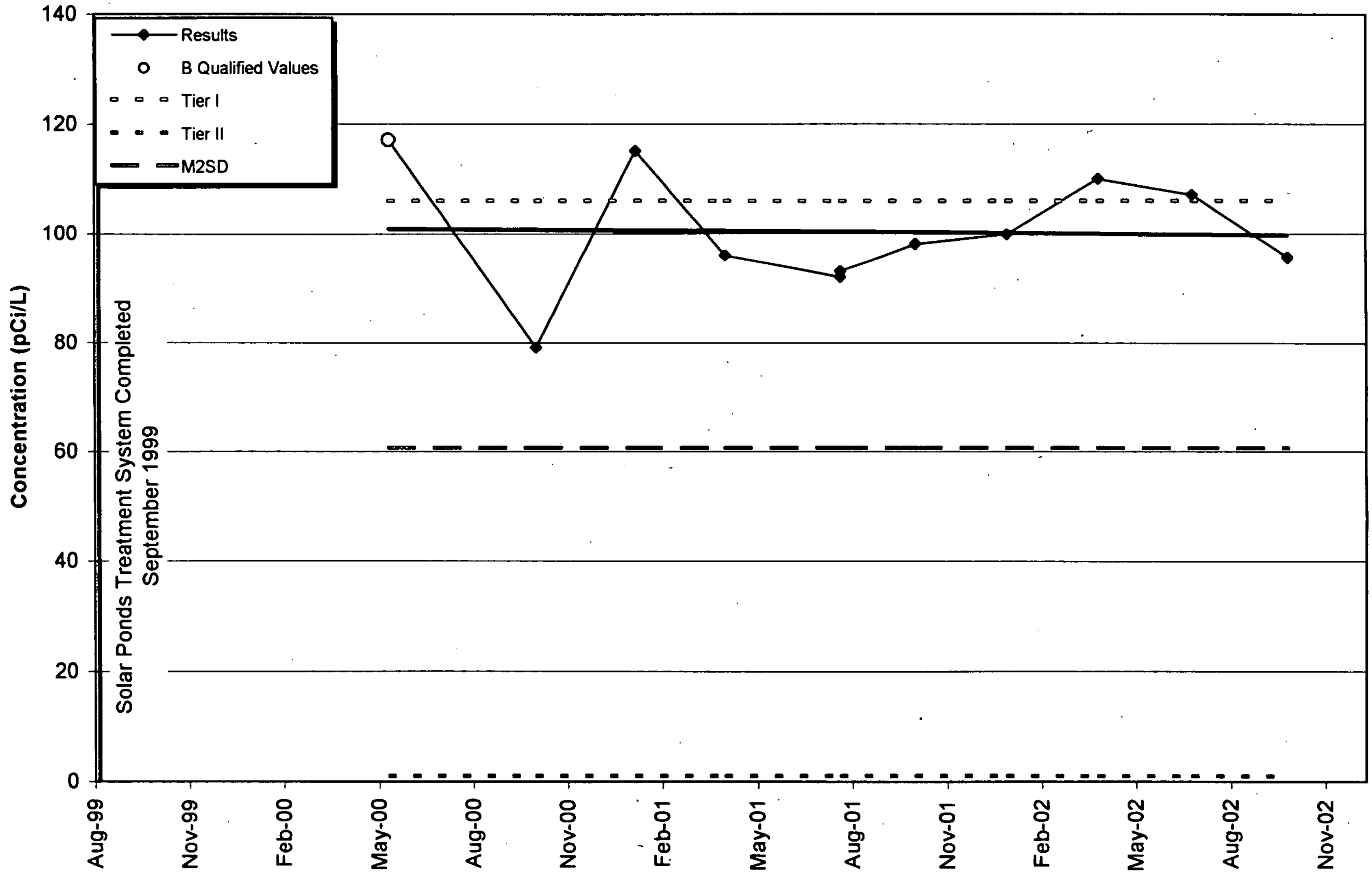
Figure 4-72
70099 Uranium 233/234



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70099 Uranium 235

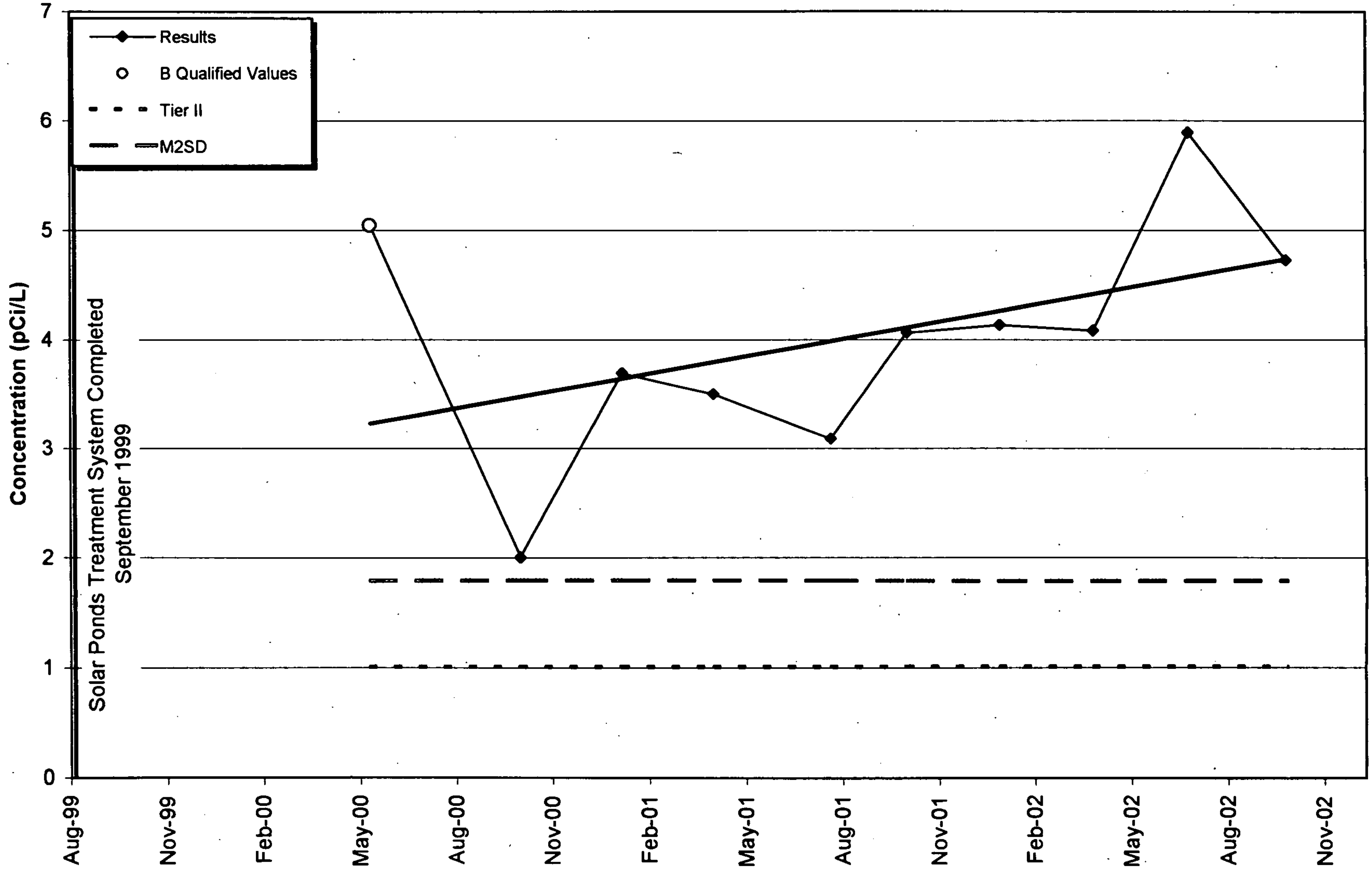

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Figure 4-74
70099 Uranium 238

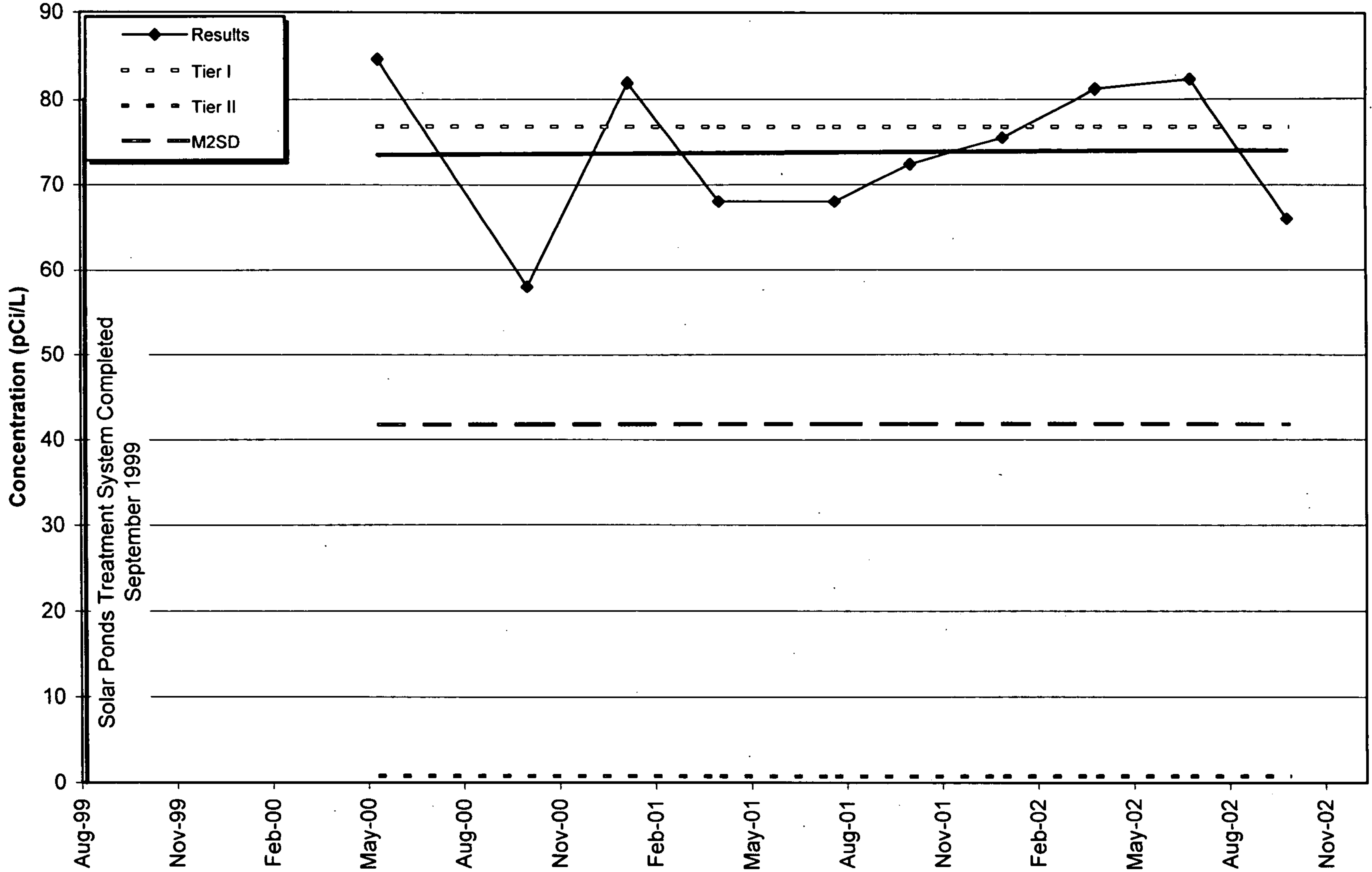

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Figure 4-75
6486 Nickel

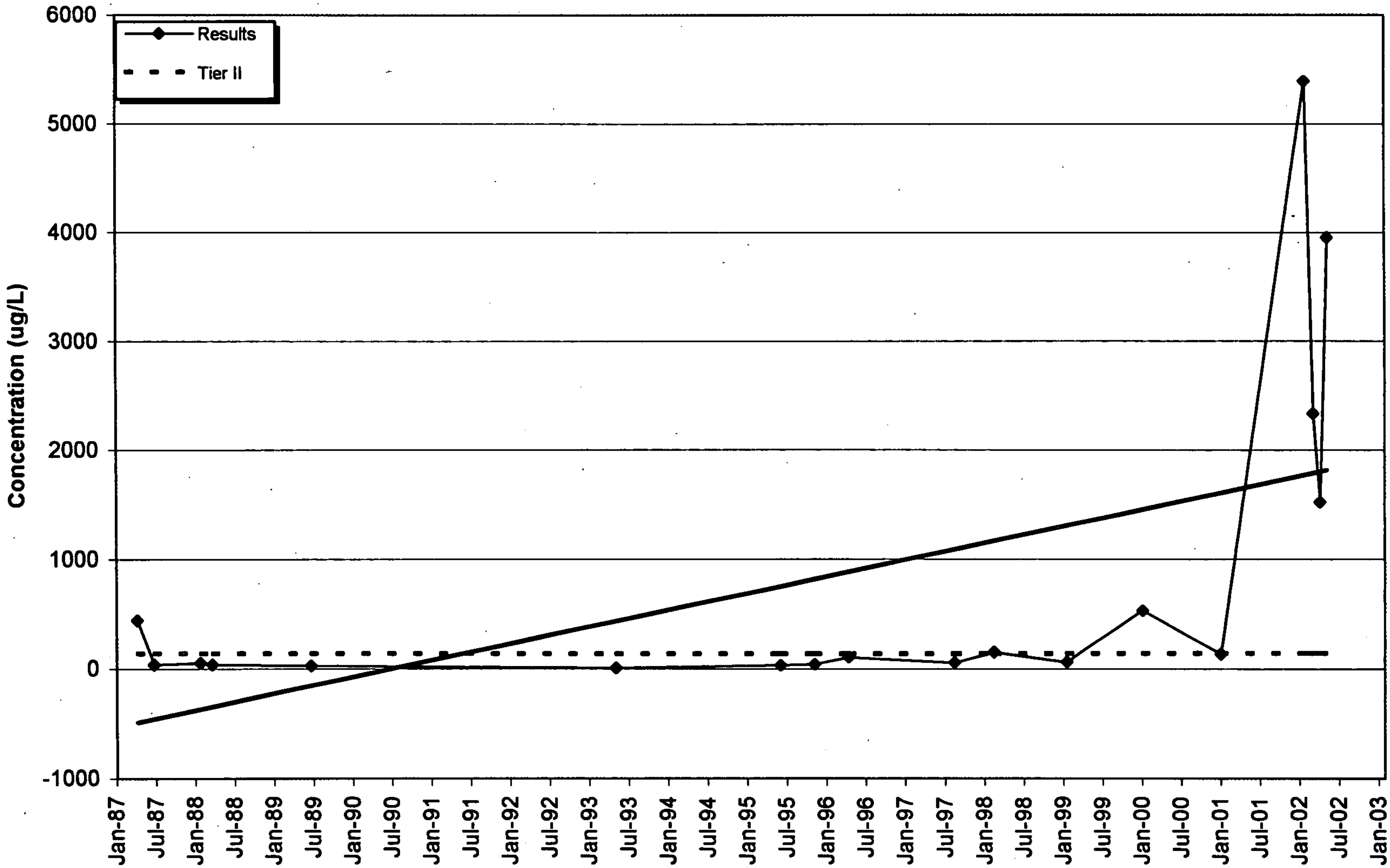

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Figure 4-76
6486 Chromium

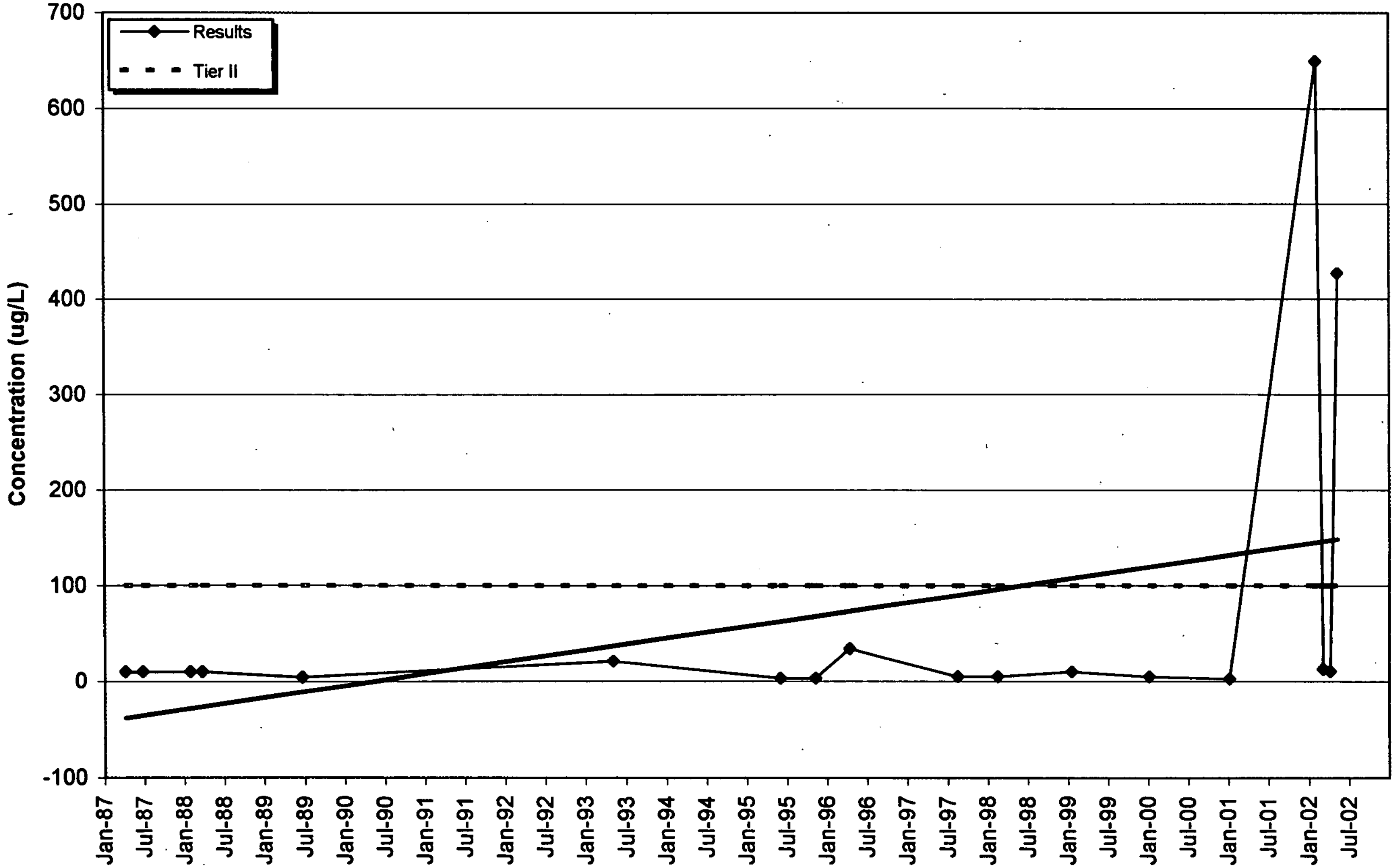

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Figure 4-77
0386 Selenium

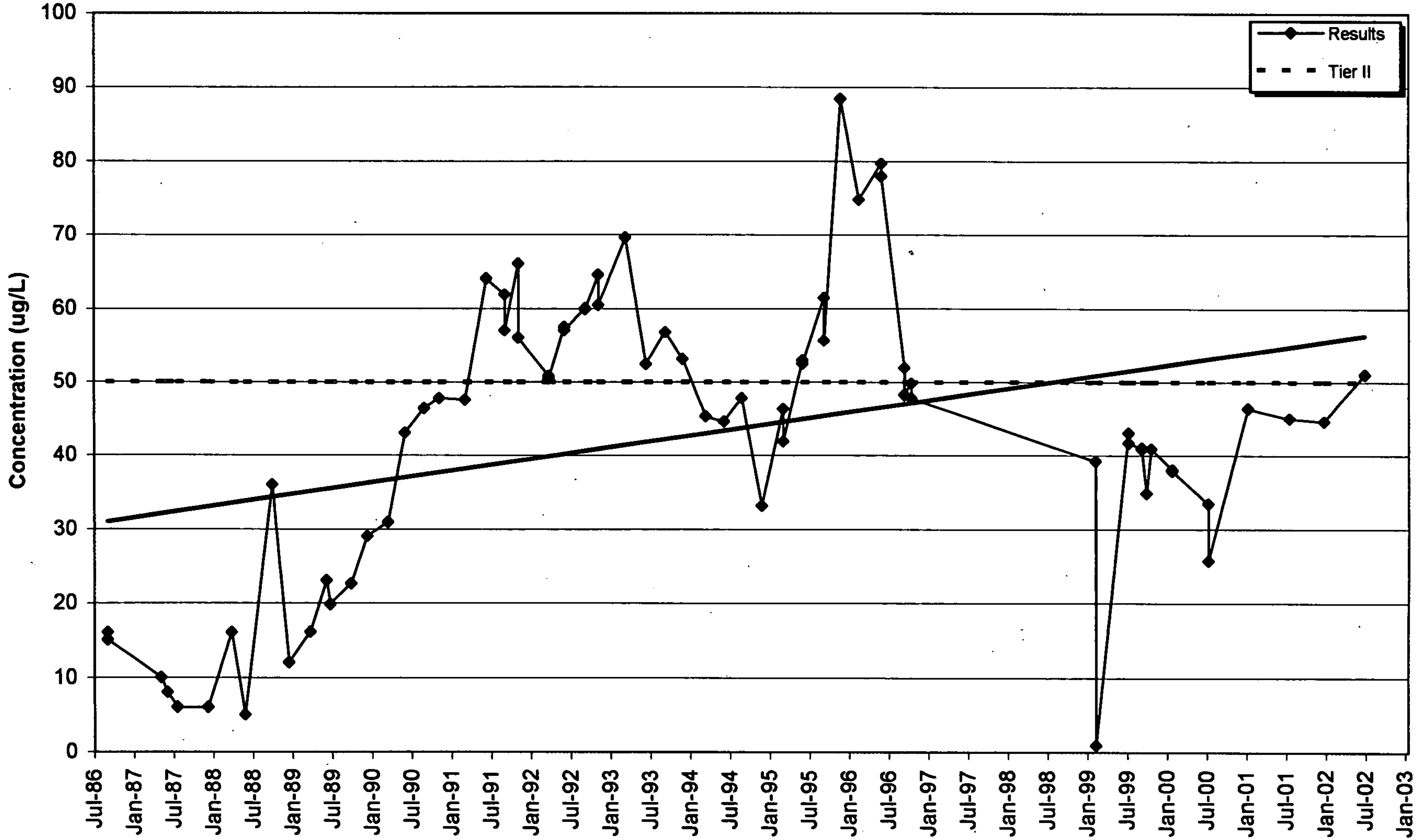

Figure 4-78
06491 Uranium-235

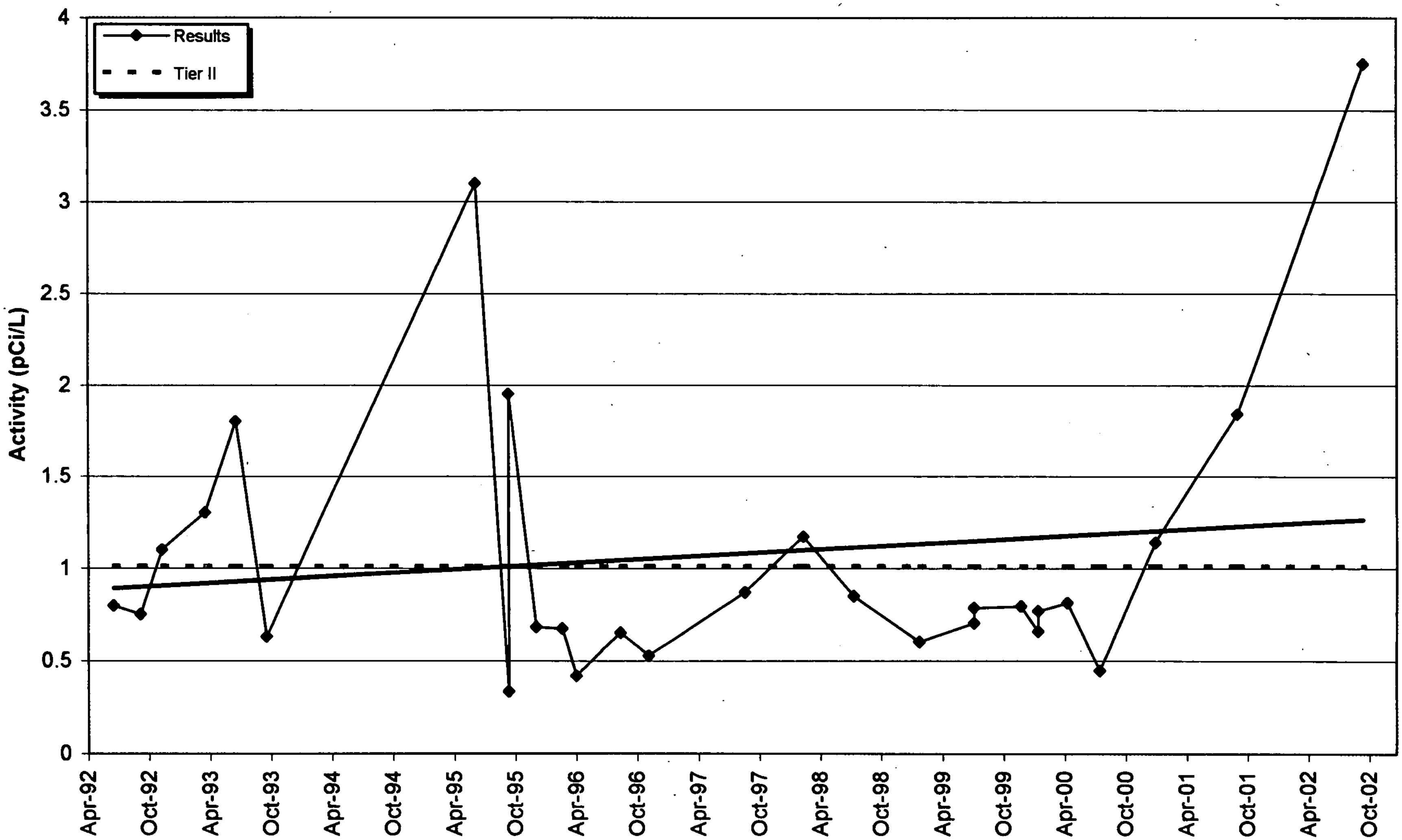

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Figure 4-79
41591 Nickel

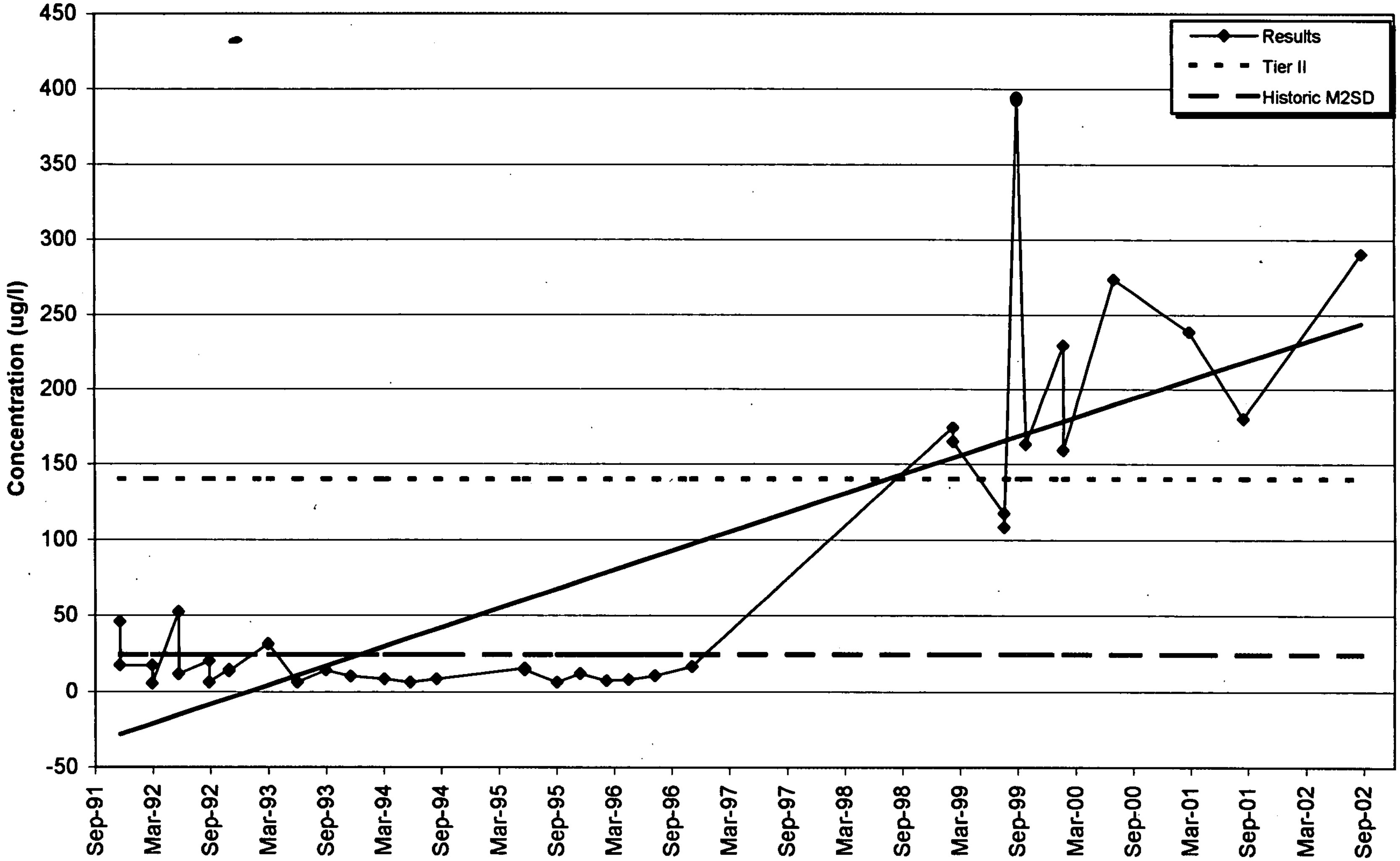

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Figure 4-80
41591 Thallium

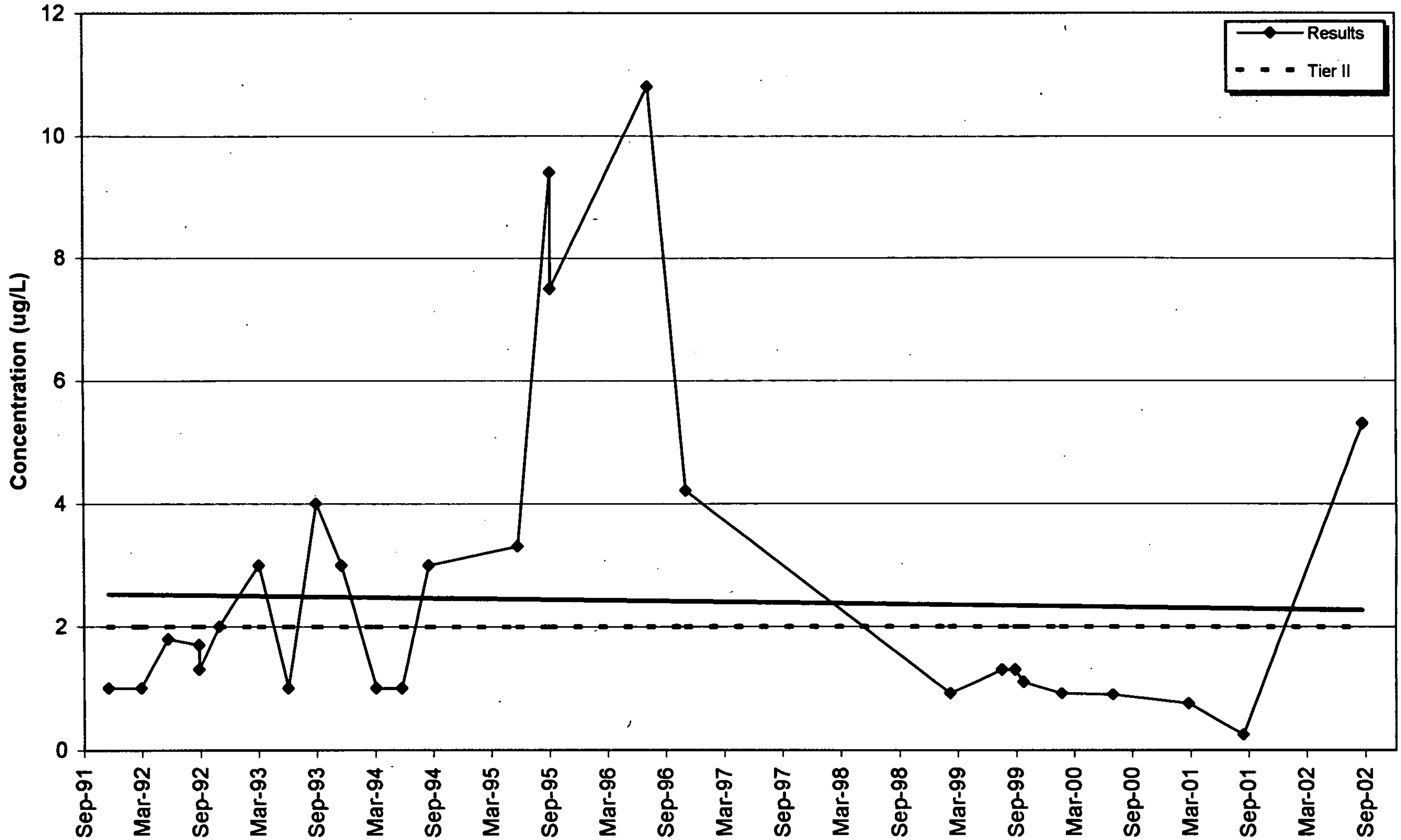

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Figure 4-81
10294 Sulfate

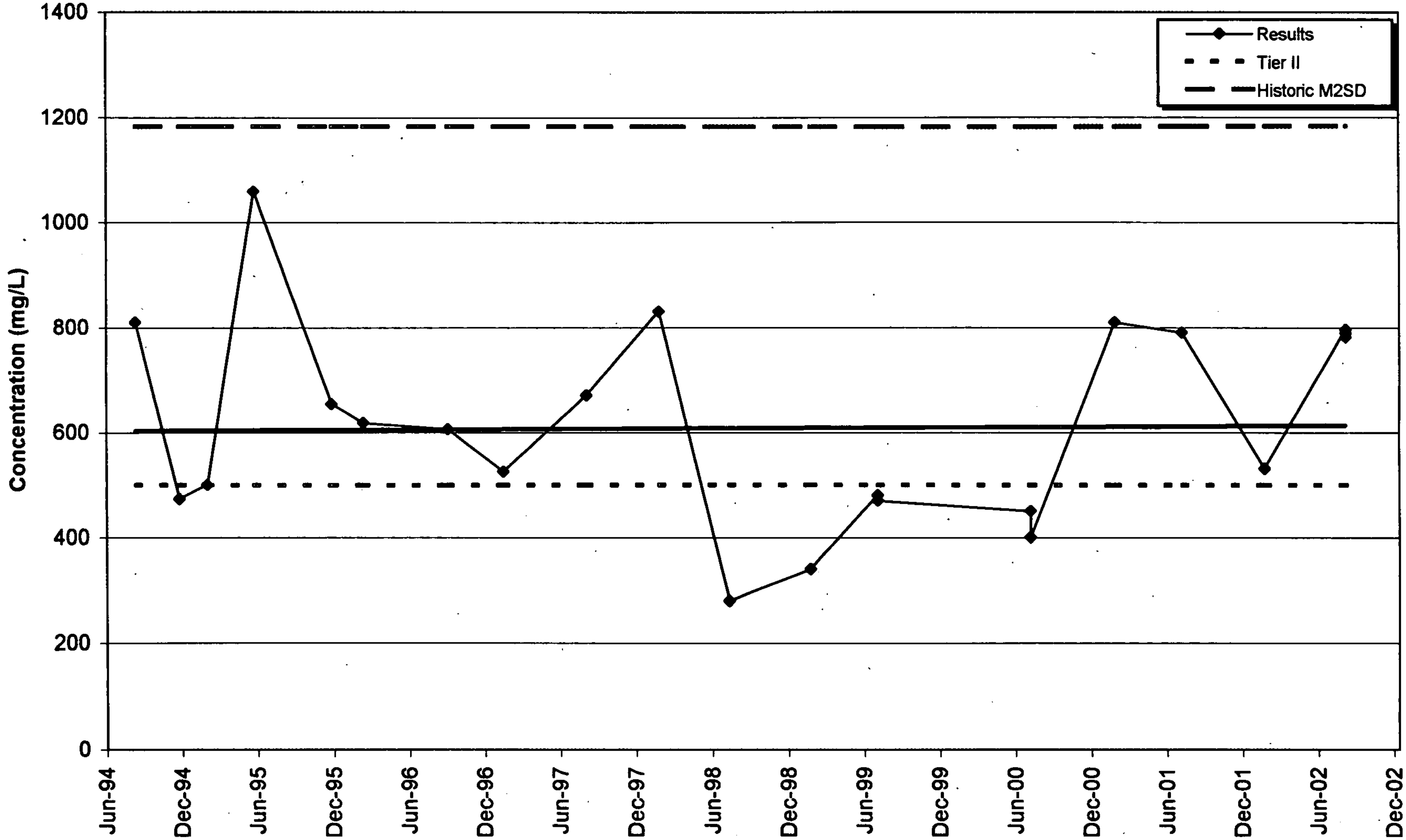

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Figure 4-82
10294 Lead

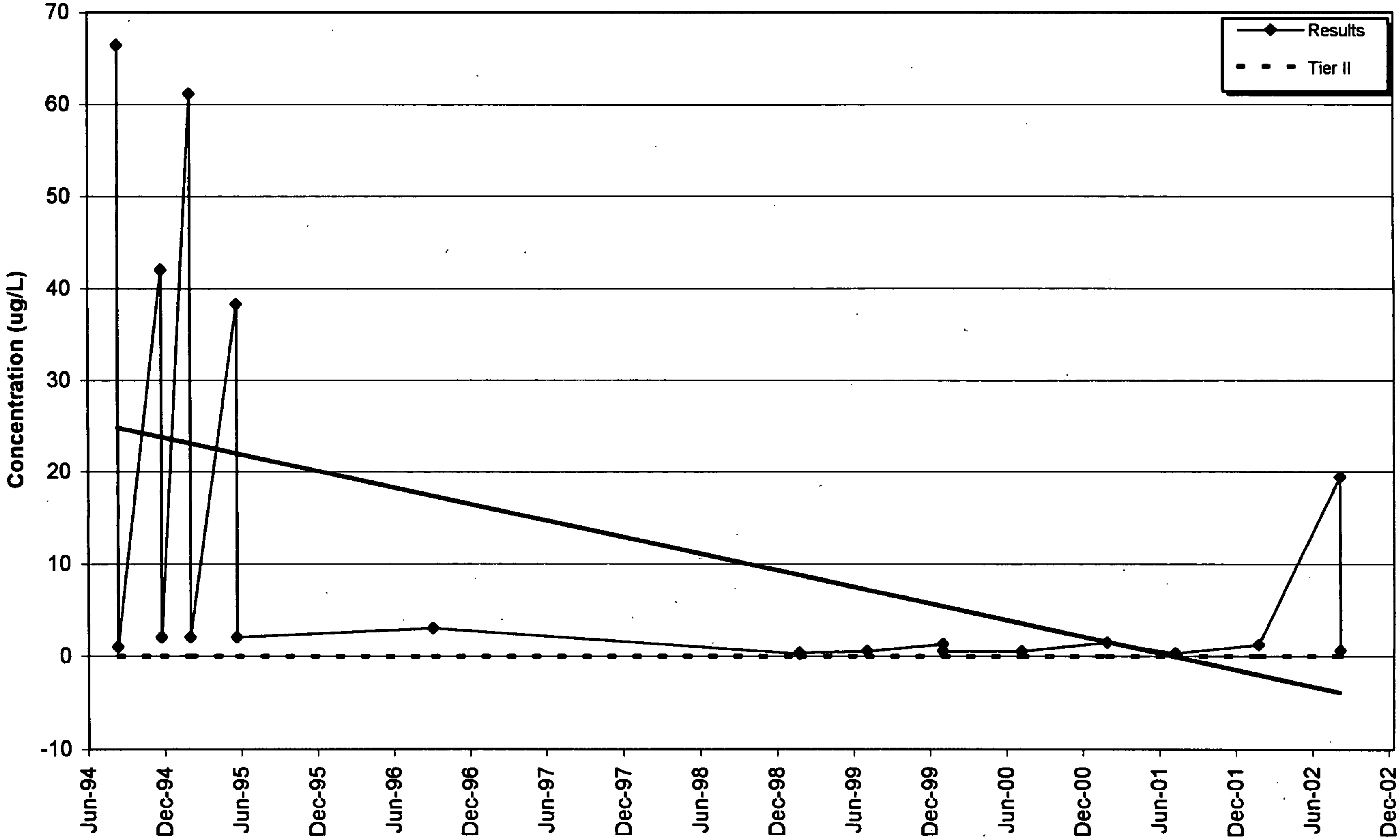

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Figure 4-83
10294 Uranium-233/234

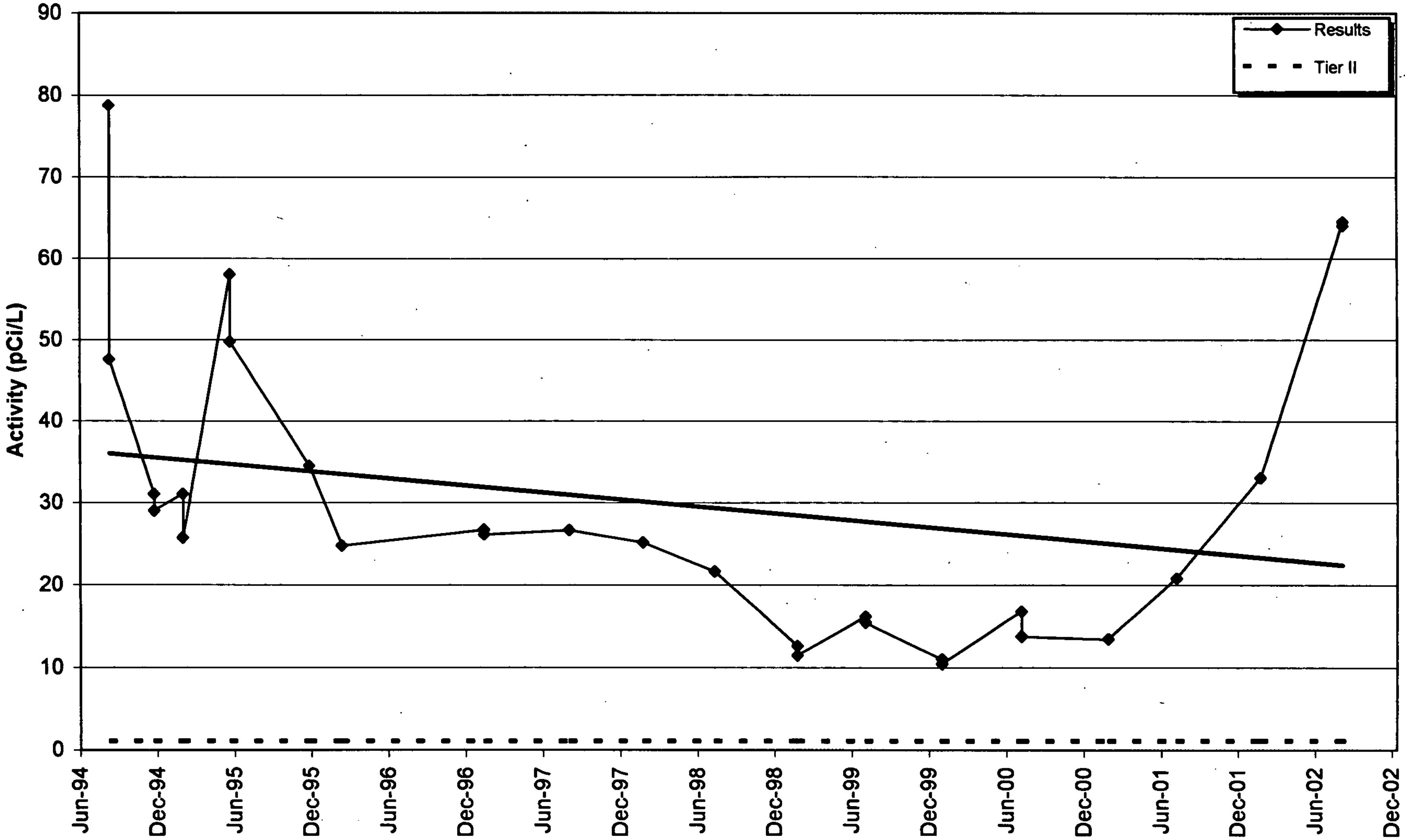

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Figure 4-84
10294 Uranium-235

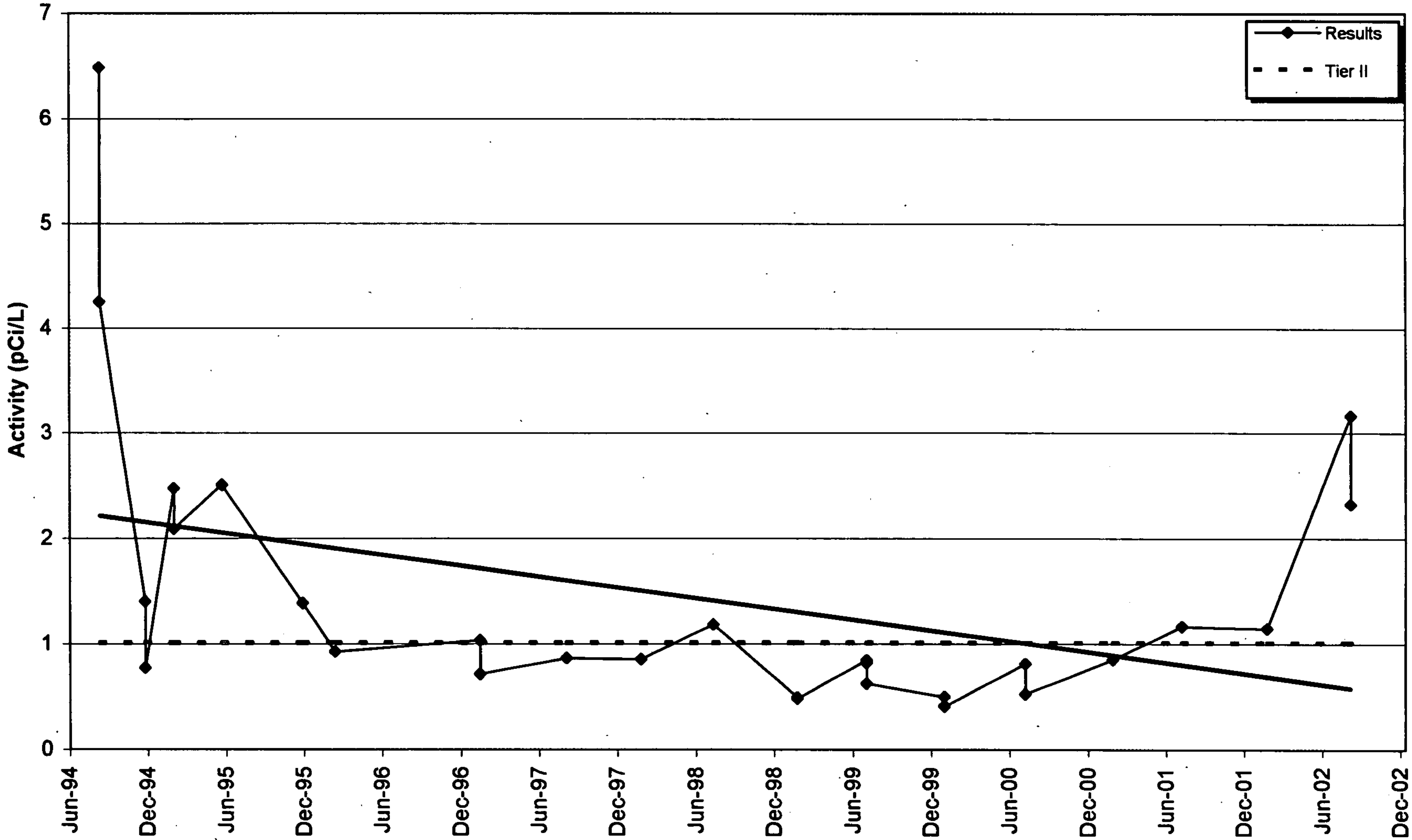

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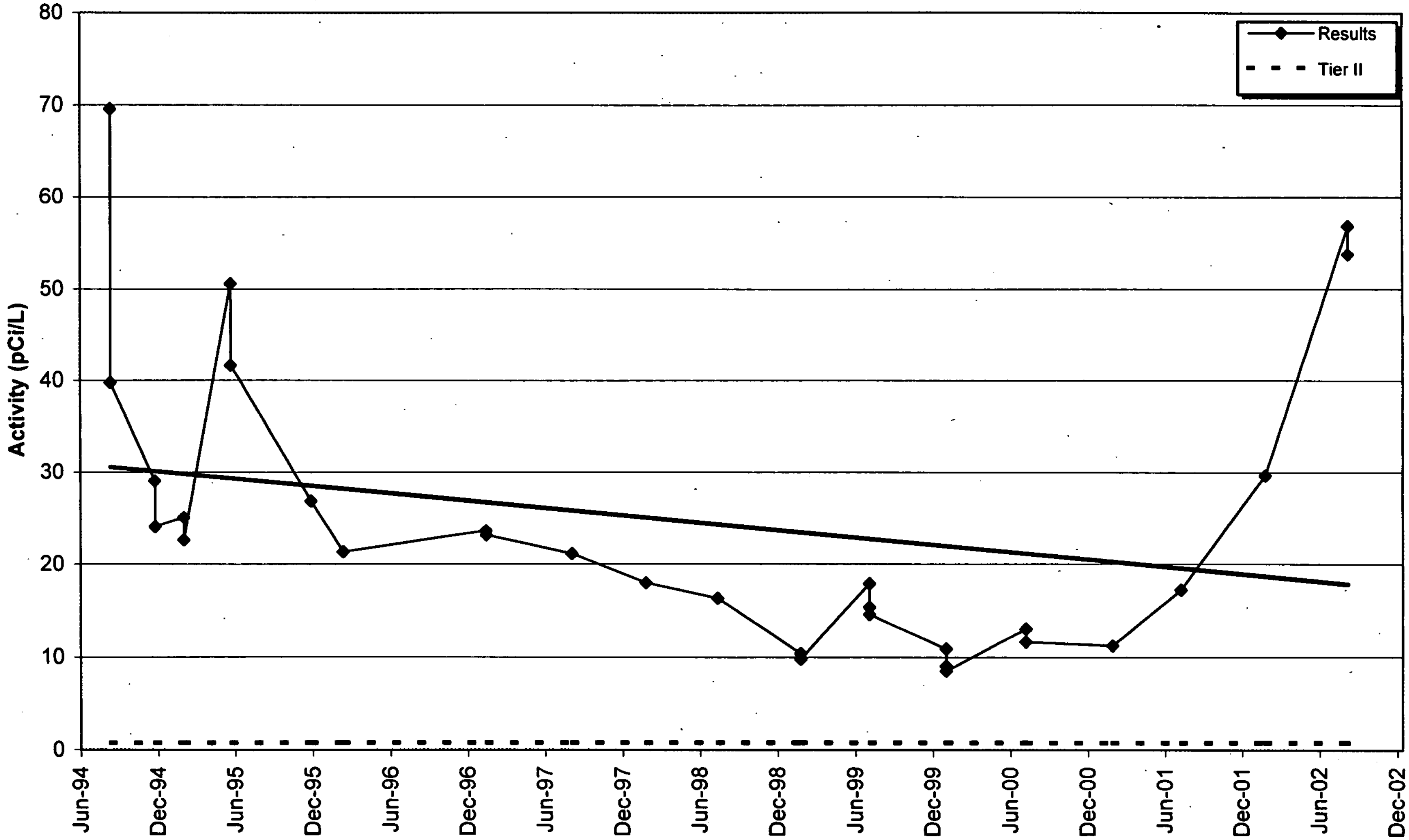
Figure 4-85
10294 Uranium-238



5.0 BUILDING D&D MONITORING THROUGH 2002

The D&D process is the sequence of events, implemented by DOE, which occurs in the disposition of surplus DOE facilities including decontamination and dismantling, removal, or entombment of the facilities.

Activities associated with these tasks involve the removal of fixed materials (including residual constituents of concern), equipment, piping, tanks, ducts, ceilings and other internal building structures, and the buildings. In general, implementation of D&D will be performed in phases, allowing alternative interim use of most buildings before the final decommissioning of the buildings (DOE, 1994b).

The IMP outlines the groundwater monitoring activities that have been established to determine whether building D&D activities impact surface water. The required groundwater monitoring will provide the data necessary to determine if the precautions and actions taken during D&D have prevented or allowed migration of contaminants to groundwater. If existing information (generally a knowledge of historical building activity and use) regarding a proposed D&D activity indicates the potential to contaminate groundwater, then a pre-D&D groundwater chemistry baseline (baseline) will be established for that building.

Based on the IMP, a minimum of four groundwater sample results (per analyte, pre-demolition) are required to enable determination of a unique baseline for each building that will undergo D&D groundwater monitoring. During the calculation of an individual analyte baseline, where a result is qualified with a U (non detect), the detection limit will be used in the calculation. Historically, two D&D groundwater monitoring rounds have been attempted per year at each building or building complex. The pre-D&D groundwater monitoring schedule for a specific building may become accelerated if it is determined that the D&D schedule for that building has become accelerated, or because the area encompassing a specific building is known to have thinly saturated or seasonally unsaturated conditions. Samples will continue to be collected twice a year, as the IMP dictates, until five years after building demolition. Additional samples collected before D&D shall be utilized in the calculations for analyte baselines. Baselines will be calculated when the aboveground portion of each building is demolished.

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Baselines will be established for all analytes at a given building based on sampling results from individual D&D wells at specific buildings. Baselines will be calculated for all downgradient D&D wells, and may be calculated for upgradient wells in areas where upgradient contaminant concentrations, with respect to flowpaths beneath a particular building, are a concern. The downgradient baseline before building demolition will be compared to the downgradient results after demolition to ascertain whether building D&D may have caused any change in the downgradient water quality. Sample results above a specific baseline will be defined as a detected concentration greater than the mean plus two standard deviations (M2SD) of the specific analyte (K-H, 1998b). Depending on the location and the availability of groundwater, some buildings currently have more sample results for analytes that require a smaller sample aliquot (for example VOCs or nitrate) than for analytes which require a much larger sample volume (for example U-isotopes or Pu/Am). At the time of submission of this 2002 Annual Report, only Building 886 has a calculated analyte baseline (see Appendix C).

Monitoring is being accomplished by the installation of D&D monitoring wells adjacent to the specific buildings. The D&D wells, in conjunction with appropriately located and constructed preexisting wells, provide the chemical data used to construct the baselines and will also be utilized for future D&D monitoring of the building specific impacts, if any, on downgradient groundwater quality. If the D&D schedule for a given building becomes accelerated, preexisting monitoring wells in the vicinity of the building may be utilized for determination of the baseline using sampling data from the previous three years. As long as time permits, baseline determination will be based on data from D&D specific monitoring wells. If D&D activities force abandonment of existing D&D monitoring wells (see discussion in Section 5.3, Building 771), replacement wells will be installed or selected from existing wells in the most appropriate locations available.

If a baseline cannot be established, water quality with respect to a given building will be evaluated in terms of an upgradient/downgradient comparison. Analytes will be screened in terms of concentrations relative to Tier I and Tier II groundwater action levels, which is an effective method for determining contaminants of concern. The Tier I and Tier II action levels are used only as a screening tool in this application and, with regard to building D&D, are not RFCA or compliance driven. Occasionally, an analyte is discussed or listed in a table even

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though it has been detected in concentrations that are below Tier II action levels. This is done on a case by case basis for analytes that are contaminants of interest for specific buildings.

Building demolition is described in terms of the fiscal year (FY) that the demolition is projected to take place. Buildings 123, 779, and 886 have previously been demolished.

Following is the current estimated schedule, based on a recent building D&D update, for demolition of buildings discussed in this section:

- Building 444 –early FY 2005;
- Building 771 Complex – mid FY 2004;
- Building 707 – early FY 2005;
- Building 776/777 – early FY 2005;
- Building 371/374 – early to mid FY 2005;
- Building 865 – late FY 2003 to early FY 2004;
- Building 883 – late FY 2004 to mid FY 2005;
- Building 881 – early FY 2004;
- Building 991 – early FY 2004 (vaults mid FY 2003); and
- Building 559 – mid FY 2005.

Many additional buildings will undergo D&D prior to Site closure. The preceding list includes buildings with possible environmental concerns, based on available historical information.

This section of the Annual RFCA Groundwater Monitoring Report has been expanded accordingly during previous years to incorporate the additional buildings where D&D groundwater monitoring activities are taking place. The subsections are organized by individual buildings as described in various Sampling and Analysis Plans (SAPs) for Building D&D Groundwater Monitoring. The subsections below discuss historical D&D activities through 2002 for Building 123 (Section 5.1), Building 444 (Section 5.2), Building 771 (Section 5.3), Building 886 (Section 5.4), Building 779 (Section 5.5), Building 707 (Section 5.6), Building 776/777

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(Section 5.7), Building 371/374 (Section 5.8), Building 865 (Section 5.9), Building 883 (Section 5.10), Building 881 (Section 5.11), Building 991 (Section 5.12), and Building 559 (Section 5.13).

Only a few of the current D&D wells contribute what might be considered "essential" Site knowledge uniquely suited for the purpose of guiding future decisions related to surface water protection. Those few wells are the ones lying along the exterior of the IA, downgradient of buildings and upgradient of drainages. Water Program staff will discuss discontinuation of all or a portion of this monitoring program with Agency staff and stakeholders at future IMP meetings.

5.1 Building 123

Building 123, used as a laboratory for bioassay, dosimetry, and air and water quality parameter analyses, was located on Central Avenue between Third and Fourth Streets at RFETS. The building underwent decommissioning activities and was ultimately demolished in 1998. Subsequent to the building demolition, six monitoring wells (10098-10598) were installed immediately adjacent to the concrete building foundation. During the spring of 2002, the concrete building foundation, original process waste lines (OPWLs), new process waste lines (NPWLs), sumps and pits were removed.

Wells 10098 and 10198 are upgradient of the Building 123 location. The rest of the wells are downgradient except 10598. Based on the current (Plates 2 and 3) and past potentiometric data, well 10598 is situated in a cross-gradient location; therefore, it is being removed it from the IMP as a D&D monitoring well. Figure 5-1 presents the location of Building 123 and associated D&D monitoring wells.

As described above, four sampling events are required to collect a data set to establish a unique baseline for each building that will undergo D&D groundwater monitoring. Unfortunately, the schedule for Building 123 D&D became accelerated, and it was not possible to install wells before demolition. In addition, there were not an appropriate number or distribution of existing monitoring wells in the vicinity of Building 123 to use for baseline determination utilizing historic sampling data. Through 2001, nine sampling rounds have been completed at the Building 123 D&D monitoring wells. One sampling round, post demolition, was completed at the

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Building 123 D&D monitoring wells during 1998. Two sampling rounds, one in each of the 1st and 3rd quarters, were completed during 1999, 2000, 2001, and 2002. Well 10598 has only eight rounds of samples as it was dry during the 3rd quarter of 2002.

Because a baseline cannot be established, water quality with respect to Building 123 has been evaluated in terms of an upgradient/downgradient comparison of water quality. Analytes at Building 123 have been screened in terms of concentrations relative to Tier I and Tier II groundwater action levels.

Linear groundwater flow velocities have been calculated for two well pairs at Building 123 utilizing 2nd quarter 2002 water level data. Each of these well pairs lies in the same groundwater flowpath. Flow velocity was calculated between well pairs 10198/10498 and 10098/10298. Hydraulic conductivity for the Qrf and effective porosity values were used as described in Section 3.2 of this RFCA Annual Report. A linear groundwater flow velocity of 1.045×10^{-4} cm/sec (108 ft/yr) was calculated between upgradient well 10198 and downgradient well 10498. A linear groundwater flow velocity of 1.421×10^{-4} cm/sec (147 ft/yr) was calculated between upgradient well 10098 and downgradient well 10298. This flow velocity would allow groundwater to travel from well 10198 to well 10498 in approximately 1.7 years, and from well 10098 to well 10298 in approximately 1.3 years. Actual contaminant travel times are longer for retarded contaminants, such as VOCs, U, and nitrate.

The contaminants of interest for Building 123 are VOCs, metals, U, Pu/Am, nitrate, cesium, and cyanide. Table 5-1 presents a summary of historical Building 123 D&D groundwater monitoring data. The only current concentration of nitrate greater than the Tier II action level is in downgradient well 10498. Current U-233/234 activity concentrations greater than the Tier II action level are found in upgradient well 10098 and downgradient well 10398. Current U-238 activity concentrations greater than the Tier II action level are found in downgradient well 10498. All of the downgradient wells and one upgradient well (10098) have at least one historic activity concentration greater than the Tier II action levels but below background M2SDs for U-isotopes. The only VOC that has been observed at a concentration greater than Tier II action levels at Building 123 is PCE in well 10498. The historic PCE concentrations have fluctuated greatly, with the highest concentrations, some greater than the Tier I action level, occurring in winter.

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During 2002 there were some metals concentrations (cadmium in downgradient well 10298) that approached Tier II action levels and concentrations of thallium in upgradient well 10198 and downgradient well 10498 that were greater than the Tier II action level. The results of the nine D&D groundwater sampling rounds completed at Building 123 to date indicate that Pu/Am, cesium, and cyanide have exhibited no results above Tier II action levels in any of the Building 123 wells.

There are no Building 123 upgradient PCE or nitrate concentrations which are greater than Tier II action levels. This is compared to downgradient PCE concentrations (well 10498) that are greater than Tier I action levels (seasonally, in the 1st quarter of 2000 and 2001) and downgradient nitrate concentrations (wells 10298 and 10498) greater than Tier II action levels. For U-233/234 and U-238, there were activity concentrations above Tier II but below background M2SDs in upgradient well 10098 that are similar to activity concentrations for these analytes in downgradient wells 10398 and 10498. Downgradient monitoring well 10298 has not shown elevated U-isotope concentrations (with respect to Tier II) since 3rd quarter 1998. Monitoring wells 10198 (upgradient) and 10598 (cross gradient) are unaffected to date by PCE, nitrate, and U-isotopes. Downgradient monitoring Well 10498 is the most impacted well to date at Building 123.

Table 5-1 Historical Building 123 D&D Groundwater Monitoring Data.

Well And Location	Date	PCE (µg/L)	Nitrate (mg/L)	U-233/234 (pCi/L)	U-238 (pCi/L)
10098 Upgradient	8/98	U	1.4	1.13	1.08
	2/99	U	4.9	INSW	INSW
	8/99	U	4.3	1.32	1.103
	2/00	U	3.4	1.19	.999
	8/00	0.1	2.9	1.21	.920
	1/01	U	0.84	1.31	.95
	7/01	U	2.8	1.26	1.06
	½	U	INSW	1.30	1.35
	7/02	U	2.2	1.49	0.547

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Well And Location	Date	PCE (µg/L)	Nitrate (mg/L)	U-233/234 (pCi/L)	U-238 (pCi/L)
10198 Upgradient	8/98	U	1.5	INSW	INSW
	2/99	U	.97	INSW	INSW
	8/99	U	2.4	0.251	0.233
	2/00	U	1.7	0.393	0.351
	8/00	U	0.75	0.229	0.227
	1/01-2/01	U	0.86	0.544	0.422
	7/01	U	0.98	0.239	0.285
	½	U	0.45	0.597	0.548
	7/02	U	0.55	0.589	0.378
10298 Downgradient	8/98	U	0.61	1.0	**1.10**
	2/99	U	0.84	INSW	INSW
	8/99	U	3	0.40	0.568
	2/00	U	1.8	0.682	0.763
	8/00	U	3	0.976	0.69
	1/01	U	7.5	0.645	0.671
	7/01	U	11	0.79	0.52
	1/02	U	5.8	0.783	0.435
	7/02	U	7	0.751	0.485
10398 Downgradient	8/98	U	INSW	INSW	INSW
	2/99	U	INSW	INSW	INSW
	8/99	0.1	INSW	**1.264**	**1.007**
	2/00	U	5.1	INSW	INSW
	8/00	U	4.1	INSW	INSW
	1/01	0.1	3.8	INSW	INSW
	7/01	U	3.5	**1.19**	0.508
	1/02	Lab*	INSW	0.756	0.733
	7/02	U	2.9	**1.26**	0.523
10498 Downgradient	8/98	**15**	**25**	**1.08**	**1.22**
	2/99	**58.9**	**17**	**2.02**	**1.51**
	8/99	**24**	6.8	0.964	0.522
	2/00	***1400***	6.9	**1.15**	**1.19**
	8/00-9/00	**15**	**10**	**1.14**	**1.10**
	1/01	***980***	7.2	**1.12**	**1.26**
	7/01	4.6	8.2	0.797	0.646
	1/02	Lab*	5.8	1.03	**0.921**
	7/02-9/02	**143**	**20**	0.86	**1.00**

Well And Location	Date	PCE (µg/L)	Nitrate (mg/L)	U-233/234 (pCi/L)	U-238 (pCi/L)
10598 Cross-gradient	8/98	U	3.7	U	0.236
	3/99	U	2.6	U	U
	8/99	U	0.37	U	U
	2/00	U	3.3	U	U
	8/00	U	1.5	U	U
	1/01	U	1.8	U	0.275
	7/01	U	0.097	0.237	U
	1/02	U	0.96	0.159	U

Notes: Concentrations greater than Tier II shown in Bold, Concentrations greater than Tier I shown in Italicized Bold, INSW = insufficient water available for sample collection, U = non detect, Lab* = VOC samples were inadvertently frozen by the analytical laboratory

A statistical comparison of upgradient versus downgradient wells has been undertaken for nitrate and U-233/234 analytes for which there are enough sample results to justify the comparison. Although there is nothing in the IMP that specifies the rationale for the upgradient versus downgradient comparison, there are at least four sample results available for the comparisons that utilize statistics. The upgradient versus downgradient comparisons involve two wells that lie in the same flowpath, as discussed above, as opposed to pooling all upgradient results versus all downgradient results. Pooling the upgradient data and comparing it to pooled downgradient data is not recommended in this case because the two Building 123 upgradient wells vary greatly in activities of U-isotopes. The well pairs discussed (10198/10498 and 10098/10298) are the same ones used above for the linear flow velocities. Well 10598 is not considered because of its cross gradient location; well 10398 is downgradient of Building 123, but, based on current potentiometric data, is not specifically in the flowpath of a Building 123 upgradient well.

Figures 5-2 and 5-3 show the upgradient versus downgradient comparison for well pair 10198/10498 for nitrate and U-233/234, respectively. The nitrate plot for this well pair (figure 5-2) shows that all sample concentrations (including the calculated mean) from downgradient well 10498 are significantly higher than the M2SD (mean plus 2 standard deviations) of upgradient well 10198. This indicates that there is a statistical difference in the data and that the downgradient well is impacted from a source potentially associated with the building. The same scenario is true for Figure 5-3, a comparison of well pair 10198/10498 for U-233/234. All the sampling results (including the mean) for U-233/234 from downgradient well 10498 are higher

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than the M2SD of upgradient well 10198; a statistically significant difference in the data exists and the downgradient well may be impacted by a source potentially associated with the building.

Figures 5-4 and 5-5 show the upgradient versus downgradient comparison for well pair 10098/10298 for the same two analytes. The nitrate plot for this well pair (Figure 5-4) shows that initially there was no significant difference in the data; however, since approximately the 3rd quarter of 2000, the nitrate concentration in downgradient well 10298 has exceeded the M2SD of the nitrate concentration of upgradient well 10098. Figure 5-5 compares U-233/234 data for well pair 10098/10298. This figure shows that the downgradient data are statistically less than the upgradient data, because none of the downgradient data is greater than the mean, much less the M2SD, of the upgradient data. This figure suggests that the U-233/234 activity at well 10098 may originate from an upgradient source.

In summary, there are no PCE or nitrate concentrations upgradient of Building 123 that are greater than Tier II action levels compared to downgradient PCE concentrations (well 10498) that are greater than Tier I action levels and downgradient nitrate concentrations (wells 10298 and 10498) greater than Tier II action levels. U-isotope data from the building is less clear. Downgradient monitoring well 10498 is the most impacted well to date at Building 123.

5.2 Building 444

Building 444 is located on the south side of Cottonwood Avenue between Fourth and Sixth Streets at RFETS. The Building 444 complex was used for the manufacturing of depleted U and beryllium components, and did not handle Pu or enriched U. Major processes conducted in the building included machining, welding, and cleaning. Building 444 also contained a foundry and a laboratory where parts could be etched, electroplated, and coated. Uranium and beryllium are the major constituents that were used in the building. In addition, solvents from machining and cleaning, and other wastes associated with electroplating were generated. Figure 5-6 presents the location of Building 444 and its D&D groundwater monitoring wells.

The Final Sampling and Analysis Plan for the D&D Groundwater Monitoring of Building 444 (RMRS, 1999) was submitted to the Agencies in July 1999. The D&D monitoring wells

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associated with the building were installed before the end of 1999. The Building 444 complex is currently scheduled for demolition in late FY 2005. This has allowed adequate time to collect enough samples for a groundwater quality baseline for these facilities. The baseline will not be calculated until the aboveground portion of the building is down.

Six new D&D monitoring wells were installed at Building 444 during the fall of 1999 (40099 through 40499, and 41299). Wells 40099 and 40199 are upgradient wells, and the rest, in addition to preexisting well P419689, are downgradient wells. Building 444 D&D monitoring wells installed during 1999 have been sampled generally seven times through CY 2002 (six rounds completed for VOCs). Preexisting Well P419689 had been sampled several times before the other Building 444 D&D wells were installed.

Based on the SAP referenced above, the contaminants of interest for Building 444 are VOCs, metals, U-isotopes, tritium, nitrate, and cyanide. Table 5-2 presents a summary of results of D&D groundwater monitoring at Building 444 to date. Earlier data from well P419689 are included for comparison to more recent D&D data.

Current analytical results (2002) indicate that there are no nitrate, tritium, cyanide, or beryllium results from any Building 444 monitoring well above the Tier II action levels. Downgradient wells 40399 and 40499 were the only wells that currently have no detections of VOCs above Tier II action levels. Upgradient well 40199 exhibited its first ever detection of a VOC above a Tier II action level (PCE at 16.4 μg/L) during the 3^{rd} quarter of 2002.

The results of all the D&D sampling completed through 2002 indicate that the analyte most commonly detected in all the Building 444 D&D wells is PCE. Four wells (40099, 40299, 41299, and P419689) exhibited PCE concentrations greater than the Tier II action level for all six sampling rounds completed to date. Well 40499 has also exhibited concentrations of PCE above the Tier II action level. The concentration of PCE in downgradient well 41299 is approximately an order of magnitude higher than the other wells listed. Wells 40399 (downgradient) had no detections of VOCs above Tier II action levels.

There have been no historical concentrations of nitrate, tritium, cyanide, or beryllium greater than Tier II action levels. There have been concentrations of thallium and chromium, especially in samples from downgradient well 41299, that have been above Tier II action levels. Monitoring well 40099, which is an upgradient well, has concentrations of TCE that are greater than the Tier I action level for all five VOC sampling rounds completed through CY 2001. The 3rd quarter 2002 TCE result for 40099 is just below the Tier I action level. This well also exhibits concentrations greater than the Tier II action level for 1,1-DCE; 1,2-DCE; and PCE for all six of the D&D sampling rounds completed to date.

Wells 40199, 41299, and P419689 have exhibited historic activity concentrations greater than Tier II action levels but below the Site M2SD of 60.7 pCi/L for U-233/234. In addition, U-238 was detected at concentrations greater than the Tier II action level during 4th quarter 1999, 2nd quarter 2000, and 3rd quarter 2001 in well 41299 and during 3rd quarter 2002 in well 40199.

An average linear groundwater flow velocity of 19 ft/yr has been calculated for Building 444 utilizing 2nd quarter 2002 water level data. Hydraulic conductivity for the Qrf and effective porosity values were used as described in Section 3.2 of this report.

Table 5-2 Historical Building 444 D&D Groundwater Monitoring Data.

Well and Location	Date	1,1-DCE (µg/L)	1,2-DCE (µg/L)	PCE (µg/L)	TCE (µg/L)	Metals > Tier II (µg/L)	U-233/234 (pCi/L)
40099 Upgradient	11/99	**240**	**780**	**28**	***830***	None	0.176
	5/00	**190**	**650**	**18**	***500***	None	0.322
	12/00	**538**	**1310**	**41**	***1340***	Tl 3.45	0.270
	2/01	**299**	**741**	**24.8**	***726***	None	0.268
	8/01	**190**	**520**	**15**	***530***	None	0.22
	1/02	Lab*	Lab*	Lab*	Lab*	None	0.408
	7/02	**160**	**510**	**28**	**490**	None	0.72
40199 Upgradient	11/99	U	U	0.9	0.1	None	**1.224**
	5/00	U	U	0.5	U	None	0.512
	12/00	U	U	0.74	U	Tl 4.64	**1.10**
	2/01	U	0.56	0.77	1.4	None	0.674
	8/01	U	U	1.2	U	None	**1.24**
	1/02	Lab*	Lab*	Lab*	Lab*	Tl 2.3	**1.13**
	7/02	U	U	**1.64**	U	None	**1.40**

Well and Location	Date	1,1-DCE (µg/L)	1,2-DCE (µg/L)	PCE (µg/L)	TCE (µg/L)	Metals > Tier II (µg/L)	U-233/234 (pCi/L)
40299 Downgradient	11/99	2	8	**34**	2	None	0.410
	5/00	4	11	**37**	**13**	None	0.553
	12/00	3.6	10.5	**77.5**	2.1	None	0.250
	2/01	3	10	**78**	2	None	0.283
	8/01	2	8.2	**56**	3	None	0.47
	1/02	Lab*	Lab*	Lab*	Lab*	None	0.537
	7/02	1.18	4.36	**62.7**	1.37	None	U
40399 Downgradient	11/99	U	0.5	0.5	0.2	None	0.165
	5/00	U	0.8	0.7	0.2	None	0.187
	12/00	U	0.92	0.69	1	None	0.20
	2/01	U	0.8	1	0.3	None	0.196
	8/01	U	0.7	U	1	None	U
	1/02	Lab*	Lab*	Lab*	Lab*	None	0.234
	7/02	U	U	U	U	None	0.316
40499 Downgradient	11/99	0.2	11	**13**	3	None	0.381
	5/00	0.1	4	**7**	2	None	0.236
	12/00	U	4.9	**8.3**	1.9	None	0.091
	2/01	0.2	5	**7**	1	None	0.317
	8/01	1	5	**6.6**	1.6	None	0.21
	1/02	Lab*	Lab*	Lab*	Lab*	Tl **2.2**	0.463
	7/02	U	1.04	3.91	0.81	None	U
41299 Downgradient	11/99	**16**	48	**290**	**33**	Cr **213**	**1.797**
	5/00	**9**	89	**280**	**77**	Cr **370** Tl **5.37**	**1.891**
	12/00	**10**	31.4	**216**	**27.2**	Cr **470**	**1.3**
	2/01	**9.1**	44.3	**330**	**38.2**	Cr **330**	**1.47**
	8/01	**11**	54	**260**	**54**	Cr **260**	**2**
	1/02	Lab*	Lab*	Lab*	Lab*	Cr **257**	**1.48**
	7/02	4.95	48.4	**338**	**53.1**	Cr **220**	1.04
P419689 Downgradient	3/96-4/96	1	5	**17**	2	None	**1.315**
	9/96	1	4	**12**	1	Tl **6.3**	NA
	12/96	NA	NA	NA	NA	Tl **7.2**	**1.174**
	11/99	1	7	**16**	2	None	0.733
	5/00	1	6	**17**	2	None	0.888
	12/00	1	7.1	**18.5**	2.3	None	0.420
	2/01	1.1	7	**18.8**	1.7	None	0.759
	8/01	0.7	4.3	**10**	1.2	None	0.97
	1/02	Lab*	Lab*	Lab*	Lab*	None	**1.29**
	7/02	U	6.68	**23.1**	1.81	None	0.856

Notes: Concentrations greater than Tier II shown in Bold, Concentrations greater than Tier I shown in Italicized Bold, U = non detect, (B) = Analyte detected in the Method Blank, NA = Not Analyzed, INSW = Insufficient water, Lab* = VOC samples were inadvertently frozen by the analytical laboratory

In summary, although upgradient Well 40099 contains TCE in concentrations which are greater than the Tier I action level, and relatively high levels of other VOCs, downgradient Well 41299 appears to be the most impacted D&D well at Building 444. In addition to VOCs, metals and

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U-isotopes have impacted well 41299. Downgradient well 40399 is the only well without an analyte concentration greater than a Tier II action level. Based on this analysis, nitrate, beryllium, cyanide, and tritium do not appear to be pre-D&D contaminants of interest in groundwater at Building 444.

5.3 Building 771

The Building 771 complex is located at the northeast end of Sixth Street, immediately south of the former PACS-3 entrance. Building 771 was the Pu component production facility at the Site from 1953 through 1957. After 1957 the building was used for the recovery of Pu and Am from manufacturing residues and scrap metal. The building also contained a laundry. Building 774 is part of the Building 771 complex and is located approximately 200 feet east of Building 771. Building 771C connects Buildings 771 and 774. Building 774 was used for the treatment of radioactive aqueous waste, waste oils, and non-radioactive photography solutions. Buildings 771C and 774 are to be decommissioned along with Building 771. Figure 5-7 presents the location of Building 771, including Buildings 771C and 774, and the D&D groundwater monitoring wells that monitor the complex.

The Final Sampling and Analysis Plan for the D&D Groundwater Monitoring of Building 771 (RMRS, 1999o) was submitted to the Agencies in July 1999. The D&D monitoring wells associated with the building were installed before the end of 1999. The Building 771 complex is currently scheduled for demolition in mid-FY 2004. Because of recent changes to the D&D groundwater monitoring network for Building 771 (see discussion below), there will be enough pre-D&D groundwater data to calculate baselines for the Building 771 complex.

The alluvial deposits are very thin or nonexistent in the vicinity of the Building 771 complex. The northern portion of the Building 771 foundation is situated in weathered bedrock. In addition, foundation drains encompass all of Building 771 and most of Building 774. These circumstances combine to allow very little groundwater for sample collection immediately adjacent to the buildings.

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Six D&D monitoring wells (40599 through 40899, 41499, and 41599) were installed at the Building 771 area during the fall of 1999. Monitoring well 40899 and preexisting well 18199 (associated with IHSS 118.1) were upgradient D&D wells. Wells 40599, 40699, 40799, 41499, 41599, and preexisting well P219089 were downgradient D&D wells.

In the 2001 Annual Report, D&D wells (primary wells) for Building 771 were recommended for substitution in the event that the primary well did not produce enough water for a full sample suite. It is rare to get enough water for more than a VOC sample from most of the primary D&D wells. CDPHE comments on the 2001 Annual Report accepted the use of the proposed alternate wells. Since that time, Building 771 D&D personnel have informed the Water Program that the demolition footprint of the building will encompass all of the primary D&D wells except upgradient well 18199.

The RFCA parties decided to discontinue use of and abandon the primary wells listed in Table 5-3 below. Table 5-3 lists the primary and alternate wells as presented in the 2001 Annual Report. Combining data from two wells (a primary and an alternate) should not be used to calculate a baseline; nor should the M2SD calculated from a D&D well be compared to the after building demolition results of an alternate well. Baselines will be calculated only from the alternate wells.

Table 5-3 Building 771 D&D Primary and Alternate Wells.

PRIMARY WELL	ALTERNATE WELL
40599	20798
40699	20498
40799	P219189
40899	P209289
41499	22796
41599	20298

An average linear groundwater flow velocity of 88 ft/yr has been calculated for Building 771 utilizing 2nd quarter 2002 water level data. Hydraulic conductivity for the Qc and effective porosity values were used as described in Section 3.2 of this report.

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In addition to the primary wells listed in Table 5-3, well P219089 is a current downgradient D&D well that has more than enough analytical results for a full analyte baseline. Unfortunately, this well is also within the demolition footprint of the building, and it would not be prudent to calculate baselines for this well if it is not going to survive D&D. A review of Figure 5-3 from the 2001 Annual Report shows that wells 41599 and P219089 lie in the same flow line and, therefore, well 20298 can also be utilized as a replacement for P219089.

Well 20998 (replaced during 2002 by well 20902) has previously been identified as an upgradient D&D well for Building 771. A review of previous and current Annual Report potentiometric maps has revealed that this well is actually cross-gradient to Building 771 and, therefore, it will no longer be utilized as a D&D well for this building.

Most of the alternate wells listed above already have the minimum number of analyses required for baseline calculation. Samples will continue to be collected twice a year, as the IMP dictates, until five years after building demolition. Additional samples collected before D&D shall be utilized in the calculations for analyte baselines. Baselines will be calculated when the aboveground portion of the specific building is down.

Based on the SAP referenced above, the analytes of interest for the Building 771 complex are VOCs, metals, U-isotopes, Pu/Am, tritium, nitrate, neptunium, and PCBs. The following discussion is related to both the primary and the alternate wells because the changes to the Building 771 monitoring program are taking place during the preparation of this Annual Report. Table 5-4 presents a summary of Building 771 primary D&D well monitoring results to date. Table 5-5 presents a summary of Building 771 alternate D&D well monitoring results to date. Analytes are discussed in terms of concentrations relative to Tier I and Tier II groundwater action levels.

Eleven sets of VOC samples have been collected from preexisting upgradient monitoring well 18199 since spring 1999. This well has yielded CT concentrations greater than the Tier I action level and CF concentrations greater than the Tier II action level for each of the 11 sampling events. The source for this contamination is IHSS 118.1, which is located approximately 60 feet upgradient of well 18199. In addition, concentrations greater than the Tier II action level were

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observed for PCE in all but one of the samples; the exception was a non-detect in March 2000. Until 2002, neither CT, CF, nor PCE had been reported in concentrations greater than the Tier II action level in primary downgradient wells at Building 771. A first time concentration greater than Tier II was observed for CT in well 40599 in October 2002. This well, like others in proximity to the building, consistently contains very little groundwater. It can be assumed that the extensive foundation drain systems for Buildings 771 and 774 are intercepting a large amount of upgradient groundwater and may be intercepting a significant amount of VOC contamination and directing it to the drain outfalls. Other analytes detected above Tier II action levels at well 18199 are listed in Table 5-4.

Concentrations greater than Tier II action levels in the primary Building 771 D&D wells are listed in the far right column of Table 5-4. Notable concentrations greater than Tier II action levels are TCE in all six samples collected to date from downgradient well 41499; 1,1-DCE in three of the four samples collected from downgradient well 40699; and U-233/234 and U-238 in all seven samples collected to date from downgradient well P219089. These U results are below the U-233/234 and U-238 Site M2SDs of 60.7 pCi/L and 41.8 pCi/L, respectively. There was also a tritium detection of 437 pCi/L (below Tier II) at well 40799 in May 2000. All VOC results for wells 40799 (5 sets of data), 40899 (1 set of data), 41599 (2 sets of data), and P219089 are below Tier II action levels.

Numerous sets of samples have been collected from the alternate Building 771 wells. The six most recent sets of results from each well are summarized in Table 5-5 below. No downgradient alternate wells exhibit any results above the Tier II action level for CT. U-isotopes are found in relatively high concentrations (above Site M2SDs for U-233/234, U-235, and U-238 in May of 2000) in downgradient well P219189. No other alternate (or primary) well has any U-235 values above Tier II action levels.

In addition, U-233/234 and U-238 are also above the Tier II action levels in downgradient wells 20498 and 22796. Downgradient wells P219189 and 20498 have values above action levels for 1,1-DCE for all sample rounds listed in Table 5-5. Downgradient well 22796 has values above the Tier II action level for TCE for each sample round listed in Table 5-5. Downgradient well 20298 has tritium values above the Tier II action level in May 2001 and May 2002. There are no

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values above Tier II for nitrate, Pu/Am, neptunium, or PCBs from any of the alternate wells. The alternate wells will be referred to as the D&D wells in the 2003 Annual Report.

Table 5-4 Historical Building 771 D&D Primary Well Data.

Well and Location	Date	CT (µg/L)	PCE (µg/L)	Chloroform (µg/L)	Other Constituents > Tier II S	
					Constituent	Concentration or Activity (µg/L, mg/L, or pCi/L)
18199 Upgradient	3/99	*15400*	37.6	2200B	Hexachloroethane	12.6
	9/99	*14000*	39	2400	Hexachloroethane	17
	12/99	*25300*	60.4	3790	VC	120
	3/00	*39000*	U	5200	INSW	INSW
	5/00	*17000*	91	3900	INSW	INSW
	12/00	*27300*	63.7	4110	Tl	8.23
	5/01	*18000*	65	3300	TCE 1,1,2-TCA	6 63
	10/01	*19000*	44	3300	Tl	2.3
	2/02	*29000*	58	4700	INSW	INSW
	4/02	*27000*	62	4300	Hexachloroethane	15
	11/02	*31100*	57.2	4360	Methylene Chloride	13.8
40899 Upgradient	Pre-2001	All Dry	All Dry	All Dry	All Dry	All Dry
	4/01	0.8	U	U	INSW	INSW
	2002	All Dry	All Dry	All Dry	All Dry	All Dry
40599 Downgradient	11/00	4	4	6.8	INSW	INSW
	4/01	2	2	7	Nitrate	26
	7/01	4.5	1.9	6.3	INSW	INSW
	10/02	5.62	1.62	9.47	INSW	INSW
40699 Downgradient	11/00	U	2	2	1,1-DCE	389
	4/01	Dry	Dry	Dry	Dry	Dry
	7/01	U	U	1.7	1,1-DCE	200
	10/02	U	U	1.35	1,1-DCE	204
40799 Downgradient	5/00	U	0.1	0.1	INSW	INSW
	11/00	U	U	U	INSW	INSW
	4/01	U	U	U	INSW	INSW
	7/01	U	U	U	U-233/234	23.6
	1/02	U	U	U	U-235 U-238	1.12 15.3
41499 Downgradient	5/00	U	U	U	TCE	53
	11/00	U	4.5	0.42	TCE	74.4
	4/01	U	2	0.4	Nitrate TCE	19 62
	7/01	U	0.16	0.46	TCE 1,1-DCE	130 9.9
	5/02	U	U	U	TCE	96.4
	10/02	U	U	0.55	TCE	191
41599 Downgradient	11/00	U	2.4	U	INSW	INSW
	4/01	Dry	Dry	Dry	Dry	Dry
	7/01	0.29	0.77	0.34	INSW	INSW
	2002	Dry	Dry	Dry	Dry	Dry

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Well and Location	Date	CT (µg/L)	PCE (µg/L)	Chloroform (µg/L)	Other Constituents > Tier II	
					Constituent	Concentration or Activity (µg/L, mg/L, or pCi/L)
P219089 Downgradient	11/00	U	0.53	U	U-233/234 U-238	**9.10** **6.40**
	4/01	U	U	U	U-233/234 U-238	**9.6** **7.3**
	7/01	U	U	U	U-233/234 U-238 Thallium	**5.43** **4.21** **2.7**
	10/01	U	U	U	U-233,234 U-238	**6.12** **3.32**
	2/02	U	U	U	U-233/234 U-238	**7.76** **6.51**
	5/02	U	U	U	U-233/234 U-238	**9.45** **8.02**
	10/02	U	U	U	U-233/234 U-238 Thallium	**6.75** **4.2** **2.6**

Notes: Concentrations greater than Tier II shown in Bold, Concentrations greater than Tier I shown in Italicized Bold, U = non detect, (B) = Analyte detected in the Method Blank, CT = carbon tetrachloride, INSW = insufficient water available for all analyses.

In summary, the 1,1-DCE occurrences observed in wells 40699 (primary) and 20498 (alternate) and TCE occurrences observed in wells 41499 (primary) and 22796 (alternate) bode well for the primary/alternate well pairings. Based on historic sample data from both the primary and alternate Building 771 wells, nitrate, Pu/Am, neptunium, and PCBs do not appear to be pre-D&D contaminants of interest in groundwater. Baselines will be calculated from the alternate wells after the Building 771 complex is demolished.

Table 5-5 Historical Building 771 Alternate Well Data.

Well and Location	Date	CT (µg/L)	PCE (µg/L)	Chloroform (µg/L)	Other Constituents > Tier II	
					Constituent	Concentration or Activity (µg/L, mg/L, or pCi/L)
P209289 Upgradient	4/98	**49**	0.5	53		
	5/99	**58**	0.6	37	U-233/234 U-238	**1.18** **0.93**
	10/99	**10**	0.2	20		
	11/00	**11.2**	1	13.6	U-233/234 U-238 Tl VC	**1.5** **0.82** **4.36** **9.6**
	4/01	2	0.2	5		
	5/02	2.03	U	2.98		

Well and Location	Date	CT (µg/L)	PCE (µg/L)	Chloroform (µg/L)	Other Constituents > Tier II: Constituent	Other Constituents > Tier II: Concentration or Activity (µg/L, mg/L, or pCi/L)
20298 Downgradient	9/98	U	U	U		
	4/99	0.5	U	U		
	5/01	U	U	U		
	11/01	U	U	U		
	5/02	U	U	U		
	10/02	U	U	U	TCE	**8.5**
P219189 Downgradient	5/00	U	U	1	U-233/234 U-238 U-235 1,1-DCE	**63** **44.9** **1.93** **23**
	11/00	U	U	1.3	1,1-DCE	**33.2**
	5/01	U	0.1	1	U-233/234 U-238 U-235 1,1-DCE	**57** **40** **1.5** **39**
	10/01	U	U	1	U-233/234 U-238 U-235 1,1-DCE	**52.8** **37.9** **1.62** **21**
	4/02	U	U	1.01	1,1-DCE	**31.2**
	12/02	U	U	0.72	1,1-DCE	**14**
20498 Downgradient	9/98	U	0.3	0.2	1,1-DCE	**110**
	4/99	U	0.1	0.1	1,1-DCE	**170**
	11/01	U	U	U	U-233/234 U-238 Tl 1,1-DCE	**2.67** **2.54** **2.8** **67**
	2/02	U	U	U	U-233/234 U-238 1,1-DCE	**3.01** **2.11** **35**
	5/02	U	U	U	U-233/234 U-238 1,1-DCE	**3.28** **2.38** **27.7**
	10/02	NS	NS	NS	U-233/234 U-238 Tl	**3.91** **2.13** **3.2**
20798 Downgradient	9/98	U	U	U		
	4/99	U	U	U		
	11/01	U	U	U		
	2/02	U	U	U	Tl	**2.3**
	5/02	U	U	U		
	10/02	NS	NS	NS	Tl	**4.0**

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Well and Location	Date	CT (µg/L)	PCE (µg/L)	Chloroform (µg/L)	Other Constituents > Tier II	
					Constituent	Concentration or Activity (µg/L, mg/L, or pCi/L)
22796 Downgradient	12/00	U	U	1.2	U-233/234 U-238 TCE Tl	**1.8** **1.1** **16.9** **7.37**
	5/01	0.8	0.4	7	U-233/234 U-238 TCE	**2.4** **2.0** **57**
	10/01	U	**22**	1.2	U-233/234 U-238 TCE Tl	**2.95** **2.22** **23** **4.3**
	2/02	U	U	0.69	U-233/234 U-238 TCE	**2.53** **1.61** **13**
	5/02	U	U	U	U-233/234 U-238 TCE	**2.07** **1.57** **12**
	10/02	U	U	U	U-233/234 U-238 TCE Tl	**3.15** **2.25** **9.1** **3.8**

Notes: Concentrations greater than Tier II shown in Bold, Concentrations greater than Tier I shown in Italicized Bold, U = non detect, (B) = Analyte detected in the Method Blank, CT = carbon tetrachloride, INSW = insufficient water available for all analyses, NS = not sampled, VC = vinyl chloride

5.3.1 Bowman's Pond Groundwater Characterization

The Bowman's Pond evaluation project was conducted in 1999 to evaluate the sediments in the pond for possible remediation (see the 1999 RFCA Annual Groundwater Monitoring Report). Surface water samples collected during the investigation from Bowman's Pond showed concentrations of CT that ranged from 5-21 µg/L.

There are six outfall locations from Building 771/774 foundation drains (771 FD OUT #2, FD-774-1, FD-774-2, FD-774-4, FD-774-5, and FD-774-6). Efforts to determine the location and extent of the footing drains for Building 771/774 have only provided partial information on where they discharge or exactly where the samples have been collected. A literature review and walkdown of the Bowman's Pond area has determined that there are four outfalls in this area

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(Figure 5-7). Three of these outfalls are probably tied to Building 774 footing drains. The fourth outfall, which is the farthest west of the four, may receive contributions from Building 771 footing drains.

Location 771 FD OUT #2, is a footing drain outfall located west of Building 771 (Figure 5-7) that produces small amounts of water with elevated levels of CT (310 µg/L and 126 µg/L in May 2001 and 2002, respectively). Grab samples (for the Building 771 analyte of interest suite) were collected from each of the footing drain outfalls, with the exception of FD-774-2 and FD-774-6, in May 2001, November 2001, and May 2002. In addition, FD-774-1 had a sample collected in November 2002. The results of these samples showed CT, U-233/234, and U-238 in FD-774-1 at concentrations/activities above the respective Tier II action levels for all four sampling rounds. Location FD-774-4 had activities of U-233/234 and U-238 (May and November 2001 only) greater than Tier II action levels. Location FD-774-5, which did not provide a November 2001 sample, had May 2001 nitrate, U-233/234, and U-238 results and May 2002 U-233/234 and U-238 results greater than the Tier II action levels.

To date, 771 FD OUT #2 is the only outfall that has been included in the IMP as a D&D monitoring location for the Building 771 complex.

5.4 Building 886

Building 886 is located on the south side of Central Avenue at RFETS, approximately 300 feet southeast of the former PACS-1 entrance to the former PA. The building was first occupied in 1965, and it housed the Critical Mass Laboratory that was used to conduct criticality experiments for nuclear safety research and development. Based on research of historical practices at the building, Pu, U, and nitrate are considered to be the analytes of interest. Figure 5-8 presents the location of Building 886 and the D&D groundwater monitoring wells associated with it.

The Final Sampling and Analysis Plan for the D&D Groundwater Monitoring of Building 886 (RMRS, 1999o) was submitted to the Agencies in July 1999. Three monitoring wells were installed during fall 1999 (40999, 41099, and 41199) and are utilized along with an existing well

(22996) for D&D monitoring. Well 40999 is utilized as an upgradient D&D well; wells 41099, 41199, and 22996 are utilized as downgradient D&D wells. Building 886 has undergone D&D activities and the aboveground portion of the building was demolished in the spring of 2002. Monitoring well 41199 was destroyed during these activities. This well was replaced during August 2002; the new well is designated 41102.

The D&D sampling suite for Building 886 includes VOCs, metals, U-isotopes, Pu/Am, and nitrate. Table 5-6 presents a summary of Building 886 D&D groundwater monitoring data collected through CY 2002. Early data from well 22996, collected before commencement of D&D sampling at Building 886, is presented in Table 5-6 for comparison to the more recent D&D data. There has been adequate time and groundwater available to collect enough samples to construct a groundwater baseline for most of the analytes at this building with the exception of Pu. Because the building was demolished in early 2002, only analytical data collected through CY 2001 was used to calculate the baseline. A preliminary baseline was established for Building 886 in the 2001 Annual Report (Table 5-4a) before the Water Program decided to construct a baseline for all analytes at all downgradient wells. An expanded baseline, which contains all analytes in all downgradient wells for which enough results are available, is found in Appendix C.

The results of the D&D sampling rounds completed at Building 886 through CY 2002 indicate that there have been no concentrations of any analytes greater than Tier I action levels. Activities greater than Tier II action levels were observed for U-233/234 and U-238 for all four Building 886 D&D monitoring wells for every sampling round to date that has produced enough water for a U-isotope sample. All of the U-isotope results are below the U-233/234 and U-238 site background values (M2SDs) of 60.7 pCi/L and 41.8 pCi/L, respectively, although the concentrations in 41099 approach the M2SD values.

In addition, U-235 activities greater than the Tier II action levels were reported in samples collected from downgradient well 41099 in 1999 and 2000. The U-235 activity concentration at well 41099 in November 1999 is above the site background M2SD value of 1.79 pCi/L. Pu/Am results for the Building 886 D&D wells have generally been non detect; any detections have been below Tier II action levels.

Table 5-6 Historical Building 886 D&D Groundwater Monitoring Data.

Well and Location	Date	U-233/234 (pCi/L)	U-238 (pCi/L)	Metals (µg/L)	Nitrate (mg/L)	Other Constituents (µg/L or pCi/L)
40999 Upgradient	11/99	**8.883**	**6.807**	Cd 4.1	U	VOCs U or <Tier II
	6/00	**10.70**	**7.83**	INSW	0.54	VOCs U or <Tier II
	11/00	**10.0**	**8.30**	INSW	INSW	VOCs U or <Tier II
	3/01	**9.7**	**7.8**	Cd 3.3	0.26	VOCs all <2
	7/01	**9.0**	**6.6**	Cd 0.3	0.47	VOCs all <2
	12/01	NS	NS	NS	NS	VOCs all U
	2/02	**9.93**	**8.83**	INSW	INSW	NS
	5/02	**8.46**	**7.7**	INSW	INSW	All U or <0.85
	8/02	**7.42**	**6.62**	Tl **5**	0.67	All U
	10/02	**7.79**	**6.55**	All < Tier II	INSW	All U
41099 Downgradient	11/99	**51.65**	**33.77**	Cd 2.3	**47**	U-235 **2.316**
	6/00	**45.50**	**27.10**	Cd **5.4**	**47**	U-235 **1.41**
	11/00	**42.0**	**27.0**	Tl **4.89**	**36**	U-235 **1.40** VOCs U or <Tier II
	3/01	**27.4**	**17.7**	Cd 4.6	**30**	U-235 0.977
	7/01	**21.5**	**13.5**	Cd 2.3	**22**	U-235 0.783
	8/02	INSW	INSW	INSW	INSW	VOCs all U
41199/41102 Downgradient	11/99	**10.74**	**3.997**	Cd 1.6	1.5	VOCs U or <Tier II
	6/00	**8.39**	**4.33** **3.70**	Cd 0.68	5.6	VOCs U or <Tier II
	11/00	**8.60**	**3.34**	Cd 0.61	INSW	VOCs U or <Tier II
	3/01	**9.03**	**3.20**	Tl 0.75	1.2	VOCs all <2
	7/01	**9.20**	INSW	Cd 0.71	0.79	VOCs all <2
	1/02	**9.91**	**3.9**	All < Tier II	3.2	NS
22996 Downgradient	8/96	**2.335**	**2.13**	Cd 4.6	1.9	VOCs U or <Tier II
	11/96	**2.325**	**1.836**	Tl **7.8**	0.65	VOCs U or <Tier II
	3/98	**3.01**	**2.68**	NA	NA	VOCs U or <Tier II
	8/98	**2.86**	**2.40**	NA	NA	VOCs U or <Tier II
	2/99	**3.573**	**3.011**	Cd 0.17	NA	VOCs U or <Tier II
	8/99	**3.38**	**2.48**	Cd 0.18	NA	VOCs U or <Tier II
	11/99	**3.58**	**2.399**		3.3	VOCs U or <Tier II
	2/00	**3.598**	**2.509**		INSW	VOCs U or <Tier II
	6/00	**4.62**	**3.02**	Cd 0.1	4.2	VOCs U or <Tier II
	12/00	**2.30**	**1.60**		0.9	VOCs U or <Tier II
	3/01	**2.42**	**1.87**		2.4	VOCs all <2
	8/01	**1.64**	**1.02**		0.77	VOCs all <2
	9/02	**1.45**	**0.834**	Tl **4.3**	0.66	VOCs all U

Notes: Concentrations greater than Tier II shown in Bold, Concentrations greater than Tier I shown in Italicized Bold, U = non detect, (B) = Analyte detected in the Method Blank, NA = not analyzed, INSW = Insufficient water available for sample collection, NS = not sampled

Samples from downgradient well 41099 contained nitrate concentrations greater than the Tier II action level for every D&D sampling round completed to date. No other Building 886 D&D well has nitrate concentrations that approach the Tier II action level. There have been no VOC detections above Tier II action levels at any Building 886 D&D wells, and most of the VOC results have been non-detect. Metals results indicate that downgradient well 41099 has been impacted by cadmium and thallium in concentrations greater than the Tier II action levels; downgradient well 22996 has been impacted by thallium in concentrations greater than the Tier II action levels. Upgradient well 40999 showed a first time thallium result greater than Tier II (5 µg/L) during the 3rd quarter 2002. Fourth quarter metals results at well 40999 were all below Tier II.

An average linear groundwater flow velocity of 45 ft/yr has been calculated for Building 886 utilizing 2nd quarter 2002 water level data. Hydraulic conductivity for the Qrf and effective porosity values were used as described in Section 3.2 of this report.

Baselines (Appendix C) were calculated for every analyte at every downgradient well that had the required minimum of four results. The M2SDs will be used to compare to post-D&D Building 886 groundwater monitoring results. Should a post-D&D monitoring result for a specific analyte at a given downgradient well exceed the calculated M2SD, the appropriate parties will be notified, an attempt will be made to identify the source, and monitoring will continue as specified in the IMP.

In summary, the most impacted well at the Building 886 site is downgradient well 41099. This well has the highest U-isotope activities, and is the only Building 886 D&D well with nitrate and cadmium concentrations above their Tier II action levels. The elevated nitrate values observed in downgradient well 41099 may be a result of historical practices in the building as there does not appear to be an upgradient source of this nitrate.

5.5 Building 779

Building 779, placed into service in 1969, housed minor production and Pu recovery operations but was primarily a research and development facility. Some metal parts were assembled in this building and bulk Pu residues were recovered (DOE, 1992a). The remainder of the operations conducted in Building 779 were research and development activities which included the following operations: pyrochemical technology, coatings, Pu and non-Pu physical metallurgy, chemical technology in support of Pu recovery operations in Building 771, and product physical

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chemistry (DOE, 1992a). The building, located in the former Protected Area (PA) approximately 200 feet south of the westernmost SEP, was demolished in 1999. Figure 5-9 presents the building location and the associated D&D monitoring wells.

Three D&D monitoring wells (02297, 02397, and 02497) were installed in 1997. Well 02397 is used for upgradient D&D monitoring; wells 02297 and 02497 were for downgradient D&D monitoring. However, during building D&D activities in late 1999, monitoring well 02297 was destroyed; it was replaced in 2000 with downgradient monitoring well 02500. Monitoring well 02500 is similar in well construction to well 02297 and, therefore, D&D monitoring data from that location includes data previously collected from well 02297. In addition, at the request of CDPHE, another new D&D well, 00100, was added to the program during 2000. This well, located near the northeast corner of Building 779, is a relatively deep well (approximately 32 feet below ground surface [bgs]) positioned to monitor groundwater quality downgradient of the Building 779 basement and sub-basement. The sub-basement is shown on Figure 5-9 as four small rectangular areas within the basement area.

The alluvial deposits are very thinly saturated in the vicinity of Building 779. In addition, a foundation drain dewaters the northwest corner and north side of the former building. These circumstances combine at drier times of the year to allow only minimal amounts of groundwater to be available for sample collection. No sampling rounds were completed during 1997 at the Building 779 D&D monitoring wells because of lack of water. Upgradient well 02397 produced no samples during 1999 and only one set of samples during each of 2000, 2001, and 2002. Downgradient wells 02297/02500 and 02497 have fared better. Through CY 2002, downgradient well 00100 had five complete sample sets (except for metals in 10/02).

A minimum of four sampling events are required to collect a data set to be used for determination of a unique chemical baseline for each building that will undergo D&D. Unfortunately, in addition to the construction of replacement D&D well 02500 and additional D&D well 00100, the schedule for Building 779 D&D became accelerated, and it was not possible to collect the required amount of pre-D&D data to derive baseline values for the analytes of interest. This situation was compounded by the fact that there was not an appropriate number or distribution of preexisting monitoring wells in the vicinity of Building 779 that could be utilized for D&D

monitoring. Because a baseline cannot be established, water quality with respect to Building 779 will be evaluated in terms of an upgradient/downgradient comparison. Analytes at Building 779 have been screened in terms of concentrations relative to Tier I and Tier II groundwater action levels.

The D&D analytical suite for Building 779 consists of VOCs, metals, U-isotopes, Pu/Am, and nitrate. Table 5-7 presents summary results of all D&D groundwater sampling at Building 779 to date. These data indicate that there were no contaminant concentrations from any Building 779 D&D monitoring well greater than Tier I action levels. All four Building 779 D&D wells have at least one analyte concentration greater than a Tier II action level. Until 2001, upgradient well 02397 had the only nitrate concentrations which were greater than Tier II action levels and downgradient well 00100 was the only well that exhibited VOC concentrations (TCE and CT) greater than Tier II action levels. During 2001, well 02297/02500 exhibited first time TCE and nitrate concentrations greater than Tier II action levels. Downgradient monitoring well 02297/02500 has produced samples with concentrations of U-233/234 and U-238 that are greater than the Tier II action levels for all sampling rounds in which there was enough groundwater available for a U-isotope sample. Until 2002, upgradient well 02397 had not had any U-isotope results above Tier II. All the U-isotope results were below Site background M2SD values. There have only been two historic Am results above Tier II; well 02497 (0.233 pCi/L) in May 1999 and well 00100 (0.321 pCi/L) in April 2002. There have only been two historic Pu results above Tier II; well 00100 in December 2000 (0.68 pCi/L) and April 2002 (2.21 pCi/L). Each of the three downgradient wells has had at least one thallium result greater than the Tier II action level.

A linear groundwater flow velocity of 73.0 ft/yr (7.06 x 10^{-5} cm/sec) was calculated between upgradient well 02397 and downgradient well 02500 utilizing 4th quarter 2002 water level data. Hydraulic conductivity for the Qrf and effective porosity values were used as described in Section 3.2 of this Annual Report. This flow velocity would allow groundwater to travel from well 02397 to well 02500 in approximately 5.1 years. Actual contaminant travel times would be longer for retarded contaminants. The groundwater travel time from the sub-basement to well 00100, a distance of approximately 210 feet, would be about 2.9 years.

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An upgradient versus downgradient statistical analysis has been performed between wells 02397 and 02297/02500 for TCE and nitrate. This analysis should also include U-233/234, but there are not enough upgradient results from well 02397 for this analyte. This analysis is similar to the one performed for Building 123 (Section 5.1 of this report). Figures 5-10 and 5-11 depict the results of this analysis. Figure 5-11 suggests that although the mean nitrate concentration in upgradient well 02397 is higher than the mean nitrate concentration in downgradient well 02500, that there is no probably statistical difference between the concentration of nitrate in wells 02397 and 02500. The same cannot be said for the TCE concentrations in the two wells (Figure 5-10). The mean TCE concentration in downgradient well 02500 is almost seven times greater than the M2SD for TCE in upgradient well 02397, which suggests that there may be a statistical difference in the two concentrations.

In summary, nitrate concentrations upgradient of Building 779 and observed in well 02397 are greater than Tier II action levels and are similar to the 2001 nitrate concentrations observed in downgradient D&D well 02500. There are no Building 779 upgradient VOC, metals, Pu/Am, or U-isotope (except 5/02, U-233/234) concentrations to date that approach the concentrations of these analytes observed in downgradient D&D wells.

Table 5-7 Historical Building 779 D&D Groundwater Monitoring Data.

Well and Location	Date	CT (µg/L)	TCE (µg/L)	Nitrate (mg/L)	U-233/234 (pCi/L)	U-238 (pCi/L)	Other Constituents (µg/L or pCi/L)
02397 Upgradient	3/98	U	U	INSW	0.582	0.69	
	11/98	U	1.0	**12**	INSW	INSW	
	5/00	U	U	**19**	INSW	INSW	INSW
	4/01	U	0.1	**11**	0.61	0.29	INSW
	5/02	U	U	**10.7**	**1.07**	0.471	Metals INSW
02497 Downgradient	3/98	U	1.0	5.9	INSW	INSW	INSW
	6/98	U	0.6	6.2	INSW	INSW	INSW
	11/98	U	3	INSW	INSW	INSW	INSW
	5/99	0.5	2	INSW	**2.599**	**1.076**	Am **0.233**
	11/99	0.3	2	8.7	**1.842**	**0.918**	
	5/00	0.4	4	4.7	**1.42**	**0.808**	
	11/00	U	2.4	INSW	INSW	INSW	Cd **15.1** Tl **5.33**
	5/01	0.2	3	7.5	1.05	0.421	
	10/01	U	2.2	3.3	INSW	INSW	INSW
	10/02	U	2.8	5.1	INSW	INSW	Metals INSW

Well and Location	Date	CT (µg/L)	TCE (µg/L)	Nitrate (mg/L)	U-233/234 (pCi/L)	U-238 (pCi/L)	Other Constituents (µg/L or pCi/L)
00100 Downgradient	12/00	**14.8**	**61.8**	3.1	**1.10**	0.61	Pu **0.68**
	5/01	**5**	**38**	4.2	**3.11**	**0.972**	
	11/01	**5.7**	**55**	3.6	**2.3**	**1.08**	Tl **2.9**
	4/02	4.41	**41.7**	2.59	**1.42**	0.459	Pu **2.21** Am **0.321**
	10/02	**6.99**	**52.7**	4.7	**1.07**	0.54	Metals INSW
02297/ 02500 Downgradient	6/98	U	2	INSW	INSW	INSW	INSW
	5/99	0.8	2	8.2	**8.169**	**4.103**	INSW
	11/00	U	1.5	7.4	**4.20**	**2.10**	
	6/01	0.2	**18**	**11**	**6.01**	**3.02**	
	10/01	U	**19**	**15.7**	**6.27**	**3.26**	Tl **7.4**
	4/02	U	**15.3**	8.65	**7.18**	**3.08**	
	8/02	U	**9.79**	5.5	**5.94**	**3.25**	
	12/02	NS	NS	4	**7.38**	**3.53**	Tl **4.8**

Notes: Concentrations greater than Tier II shown in Bold, Concentrations greater than Tier I shown in Italicized Bold, U = non detect, (B) = Analyte detected in the Method Blank, NS = not sampled, INSW = Insufficient water available for sample collection, CT = carbon tetrachloride

5.5.1 SW085 Sampling

SW085 is the surface water sampling station that is located at the outfall of the Building 779 foundation drain. This outfall was sampled in May and August of 2001 and March and June of 2002. In addition, a Pu/Am sample was collected in September 2002. Currently this location is not sampled as part of the IMP requirements for D&D sampling at Building 779 but was part of the previously concluded sump and basement sampling project (see Section 5.5.1 of the 2000 RFCA Annual Groundwater Monitoring Report). The recent samples collected from this location could not be collected earlier because the location only produces water during or following significant precipitation events. In addition, there are some inherent problems with the outfall itself as the water collected at this location comes out of the hillside (soil around the pipe) and not out of the outfall pipe. This leads to the question of whether the sample that is collected at this location is water that the foundation drain collects, water from some other origin seeping out of the hillside at this location because of a preferential flowpath, or some combination of the two waters. It is possible that samples from this location may contain analytes that do not originate at Building 779.

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The results of these recent SW085 sample events indicate that CT and TCE were not detected, nitrate results were all below the Tier II action level, and U-233/234 and U-238 activities were all above Tier II action levels. The Pu/Am results for the May 2001, and September 2002 sampling events were above the Tier II action level for both analytes. The Pu result for June 2002 was also above Tier II; the rest of the Pu/Am results were below the Tier II action levels. The three rounds of sampling have confirmed the results of historic surface water samples for this outfall. Additional samples will not be collected from this location after 2002.

5.6 Building 707

Building 707 is located on the north side of Central Avenue between Eighth and Ninth Streets in the former PA. It is just south of the Building 776/777 complex. Building 707 is a two-story building with a single story section on its east side. The two-story portion is 72,240 square feet, while the single story section is 18,560 square feet. The main floor of the building is compartmentalized into eight modules (A through H). There is a small basement (referred to as the C-pit) under Module C with an area of 1,000 square feet. During its operation, no significant changes were made to the building design.

Construction of Building 707 began in 1967 to support production that could not be fully accommodated in Building 776/777. Because of a major fire in Building 776/777 in 1969, Building 707 acquired additional Pu foundry, casting, and machining functions that were moved from Building 776/777. After the fire, Building 707 became the main Pu components production facility at the plant. Pu manufacturing operations began in May 1970, and between 1970 and 1989, Building 707 provided metallurgical support for Pu and was involved in final product assembly. Pu was cast into ingots in the foundry, then rolled and formed prior to being machined, cleaned, and assembled in various areas within the building. Plant operations involving radioactive and fissile material were discontinued in 1989. As of 1992, certain non-production operations had resumed in Building 707.

A Final Sampling and Analysis Plan for the D&D Groundwater Monitoring of Building 707 (RMRS, 2000c) was submitted to the Agencies in August 2000. Building 707 is currently

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scheduled for demolition in early FY 2005, which should provide adequate time to construct a chemical baseline for the D&D monitoring wells.

Monitoring wells 60499, 60599, and 60699, which were installed for the East Industrial Area Plume (EIAP) characterization project, are utilized as upgradient Building 707 D&D wells. During 2000, downgradient D&D monitoring wells 00200 and 00300 were installed and partially developed. EIAP well 61499 and older well P218089 are also utilized as downgradient D&D wells. Because P218089 was not sampled between May 1995 and December 2000, the previous three years of data is not available for baseline determination. Besides the monitoring wells, the Building 707 D&D SAP states that a VOC sample will be collected from the Building 707 foundation drain at FD-707-4, which is a manhole within Building 763 just southeast of the building. In addition, radionuclide and metals samples are routinely collected from a surface water location east of the 750 Pad, designated GS40, where the outfall from the Building 707 foundation drain is located. Figure 5-12 presents the site location as well as the location of D&D monitoring wells and other sampling locations.

The deletion of FD-707-4 and GS40 from the IMP designated sampling for Building 707 will be implemented. FD-707-4 has been most currently sampled for VOCs only. There are two reasons for making this change at FD-707-4; first, the manhole sample is a composite of water from various storm drains and the Building 707 foundation drain. The origin of the water is not definitive. Second, sampling a manhole is not an effective way to collect a VOC sample. VOC samples were collected from FD-707-4 in May and October of 2002. There were very few detections of VOCs at this location during 2002; most were laboratory blank (B) qualified and none were greater than the respective Tier II action level for the analyte. With regard to GS40, the surface water samples from this location are collected under different protocol than groundwater samples (i.e., there is no field filtering of U-isotope or metals samples; all analyses are for total U and metals), and the origin of this water is also undefined. It is known that under baseflow conditions the water at GS40 is generally just from the Building 707 foundation drain; during precipitation events there are contributions to this outfall from storm water runoff. Very little information pertinent to groundwater is obtained from these two locations, and they will not be sampled, with respect to Building 707 D&D, in the future.

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For upgradient well 60699 and downgradient well 61499, there has been little groundwater available for sampling through CY 2002. The alluvial saturated thickness in this portion of the site is very thin. This is compounded by the fact that Building 707 contains an extensive foundation drain that encompasses the entire building except for the northwest corner. At certain times of the year UHSU groundwater flow may be restricted to the weathered bedrock.

Based on the research performed in support of the Building 707 D&D SAP, the most abundant potential contaminants associated with Building 707 are Pu/Am, U-isotopes, chlorinated solvents (TCE, TCA, and CT), and a variety of metals including lead, chromium, and mercury. The D&D analytical suite for Building 707 is VOCs, metals, U-isotopes, Pu/Am, and neptunium. Neptunium, a decay product of Am-241, was noted in research for the SAP as a potential analyte of interest for this building. Table 5-8 presents a summary of Building 707 D&D groundwater monitoring data collected through CY 2002. Until a baseline is established for Building 707, analytes will be discussed in terms of concentrations relative to Tier I and Tier II groundwater action levels.

The results of the D&D sampling rounds through CY 2002 indicate no concentrations of any analytes above Tier I action levels. Upgradient well 60599 has been impacted by PCE in concentrations greater than the Tier II action level during all six D&D sampling events to date. Downgradient wells 61499 (PCE) and 00300 (TCE) have been impacted by the listed VOCs at or slightly above Tier II action levels. There are no detections of TCA or CT above Tier II action levels, and most results for these two VOCs are non detect. Samples from all Building 707 upgradient D&D wells have activities of U-233/234 and U-238 greater than their Tier II action levels, and at well 60699, these isotopes approach Tier I action levels during 2001, where sufficient water was available for U-isotope samples. At well 60699, the activity concentrations of all U-isotopes (including U-235) are greater than Site M2SD background values. U-233/234 and U-238 activity concentrations from downgradient wells P218089 and 00300 are all above Tier II action levels. All historical results of neptunium have been non-detect and, therefore, we would like to discontinue sampling for this analyte. There have not been any historical activity concentrations of Pu/Am above Tier II action levels at Building 707. Metals results indicate there have been some concentrations of thallium, mostly at downgradient wells, which are greater than the Tier II action level. There have been no detections of beryllium at Building 707. Upgradient

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wells 60599 and 60699 and downgradient wells 00300 and P218089 appear to be the most impacted at this time.

An average linear groundwater flow velocity of 97 ft/yr has been calculated for Building 707 utilizing 2nd quarter 2002 water level data. Hydraulic conductivity for the Qrf and effective porosity values were used as described in Section 3.2 of this report.

Table 5-8 Historical Building 707 D&D Groundwater Monitoring Data.

Well and Location	Date	U-233/234 (pCi/L)	U-238 (pCi/L)	PCE (µg/L)	TCE (µg/L)	Other Constituents > Tier II (µg/L or pCi/L)
60499 Upgradient	1/00	INSW	INSW	0.3	0.8	
	12/00	INSW	INSW	1.1	1.5	
	5/01	**5.33**	**3.39**	0.6	2	
	10/01	**4.74**	**2.81**	0.72	1	Tl **3.5**
	4/02	**2.62**	**1.83**	1.2	3.94	
	10/02	**2.86**	**1.92**	U	0.75	
60599 Upgradient	2/00	INSW	INSW	**100**	U	INSW Metals
	12/00	INSW	INSW	**111**	U	INSW Metals
	5/01	**16.3**	**13.2**	**260**	0.6	
	10/01	**16.5**	**10.5**	**170**	0.25	
	4/02	**29.5**	**20.8**	**118**	U	U-235 **2.07**
	10/02	**18.5**	**11.6**	**171**	U	U-235 **1.77** INSW Metals INSW Pu/Am
60699 Upgradient	5/00	INSW	INSW	U	U	INSW
	3/01	**95**	**60.9**	0.1	U	U-235 **2.81**
	6/01	**70**	**48**	U	U	U-235 **2.1**
	11/01	INSW	INSW	U	U	
	4/02	INSW	INSW	U	U	INSW Metals
	10/02	INSW	INSW	U	U	INSW Metals CT **7.42**
61499 Downgradient	5/00	INSW	INSW	**5**	0.1	INSW
	12/00	INSW	INSW	U	U	INSW
	4/01	**8.11**	**6.72**	**5**	0.2	
	2002	Dry	Dry	Dry	Dry	
P218089 Downgradient	12/00	**3.30**	**2.30**	U	U	
	4/01	**1.50**	**0.90**	U	U	
	10/01	**4.13**	**2.04**	1.2	U	Tl **4.5**
	4/02	**1.06**	**1.23**	U	U	
	10/02	**2.35**	**1.09**	U		Tl **3.4**
00200 Downgradient	11/00	U	U	U	0.27	Cd **8.49** Tl **3.78**
	4/01	0.16	0.1	0.1	U	
	10/01	0.0343	0.0911	U	U	Tl **3.9**
	4/02	U	U	U	U	
	10/02	U	U	U	U	

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Well and Location	Date	U-233/234 (pCi/L)	U-238 (pCi/L)	PCE (µg/L)	TCE (µg/L)	Other Constituents > Tier II (µg/L or pCi/L)
00300 Downgradient	11/00	Dry	Dry	Dry	Dry	Dry
	5/01	**27**	**19**	U	**17**	
	10/01	**23.9**	**15.8**	U	**5.8**	Tl **3.0**
	4/02	**23.9**	**15.8**	U	4.84	U-235 **2.34**
	10/02	**17.9**	**12.2**	U	4.86	INSW Metals INSW Pu/Am INSW Np

Note: Concentrations greater than Tier II shown in Bold, Concentrations greater than Tier I shown in Italicized Bold, U = non detect, NA = not analyzed, INSW = Insufficient water available for sample collection, CT = carbon tetrachloride, Np = neptunium

In summary, a baseline for Building 707 will be calculated once the aboveground portion of the building comes down. The impacts to upgradient wells 60599 and 60699, and possibly downgradient well 00300, are probably not related to contamination from Building 707. A process waste line that runs north-south on the west side of the building, along Eighth Street, has documented leaks along a section of the line to the southwest of the building. Based on current potentiometric data, this section of process waste line is upgradient of the three wells, and may be responsible for the high U-isotope activities observed in those locations (and potentially the high PCE concentration in well 60599).

5.7 Building 776/777

The Building 776/777 complex is located in the former PA, between Eighth and Ninth Streets, just north of Building 707. Buildings 776 and 777 share a common wall, utilities, and maintenance facilities. All floors in the building are reinforced concrete slabs. The main floor has an area of 135,000 square feet. Metal processing facilities and waste handling each occupy approximately half of this space. The second floor contains 88,000 square feet and is almost entirely occupied by utilities. There are two sub-basement areas: a four bay area of approximately 1,600 square feet and an elevator pit area which is adjacent to the tunnel connecting Buildings 776 and 771.

Building 776/777 began operations in 1957 and has undergone several major production changes since then. Beginning in 1958 and continuing through 1969, Building 776 was the main manufacturing facility for Pu weapons components and housed a Pu foundry and fabrication

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operations. The main function of Building 777 was assembly of parts. A major fire in 1969 required that the majority of the Building 776/777 foundry and fabrication operations be transferred to Building 707. Limited production operations were resumed in Building 776/777 several months after the fire; however, the main focus of the building moved towards waste and residue handling, disassembly of site returns, and special projects. Processes included waste size reduction, pyrochemistry, coatings operations, machining, and product assembly and disassembly (including testing and inspection). Post-1989 activities included waste handling and maintenance activities in Building 776, and a tritium surveillance laboratory and container repackaging operations in Building 777 (DOE, 1994a).

The Final Sampling and Analysis Plan for the D&D Groundwater Monitoring of Building 776/777 (RMRS, 2000c) was submitted to the Agencies in August 2000. Building 776/777 is currently scheduled for demolition in early FY 2004. This should allow adequate time for construction of a chemical baseline for all of the downgradient D&D monitoring wells.

During 2000, upgradient monitoring well 00400, located between Building 778 and Building 777, and downgradient monitoring wells 00500, 00600, and 00700, were installed and sampled during the 4th quarter. Preexisting EIAP monitoring well 60299 is utilized as an upgradient D&D well. Figure 5-13 presents the building location along with the locations of the D&D monitoring wells.

Based on the research performed in support of the Building 776/777 D&D SAP, the most abundant potential contaminants associated with the building are Pu/Am, U-isotopes, tritium, chlorinated solvents, a variety of metals including beryllium, and potentially nitrate. The analytical suite for D&D wells at Building 776/777 includes VOCs, metals, U-isotopes, Pu/Am, tritium, and nitrate. Table 5-9 presents summary Building 776/777 D&D groundwater monitoring data collected through CY 2002. Until a baseline is established for Building 776/777, immediately after the aboveground portion of the building is demolished, analytes will be discussed in terms of concentrations relative to Tier I and Tier II groundwater action levels.

Except for upgradient D&D well 60299, all of the Building 776/777 D&D wells generally produced full sample suites (VOCs, metals, U-isotopes, Pu/Am, tritium, and nitrate) during the 2nd and 4th quarters of 2001 and 2002. Monitoring well 60299 only produced enough water for

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VOC and nitrate samples during the 2nd quarter of 2001 and the 2nd and 4th quarters of 2002; the well was dry during the 4th quarter of 2001.

The results of the Building 776/777 D&D sampling to date indicate that the CT concentration in downgradient well 00700 for the five sampling rounds completed to date is greater than the Tier I action level. There were no concentrations of any other analytes that were above Tier I action levels from Building 776/777 D&D wells. Well 00700 also contains CF; 1,1-DCE; 1,2-DCA; and PCE in concentrations greater than their respective Tier II action levels for all five sampling rounds to date. None of the other four Building 776/777 D&D monitoring wells had any VOC detections above Tier II action levels before 2002. During 2002, upgradient well 60299 had first time detections of TCE above the Tier II action level for both the 2nd and 4th quarters.

Upgradient well 00400 has been impacted by U-isotopes, cadmium, and thallium in concentrations greater than their Tier II action levels. No other Building 776/777 D&D well had activities of U-isotopes above Tier II action levels before 2002. Downgradient well 00500 exhibited first time U-233/234 and U-238 activities greater than the Tier II action level during the 2nd quarter of 2002. Subsequent U-isotope analyses from this well during 2002 were below Tier II or non-detect.

Well 00500 has also exhibited manganese and thallium concentrations greater than their respective Tier II action levels. No other Building 776/777 D&D well has exhibited manganese concentrations greater than the Tier II action level, although downgradient well 00600 has relatively high manganese concentrations that are approaching the Tier II action level. Tritium was detected in downgradient well 00700 at an estimated activity concentration of 300 pCi/L in 4th quarter 2000, at 264 pCi/L in 4th quarter 2001, and at 332 pCi/L in 2nd quarter 2002 (all below Tier II); tritium was not detected at any other wells.

Americium was detected for the first time above the Tier II action level at downgradient wells 00600 and 00700 during the 4th quarter of 2002. There have been no other detections of Am above the Tier II action level at any Building 776/777 D&D well. Beryllium and nitrate were either non detect or detected at concentrations below their Tier II action levels at all wells for all D&D sampling rounds to date.

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Table 5-9 Historical Building 776/777 D&D Groundwater Monitoring Data.

Well and Location	Date	Pu Am (pCi/L)	U-Isotopes (pCi/L)	Metals Elevated or >Tier II (µg/L)	VOCs >Tier II (µg/L)
60299 Upgradient	3/00	INSW	INSW	INSW	
	11/00	INSW	INSW	INSW	
	5/01	INSW	INSW	INSW	
	4/02	INSW	U	INSW	TCE **20.8**
	10/02	INSW	INSW	INSW	TCE **39**
00400 Upgradient	11/00	0.012 U	U-233/234 **2.60** U-238 **1.20**	Cd **7.09** Tl **4.95**	
	5/01	U	U-233/234 **3.2** U-238 **1.88**		
	11/01	0.0173 0.0142	U-233/234 **2.05** U-238 **1.01**		
	4/02	U	U-233/234 **1.74** U-238 **1.44**		
	10/02	U	U-233/234 **1.68** U-238 **0.951**	Tl **2.27**	
00500 Downgradient	11/00	0.058 U	U-233/234 0.18 U-238 0.16	Tl **3.82** Mn **2540**	
	5/01	U 0.013	U-233/234 0.28 U-238 0.21	Mn **4660**	
	11/01	U	U-233/234 0.141 U-238 0.23	Mn **2610** Tl **2.4**	
	4/02	0.0235 U	U-233/234 **1.63** U-238 **1.19**	Mn **1760** As 39.1	
	8/02	U 0.012	U-233/234 0.947 U-238 0.294	Mn **3700**	
	10/02	U	U	INSW	
00600 Downgradient	11/00	0.016 U	U-233/234 0.19 U-238 0.20	Mn 1150 As 11.6	
	6/01	U	U-233/234 0.563 U-238 0.429	Tl **4.4** Mn 1420	
	11/01	U	U-233/234 0.288 U-238 U	Mn 1180	
	4/02	U 0.0265	U-233/234 0.476 U-238 U	Mn 1210	
	10/02	U **0.198**	U-233/234 0.596 U-238 U	Mn 1630	

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Well and Location	Date	Pu Am (pCi/L)	U-Isotopes (pCi/L)	Metals Elevated or > Tier II (µg/L)	VOCs > Tier II (µg/L)
00700 Downgradient	11/00	U	U-233/234 0.035 U-238 0.028		CT ***3920*** CF **244** 1,1-DCE **366** 1,2-DCA **8** PCE **9.9**
	5/01	0.0112 0.0191	U-233/234 U U-238 U		CT ***2900*** CF **230** 1,1-DCE **330** PCE **11** TCE **17**
	11/01	0.00811 U	U-233/234 0.216 U-238 U		CT ***3000*** CF **340** 1,1-DCE **500** 1,2-DCA **7.9** PCE **11**
	5/02	U	U		CT ***2830*** CF **278** 1,1-DCE **352** 1,2-DCA **9.6** PCE **10.2**
	10/02	U **0.168**	U		CT ***2020*** CF **292** 1,1-DCE **282** 1,2-DCA **6.7** PCE **7.5**

Note: Concentrations greater than Tier II shown in Bold, Concentrations greater than Tier I shown in Italicized Bold, U = non detect, NA = not analyzed, INSW = Insufficient water available for sample collection, CT = carbon tetrachloride, Np = neptunium.

An average linear groundwater flow velocity of 22 ft/yr has been calculated for the western portion of Building 776/777 (Building 776) and a velocity of 100 ft/yr for the eastern portion of Building 776/777 (Building 777) utilizing 2nd quarter 2002 water level data. The western portion of Building 776/777 is affected by the Building 771 foundation drain and the unnamed southwest-northeast trending drainage east of Building 371/374. Hydraulic conductivity for the Qrf and effective porosity values were used as described in Section 3.2 of this report.

In summary, beryllium and nitrate do not appear to be pre-D&D analytes of interest for Building 776/777. Tritium, although detected at low concentration in downgradient well 00700, does not appear to be of consequence at this point as a pre-D&D analyte of interest. The Tier I CT and high CF concentrations observed at downgradient well 00700 are likely associated with IHSS

118.1, which is located immediately north of the central portion of Building 776/777. Slightly elevated U-isotope activities observed in well 00400 (well below Site M2SDs), and Am activities in wells 00600 and 00700 (4th quarter 2002 only), appear to be from an upgradient source.

5.8 Building 371/374

The Building 371/374 complex is located in the northwestern portion of the IA at RFETS, and it is the only building complex within the newly configured PA. The building is a four level, partially buried structure constructed of reinforced concrete. It contains approximately 186,000 square feet of floor space. The building contains a large basement beneath the ground floor and a sub-basement beneath the basement. Building 371 proper contains a glovebox system, a large central storage area, office areas, maintenance shops, and outside loading docks. Building 374 proper contains office space and liquid waste processing facilities. Figure 5-14 presents a site location map of the Building 371/374 complex and surrounding area along with the locations of the D&D monitoring wells.

Building 371 was originally built to assume the Pu recovery operations of Buildings 771 and 776 using advanced technology for Pu handling, recovery, and safety. The projected operations for the building focused primarily on the recovery of Pu from both solid and liquid wastes. Pilot-scale recovery operations began in 1981 and continued until the mid-1980s when serious design and construction deficiencies were identified (DOE 1994a). The last recovery operations in the facility were terminated in 1986. Since that time, operations in Building 371 have focused mainly on waste and Special Nuclear Material (SNM) handling and storage and laboratory operations. The majority of Building 371 is used for handling and storing SNM and wastes. Wastes stored in the building include transuranic waste, transuranic mixed waste, low-level waste, and low-level mixed waste (DOE, 1994a).

Building 374 was constructed for the purpose of handling process waste generated in Building 371 and high-level waste from Building 771. It began waste treatment operations in 1978 and began handling radioactive wastes from Building 371 in 1980 (DOE, 1994a).
A complex foundation drain system is present beneath Building 371/374. The system operates by gravity flow. The perimeter portion of the drain is located at an approximate elevation of 5,984

feet above msl and is associated with the basement. The inner, deeper, portion of the drain is located at an approximate elevation of 5,967 feet above msl and is associated with the sub-basement. The drain system impacts the localized water table in the immediate vicinity of Building 371/374, and creates a steep groundwater sink (effectively, a cone of depression) encompassing the building (as shown on Plates 2 and 3 and Figure 5-14).

The Final Sampling and Analysis Plan for the D&D groundwater monitoring of Building 371/374 (RMRS, 2000c) was submitted to the Agencies in August 2000. Building 371/374 is currently scheduled for demolition in early to mid FY 2006, which will allow adequate time for construction of a chemical baseline for the D&D monitoring wells.

Seven D&D monitoring wells (37101 through 37701) were installed and developed during the spring of 2001 and the first round of groundwater samples were collected during the 3rd quarter of 2001. Wells 37101, 37201, and 37301 are upgradient wells. Wells 37401, 37501, 37601, and 37701 are downgradient wells. Monitoring well 37401 was subsequently destroyed by activities related to the removal of a cement silo and replaced in 2002 with well 37402 (Figure 5-8).

Based on the research performed in support of the Building 371/374 D&D SAP, the most abundant potential contaminants associated with Building 371/374 are Pu/Am, nitric acid, and VOCs. The D&D analytical suite for the Building 371/374 complex consists of VOCs, metals, U-isotopes, Pu/Am, and nitrate. Table 5-10 presents a summary of Building 371/374 D&D groundwater monitoring data collected through CY 2002. Until a baseline is established for Building 371/374, analytes will be discussed in terms of concentrations relative to Tier I and Tier II groundwater action levels.

All of the Building 371/374 D&D monitoring wells (except 37401/37402) produced full sample suites (VOCs, metals, U-isotopes, Pu/Am, and nitrate) in 2001 and 2002. There have been very few detections of VOCs and no concentrations above Tier II action levels. The metals results indicate that there have been very few detections of beryllium (listed in the SAP as a potential metal of interest) and none above Tier II action levels. Manganese and barium were observed at concentrations well above their Tier II action levels in well 37301 for all three sample rounds completed to date. Thallium has been observed at four sampling locations (37201, 37501, 37601,

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basement) at a concentration greater than the Tier II action level. Well 37701, the basement, and subbasement all had U-233/234 and U-238 concentrations that were higher than their Tier II action levels for all three sampling rounds completed to date. There have been no activities of Pu/Am above their Tier II action levels. Nitrate was detected at concentrations greater than the Tier II action level for the first time in the samples collected during 2002 from downgradient well 37501.

An average linear groundwater flow velocity of 252 ft/yr has been calculated for Building 371/374 utilizing 2[nd] quarter 2002 water level data. Hydraulic conductivity for the Qrf and effective porosity values were used as described in Section 3.2 of this report.

Table 5-10 Historical Building 371/374 D&D Groundwater Monitoring Data.

Well and Location	Date	U-233 U-238 (pCi/L)	Pu Am (pCi/L)	Nitrate (mg/L)	Metals >Tier II (µg/L)
37101 Upgradient	8/01	U 0.049	U 0.019	3.6	
	1/02	U U	U 0.0221	2	
	7/02	0.658 U	U U	2.3	
37201 Upgradient	8/01	**1.3** **1.08**	U U	0.84	Tl **3.9**
	1/02	0.982 **0.909**	U 0.0414	1	Tl **3.9**
	8/02	0.976 **0.945**	U U	1.6	
37301 Upgradient	8/01	0.323 0.328	U U	U	Mn **8400** Ba **2300**
	1/02	0.356 0.272	0.0174 0.0375	0.031	Mn **11300** Ba **2190**
	8/02	0.429 0.465	U 0.0228	U	Mn **25600** Ba **5880**
37401/37402 Downgradient	8/01	**27.5** **22**	0.063 U	1.3	
	3/02	INSW	INSW	0.16	INSW
	7/02	**1.74** **0.95**	U U	4	
37501 Downgradient	8/01	0.84 0.49	U U	9	
	1/02	0.325 U	U 0.0178	**10.6**	Tl 5
	7/02	0.617 0.544	U 0.0196	**22**	Ba **2900**

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Well and Location	Date	U-233 U-238 (pCi/L)	Pu Am (pCi/L)	Nitrate (mg/L)	Metals >Tier II (µg/L)
37601 Downgradient	8/01	**2.31** **1.5**	U U	4.2	
	1/02	0.78 0.677	U 0.0225	2	Tl **2.4**
	7/02	0.236 U	U U	3	
37701 Downgradient	8/01	**7.3** **5.08**	U U	U	
	2/02	**1.95** **1.44**	U U	0.12	
	7/02	**2.58** **1.96**	0.0144 U	0.023	
Basement Drain Outfall	8/01	**2.39** **1.4**	U U	2.7	
	2/02	**1.35** **0.946**	U 0.0292	0.85	
	8/02	**1.25** **1.03**	U U	1.3	Tl **4**
Sub-Basement Drain Outfall	8/01	**2.44** **1.68**	U U	0.57	
	2/02	**2.11** **1.59**	U U	0.31	
	8/02	**1.68** **1.15**	U U	0.42	

Notes: Concentrations greater than Tier II shown in Bold, Concentrations greater than Tier I shown in Italicized Bold, U = non detect, INSW = insufficient water available for sample collection, Mn = manganese, Ba = barium

In summary, based on the limited sampling completed to date, Pu/Am, VOCs, and beryllium do not appear to be pre-D&D contaminants of interest at Building 371/374. U-isotopes appear to be a downgradient, pre-D&D contaminant of interest at Building 371/374. Manganese and barium are potential upgradient contaminants of interest for this building.

5.9 Building 865

Building 865 is located immediately south of Central Avenue and east of Eighth Street in the south central portion of RFETS. The building is due south and across Central Avenue from the previously existing Portal 1 entrance to the former PA. The southwest corner of Building 865 is approximately 100 feet due east of the northeast corner of Building 883.

Building 865 was placed into service in 1972. This building was used for material processing and development work, including: fabrication, processing, and testing of metal parts. Depleted U and beryllium were processed in this building (DOE, 1992b). Beryllium powder was mixed with other metals, placed in molds, and compressed into shapes. In addition, from 1983 through 1986, ultra-pure beryllium metal was produced electrolytically (ChemRisk, 1992). There is little available literature regarding the historic configuration of the building or the description and time line of historical operations at this building.

The Final Sampling and Analysis Plan for the D&D groundwater monitoring of Building 865 (RMRS, 2000c) was submitted to the Agencies in August 2000. Building 865 is currently scheduled for demolition in late FY 2003 to early FY 2004. This will allow adequate time for construction of a chemical baseline for most of the D&D monitoring wells (except well 86701).

During 2001, upgradient monitoring well 86501 and downgradient monitoring wells 86601 and 86701 were installed and developed. Preexisting monitoring wells 40999 (upgradient D&D well for Building 886) and P317989 are utilized as additional downgradient monitoring wells. In addition, surface water station BS-865-2, a foundation drain outfall located in a manhole at the northeast portion of the building, was sampled. Figure 5-15 presents the location of Building 865 and the locations of the D&D monitoring wells. Preexisting well P317989 had no samples collected from it between March 1995 and November 1999, but there are three rounds of partial samples from this well, previous to the first Building 865 D&D data (2001), which can be utilized for baseline calculations. There are also four rounds of partial samples from well 40999 that were collected previous to the first Building 865 D&D samples, which can be utilized for baseline calculations. These two wells have historically had problems producing enough water for a full sample suite.

Based on the research performed in support of the Building 865 D&D SAP, the most abundant potential contaminants associated with Building 865 are U-isotopes, beryllium, and nitric acid. The D&D analytical suite for Building 865 is VOCs, metals, U-isotopes, and nitrate. Table 5-11 presents a summary of Building 865 D&D groundwater monitoring data collected through CY 2002. Until a baseline is established for Building 865, analytes will be discussed in terms of Tier I and Tier II action levels.

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Table 5-11 Historical Building 865 D&D Groundwater Monitoring Data.

Well and Location	Date	Metals >Tier II (µg/L)	Nitrate (mg/L)	U-233 U-235 U-238 (pCi/L)	VOCs >Tier II (µg/L)
86501 Upgradient	11/01		0.43	37.2 1.1 26.5	
	2/02		0.75	31.4 1.92 24.4	
	5/02		3.2	67 3.36 51.7	
	7/02		3.6	62.8 3.45 51.1	
	10/02	Thallium 2.5	INSW	69 8.72 53.4	
86601 Downgradient	11/01		U	17.4 0.565 12	
	2/02		0.17	16.3 1.22 10.7	
	5/02		0.56	18 0.517 12.6	
	7/02		0.74	15.2 1.09 9.78	
	10/02	Tl 3.4	0.6	18.8 2.99 12.3	
86701 Downgradient	1/02		1.3	44.7 1.27 39.3	TCE 34.1
	5/02		1.5	51.5 2.99 41.5	TCE 38.7
	7/02		1.6	35.8 3.6 28.3	TCE 31.4
	10/02	Tl 9.8	1.6	30.8 4.6 23.6	TCE 36

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Well ID and Location	Date	Metals > Tier II (µg/L)	Nitrate (mg/L)	U-233 U-235 U-238 (pCi/L)	VOCs > Tier II (µg/L)
40999 Downgradient	11/99		U	**8.88** 0.362 **6.807**	NS
	6/00	INSW	0.54	**10.7** 0.343 **7.83**	NS
	11/00	INSW	INSW	**10** 0.32 **8.3**	NS
	3/01		0.26	**9.7** 0.28 **7.8**	NS
	7/01		0.47	**9** 0.33 **6.6**	NS
	2/02	INSW	INSW	**9.93** 0.276 **8.83**	NS
	5/02	INSW	INSW	**8.46** U **7.7**	NS
	8/02	Tl **5.0**	0.67	**7.42** 0.394 **6.62**	NS
	10/02		INSW	**7.79** 0.326 **6.55**	NS
P317989 Downgradient	11/99	Se **121**	3.8	INSW	
	6/00	Se **120**	INSW	**51.1** **2.28** **38.5**	
	12/00	Se **128** Tl **4.45**	INSW	INSW	
	7/01	Se **96**	1.4	**50.4** **2.3** **37.8**	
	6/02	INSW	1.4	**68.1** **5.45** **55.1**	

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Well and Location	Date	Metals > Tier II (µg/L)	Nitrate (mg/L)	U-233 U-235 U-238 (pCi/L)	VOCs > Tier II (µg/L)
BS-865-2 NE corner of B865	12/01		6.7	**4.2** 0.242 **3.23**	
	2/02		6.5	**3.72** U **2.62**	
	5/02		3.5	**3.54** U **2.67**	
	7/02		3.3	**1.47** U 0.56	
	11/02		NS	**1.54** U **2.16**	

Notes: Concentrations greater than Tier II shown in Bold, Concentrations greater than Tier I shown in Italicized Bold, U = non detect, (B) = Analyte detected in the Method Blank, NA = not analyzed, INSW = insufficient water available for sample collection, NS = not sampled, Se = selenium.

Monitoring wells 86501, 86601, and 86701 all produced full sample suites (VOCs, metals, U-isotopes, and nitrate) for all four quarters of 2002. Well P317989 produce only a partial 2nd quarter sample in 2002; well 40999 produced partial 1st, 2nd, and 4th quarter samples and a full sample suite in the 3rd quarter of 2002.

The results of the sampling to date at Building 865 indicate that there have been almost no detections of VOCs; and none above Tier II action levels with the exception of TCE at well 86701 for all four quarters of 2002. Nitrate concentrations at all sampling locations are below The Tier II action level. Metals results indicate that beryllium has been non detect or detected at very low concentrations for all Building 865 D&D monitoring locations including manhole BS-865-2. Selenium has historically been found in well P317989 at concentrations above the Tier II action level, but at no other Building 865 D&D locations above detection limits. Thallium has been detected at least once above the Tier II action level at all five wells. U-233/234 and U-238 are found at activities above Tier II action levels at all sampling locations, and at activities approaching or greater than the Site M2SDs at wells 86501, 86701, and P317989. U-235 is found above the Site M2SD at wells, 86501, 86601, 86701, and P317989.

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An average linear groundwater flow velocity of 102 ft/yr has been calculated for Building 865 utilizing 2nd quarter 2002 water level data. Hydraulic conductivity for the Qrf and effective porosity values were used as described in Section 3.2 of this report.

In summary, historical and current sampling results indicate that beryllium and nitrate are not pre-D&D contaminants of interest in groundwater at Building 865. Based on the sampling completed to date, U-isotopes appear to be the contaminant of interest at Building 865. Selenium and thallium are potentially metals of interest in groundwater at this location.

5.10 Building 883

Building 883, located approximately 300 feet south of the southeast corner of the intersection of Central Avenue and Eighth Street in the south central portion of RFETS, is a two-story steel framed building that is connected to Building 881 (located 150 feet due south) by a tunnel. The tunnel connects the southwest basement corner of Building 883 to the northwest corner of the second floor of Building 881. Building 883 has a partial basement containing approximately 7,600 square feet, and a small second floor on the north and south ends. The building consists of 76,500 square feet of space, most of which is taken up by a high bay metal working facility containing large equipment (DOE, 1994a).

Building 883 was put into service in 1957. At that time there were two parallel U fabrication operations that involved the use of presses, rolling mills, and annealing furnaces. One operation was for enriched U fabrication and the other was for depleted U fabrication. The enriched U work was discontinued in the mid 1960s. In addition, beryllium ingots were also rolled into sheet material and etched in this building. Beryllium machining occurred in this building from the mid-1960s through the mid-1970s. Later, Building 883 served as a metals preparation area where parts were cleaned, rolled, formed, swaged, sheared, bent, and grit blasted before they were further used by other machining and production processes at various locations at the plant (DOE, 1992b). A major addition to Building 883 was completed in 1985 to support manufacturing of armor plates containing depleted U for the M1A1 tank (DOE, 1994a).

The Final Sampling and Analysis Plan for the D&D groundwater monitoring of Building 883 (RMRS, 2000c) was submitted to the Agencies in August 2000. Building 883 is currently scheduled for demolition in late FY 2004 to mid-FY 2005. This should allow adequate time for construction of a chemical baseline for the D&D monitoring wells.

Two new downgradient D&D wells, 83101 and 83201, were installed, developed, and sampled during the 4th quarter of 2001. Preexisting monitoring wells 61099 and 61199 are utilized as Building 883 upgradient D&D wells. Figure 5-16 presents the building location along with the location of the D&D monitoring wells.

Based on the research performed in support of the Building 883 D&D SAP, the contaminants of interest associated with Building 883 are U-isotopes, beryllium, and nitric acid. The D&D analytical suite for Building 883 consists of VOCs, metals, U-isotopes, and nitrate. Table 5-12 presents a summary of Building 883 D&D groundwater monitoring data collected through CY 2002. Until a baseline is established for Building 883 wells, analytes will be discussed in terms of concentrations relative to Tier I and Tier II action levels.

Table 5-12 Historical Building 883 D&D Groundwater Monitoring Data.

Well and Location	Date	Beryllium (µg/L)	Nitrate (mg/L)	U-233 U-235 U-238 (pCi/L)	TCE (µg/L)	PCE (µg/L)	Metals > Tier II (µg/L)
61099 Upgradient	12/99	NS	NS	NS	1	**27**	
	3/01	NS	NS	**1.33** 0.067 **0.916**	2	**26**	
	12/01	U	5.9	**1.19** 0.053 **0.804**	0.92	**15**	
	2/02	U	4.9	0.825 U 0.245	1.5	**32**	Tl **3.0**
	5/02	0.05	5.1	0.783 U 0.491	1.3	**19.7**	
	8/02	U	5.6	**1.61** U 0.322	1.75	**34**	
	10/02	U	4.5	**1.28** U 0.482	1.33	**27.8**	

Well and Location	Date	Beryllium (µg/L)	Nitrate (mg/L)	U-233 U-235 U-238 (pCi/L)	TCE (µg/L)	PCE (µg/L)	Metals > Tier II (µg/L)
61199 Upgradient	12/99	NS	NS	NS	12	230	
	3/01	NS	NS	**2.75** 0.14 **1.59**	17	230	
	12/01	U	4.9	**2.33** 0.165 **1.17**	12	160	Tl **2.2**
	2/02	U	5.1	**2.37** U **1.77**	16	200	Tl **2.7**
	5/02	0.06	5.4	**1.74** U **1.12**	24.5	293	
	8/02	U	NS	**2.32** 0.209 **1.32**	15.9	224	
	10/02	U	5.1	**2.66** U **1.75**	12.8	202	
83101 Downgradient	12/01	U	4	**8.14** 0.636 **7.56**	**8.6**	**29**	Cd **5.3**
	2/02	U	4.1	**6.56** U **4.6**	**13**	**42**	Tl **2.2**
	5/02	0.07	5	**7.56** U **7.47**	**13.3**	**49.4(B)**	
	8/02-9/02	0.03	5.1	**4.9** 0.71 **3.99**	**10.8**	**40.7**	
	10/02	NS	5.7	**4.24** 0.257 **3.99**	**9.1**	**38.6**	
83201 Downgradient	12/01	U	0.56	***161*** **7.19** ***127***	0.62	0.63	Hg **2.9** Se **58.3** Tl **3.6**
	2/02	U	2.6	***142*** **8.34** ***108***	0.73	0.63	Tl **3.3**
	5/02	0.13	2.4	***160*** **6** ***133***	0.81	0.89(B)	
	8/02	0.04	1.3	***171*** **6.19** ***130***	1.49	0.49	
	10/02	NS	2.3	***157*** **10.6** ***117***	U	U	NS

Notes: Concentrations greater than Tier II shown in Bold, Concentrations greater than Tier I shown in Italicized Bold, U = non detect, (B) = Analyte detected in the Method Blank, NA = not analyzed, INSW = Insufficient water available for sample collection, NS = not sampled

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Monitoring wells 61099, 61199, 83101, and 83201 generally produced full sample suites (VOCs, metals, U-isotopes, and nitrate) for all four quarters of 2002. The results of sampling to date indicates PCE is found in concentrations greater than Tier II action levels at all wells except downgradient well 83201; TCE is found in concentrations greater than the Tier II action level at wells 61199 and 83101. No other VOCs are found at concentrations greater than Tier II action levels. U-233/234 and U-238 are found in activity concentrations greater than Tier II action levels at wells 61199 and 83101 for all sampling rounds to date, and at activities greater than Tier I action levels at well 83201 for all sampling rounds to date. In addition, the U-235 activity concentration at well 83201 is greater than the Tier II action level for all sampling rounds to date. All of the U-isotope activities at well 83201 are greater than the Site Background M2SD values for those analytes. Beryllium was non detect or detected at very low concentrations, well below Tier II, at all locations. Nitrate was detected at all locations at concentrations below the Tier II action level. A few metals concentrations above Tier II action levels have been observed; most of them at downgradient well 83201. Thallium is the metal seen most; at least one historical occurrence above the Tier II action level at each monitoring well.

An average linear groundwater flow velocity of 14 ft/yr has been calculated for Building 883 utilizing 2nd quarter 2002 water level data. The hydraulic gradient is extremely flat in the area encompassing this building. Hydraulic conductivity for the Qrf and effective porosity values were used as described in Section 3.2 of this report.

In summary, based on the sample results to date, beryllium and nitrate do not appear to be pre-D&D contaminants of interest in groundwater at Building 883. PCE and potentially TCE appear to be upgradient contaminants of interest at Building 883; the source of the high PCE in well 61199 is probably responsible for the PCE concentration in downgradient well 83101. The high U-isotope activities in downgradient well 83201 are naturally occurring based on ICP/MS analyses (Safe Sites, 2002b).

5.11 Building 881

Building 881, a three-story reinforced concrete structure, is located immediately south of Building 883 in the south central IA at RFETS. A tunnel, described above, which connects the

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buildings, was originally used to convey enriched U parts and other materials between the two buildings (DOE, 1994b). The total Building 881 floor area of 245,160 square feet generally consists of an 86,000 square foot first floor, an approximately 121,000 square foot second floor, and approximately 14,000 square foot second floor mezzanine, and an approximately 18,000 square foot basement (DOE, 1994b).

During the early 1950s, the United States adopted a nuclear weapons defense policy that called for at least two installations to have the capability to produce any of the nuclear components for the national stockpile. Rocky Flats Building 881was selected, along with the Oak Ridge Y-12 plant, to fabricate weapon parts from enriched U (ChemRisk, 1992). Operations producing U components began in the summer of 1952. The specific process operations involved in the fabrication of U components included heating and casting of parts, parts shaping and forming, machining, assembly, and U recovery (ChemRisk, 1992).

Enriched U fabrication operations were moved to Oak Ridge between 1964 and 1966 when the U.S. Atomic Energy Commission adopted a single mission policy and made the production of Pu components the focus of operations at Rocky Flats. From this time until 1984, Building 881 housed the manufacturing process for precision stainless steel parts that were used in Pu based weapons. After stainless steel manufacturing was moved to Building 460 in 1984, the role of Building 881 was expanded to a multipurpose facility for research and development, analytical support, administrative, and computer functions (DOE, 1994b).

During the period of U and stainless steel component production, most of the production related operations occurred on the second floor. Floors in the process areas were covered with stainless steel sheeting with welded seams to contain spills and facilitate cleaning (DOE, 1994b). In addition, some floors were covered with stainless steel sheeting to cover previous spills. Support functions such as laboratories, utilities, and maintenance were located on the first floor and in the basement (ChemRisk, 1992).

Building 881 has a gravity-flow foundation drain system at approximate elevations that range from 5,973 feet above msl at the north end of the building to 5,949 feet above msl at the south end of the building. The drain is located around the exterior of the foundation at elevations that impact localized potentiometric contours based on the potentiometric surface of permeable units of the UHSU presented in Plates 2 and 3 and Figure 5-17. The foundation drain outfall, referred to as surface water station SW13494, is located immediately south of the security fence on the south side of Building 881. The foundation drains of Buildings 881 and 883 are possibly connected. If true, this could provide a pathway for the migration of contaminants from Building 883 to surface-water station SW13494.

The Final Sampling and Analysis Plan for the D&D Groundwater Monitoring of Building 881 (RMRS, 2001d) was submitted to the Agencies in July 2001. Building 881 is currently scheduled for demolition in early FY 2004. This may allow adequate time for construction of a chemical baseline for some of the D&D monitoring wells.

Well installation and groundwater sampling activities that took place at this building during 2001 include the installation and partial development of downgradient well 88101 in addition to the installation of upgradient well 83101 (discussed above and associated with Building 883). Preexisting monitoring wells 37791 and 39691 are utilized as upgradient D&D monitoring wells; preexisting well 5187 is utilized as a downgradient D&D monitoring well. In addition, data from SW13494, currently sampled quarterly, will be utilized. Figure 5-17 presents the location of Building 881 along with the D&D monitoring locations.

Based on the research performed in support of the Building 881 D&D SAP, the contaminants of interest associated with Building 881 are U-isotopes and chlorinated solvents. The D&D analytical suite for Building 881 consists of VOCs, metals, U-isotopes, Pu/Am, and nitrate. Table 5-13 presents a summary of Building 881 D&D groundwater monitoring data collected through CY 2002. Until a baseline is established for Building 881, analytes will be discussed in terms of concentrations relative to Tier I and Tier II groundwater action levels.

Four D&D sampling rounds were attempted during 2002 at Building 881. Existing well 39691 was dry for all four quarters of 2002 and existing well 5187 produced only one full sample suite (minus nitrate; 3rd quarter) during 2002. The results to date from D&D sampling at Building 881 indicate that upgradient D&D well 83101 is impacted with VOCs (PCE and TCE) and U-isotopes (U-233/234 and U-238) at concentrations/activities greater than their Tier II action levels.

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Table 5-13 Historical Building 881 D&D Groundwater Monitoring Data.

Well and Location	Date	Pu Am (pCi/L)	Nitrate (mg/L)	U-233 U-235 U-238 (pCi/L)	VOCs >Tier II (µg/L)	Metals >Tier II (µg/L)
37791 Upgradient	12/01	U 0.0376	1.1	7.36 0.461 5.87		Tl 2.3
	2/02	U 0.0188	0.74	13 0.326 10.9		NS
	4/02	U U	0.36	12.4 1.05 10.4		
	8/02	U U	NS	8.87 0.732 6.35		
	10/02	U 0.0158	0.98	11.5 0.501 10.3		Tl 3.2
39691 Upgradient	All	Dry	Dry	Dry	Dry	Dry
83101 Upgradient	12/01	NS	4	8.14 0.636 7.56	TCE 8.6 PCE 29	Cd 5.3
	2/02	U/U	4.1	6.56 U 4.6	TCE 13 PCE 42	Tl 2.2
	5/02	U/0.0217	5	7.56 U 7.47	TCE 13.3 PCE 49.4	
	8-9/02	U/U	5.1	4.9 0.71 3.99	TCE 10.8 PCE 40.7	
	10/02	U/U	4.7	4.24 0.257 3.99	TCE 9.1 PCE 38.6	NS
5187 Downgradient	12/01	Dry	Dry	Dry	Dry	Dry
	8/02	U U	NS	5.31 0.921 3.7	PCE 6.46	Ni 192
	10/02	INSW	INSW	INSW		INSW
88101 Downgradient	2/02	U U	0.047	*246* 12.1 *173*		Tl 3.6
	4/02	0.021 U	NS	*115* 4.76 *79.5*		Li 746
	8/02	NS	NS	60.2 2.45 38.1		
	10/02	U U	NS	60.5 2.27 37.7		NS

Well and Location	Date	Pu Am (pCi/L)	Nitrate (mg/L)	U-233 U-235 U-238 (pCi/L)	VOCs > Tier II (µg/L)	Metals > Tier II (µg/L)
SW13494 South of B881, Foundation Drain Outfall	12/01	U 0.034	5.4	**3.17** 0.203 **2.53**	PCE **27**	
	3/02	U 0.0253	4.2	**2.88** U **2.4**	PCE **22.5**	Tl **2.8**
	5/02	U U	4.6	**4.87** 0.285 **1.67**	PCE **30.5**	
	8/02	0.046 0.029	NS	**1.92** U **1.49**	TCE **8.8** PCE **8.9**	
	11/02	U U	NS	**1.82** U **1.45**	PCE **14**	Tl **3.9**

Notes: Concentrations greater than Tier II shown in Bold, Concentrations greater than Tier I shown in Italicized Bold, U = non detect, (B) = Analyte detected in the Method Blank, NS = not sampled, INSW = Insufficient water available for sample collection

Upgradient D&D well 37791 had U-233/234 and U-238 (and one detection of U-235) at activities greater than their Tier II action levels. Downgradient well 88101 has high activities of all U-isotopes, including Tier I U-233/234 and U-238 results during the 1st and 2nd quarters of 2002 and Tier II U-235 results for all 4 quarters of 2002. There have been no VOCs detected above Tier II action levels at upgradient well 37791 and downgradient well 88101. There has been no Pu/Am or nitrate detected above the Tier II action level at any Building 881 D&D well. Surface water sampling station SW13494 has exhibited U-233/234, U-238, and PCE at activities/concentrations greater than their Tier II action levels for every sample since D&D monitoring began.

An average linear groundwater flow velocity of 51 ft/yr has been calculated for Building 881 utilizing 2nd quarter 2002 water level data. Hydraulic conductivity for the Qc and effective porosity values were used as described in Section 3.2 of this report.

In summary, Pu/Am and nitrate are not analytes of interest at Building 881. Based on the sample results to date, U-isotopes, PCE, and TCE may be the analytes of interest at Building 881. The PCE in upgradient well 83101 is probably from a groundwater source upgradient of Building 883, which has impacted wells upgradient of that building. This PCE source upgradient of Building 883 may ultimately be responsible for the PCE concentration at SW13494, especially if the foundation drains from Buildings 883 and 881 are linked. The high activities of U-isotopes observed at downgradient well 88101 are probably a result of historical activities within Building 881, especially because there are no similar concentrations of these analytes in any Building 881 upgradient wells. If no pertinent data are retrieved from dry well 39691 during calendar year 2003, it will be removed from the IMP as a D&D monitoring well and abandoned.

5.12 Building 991

Building 991 is located in the southeast corner of the former PA at RFETS and is the center of a complex that includes a series of four underground storage vaults connected by tunnels. The vaults, currently scheduled for demolition in mid-FY 2003, are referred to as Buildings 996, 997, 998, and 999. Building 991 encompasses 37,880 square feet on a first floor and basement. The four underground vaults have a total area of 20,940 square feet. The north half of Building 991 was used for shipping, receiving, final assembly, storage of classified material and SNM, laboratories, and housing of the PA alarm maintenance system. Offices occupy the south side of the building (DOE, 1994b).

Building 991 was the first production building to be completed at the Rocky Flats and was constructed between 1951 and 1952. At that time the building was designated as the "D" Plant and was used for shipping and receiving, and for the final assembly of Pu, enriched U, and depleted U components received from onsite fabrication operations. In addition, components from Oak Ridge and Hanford were assembled into final products (ChemRisk, 1992). Building 991 also served to house Rocky Flats administrative functions until Building 111 was completed. During 1957, when new weapons design began, final pit assembly took place in newly constructed Building 777. It is believed that assembly of the older U-based weapon continued in Building 991 until 1960. However, after 1957, the mission of Building 991 increasingly became one of a shipping, receiving, and storage facility. As of 1994, this building had the only shipping/receiving dock at the plant capable of handling offsite shipments of SNM and classified materials (DOE, 1994b).

The current D&D plan is that the vault and tunnel network will be left in place and that the main tunnel entrance(s) on the north side of Building 991will be sealed from top to bottom with expansive foam at least four feet thick to block any preferential pathway towards the main building (personal communication with JR Marshall, July 2003).

The Final Sampling and Analysis Plan for the D&D Groundwater Monitoring of Building 991 (RMRS, 2001d) was submitted to the Agencies in July 2001. Building 991 is currently scheduled for demolition in early FY 2004. This will allow adequate time for construction of a groundwater contaminant baseline for the D&D monitoring wells.

During 2001, upgradient monitoring wells 99101 and 99201 and downgradient monitoring wells 99301 and 99401 were installed. Only monitoring well 99301 could be fully developed during 2001; well 99101 was dry during 2001; monitoring wells 99201 and 99401 were in the process of being developed and were not able to be sampled during the 4th quarter 2001. Sampling results for 2002 ranged from three full sample rounds at well 99301 to one partial round for 99101. The SAP referenced above specified a D&D sampling location for the foundation drain for Building 991 (FD-991-1) as a manhole approximately 35 feet south of the northeast corner of the building. The location of this manhole could not be identified and therefore it was not sampled; this D&D sampling location has been removed from the IMP. Figure 5-18 presents the building location as well as the locations of the D&D monitoring wells.

Based on the research performed in support of the Building 991 D&D SAP, the contaminants of interest associated with Building 991 are U-isotopes and various VOCs. The D&D analytical suite for Building 991 consists of VOCs, metals, U-isotopes, Pu/Am, nitrate, and total petroleum hydrocarbons (TPH). A TPH sample was collected from each of wells 99301 and 99401 during 2002. TPH will be eliminated from the analytical suite, unless an excessively high result is obtained, once a sample has been collected from each of wells 99101 and 99201. Table 5-14 presents a summary of Building 991 D&D groundwater monitoring data collected through CY 2002. Until a baseline is established for Building 991, analytes will be discussed in terms of concentrations relative to Tier I and Tier II groundwater action levels.

Results of analyses performed on samples from Building 991 D&D wells indicate that, at all wells where groundwater has been available, activities of U-233/234 and U-238 are above Tier II action levels. At downgradient well 99401, U-233/234 and U-238 activities are above Tier I

Table 5-14 Historical Building 991 D&D Groundwater Monitoring Data.

Well and Location	Date	Metals Tier II (µg/L)	Nitrate (mg/L)	U-233 U-235 U-238 (pCi/L)	PCE (µg/L)	TCE (µg/L)	Pu Am (pCi/L)
99101 Upgradient	9/02	INSW	**150**	INSW	U	0.39	INSW
99201 Upgradient	2/02	INSW	0.76	**33.4** 0.897 **22.6**	U	U	INSW
	5/02	INSW	2.7	INSW	U	U	INSW
	8/02	INSW	2.5	**56.2** **3.8** **40.1**	U	**18.7**	INSW
99301 Downgradient	12/01	Se **164**	0.23	**21.4** 0.852 **16.2**	1.8	**55**	0.0123 0.0445
	3/02	Se **138** Tl **2.4**	0.47	**19.2** 0.766 **13.2**	1.1	**24.2**	0.0171 0.0218
	5/02		0.31	**12.6** U **9.78**	1.1	**31**	0.0193 U
	8/02	Se **175**	1.2	**15.1** **1.64** **10**	2.2	**58.9**	U 0.0311
99401 Downgradient	1/02	Se **424**	2	***241*** **9.68** ***185***	U	U	U 0.0283
	5/02	INSW	2.4	***317*** **19.8** ***233***	U	U	INSW
	7/02	Se **360** Tl **3.4**	2.8	***317*** **13.4** ***230***	U	U	0.0087 U

Notes: Concentrations greater than Tier II shown in Bold, Concentrations greater than Tier I shown in Italicized Bold, U = non detect, (B) = Analyte detected in the Method Blank, NA = not analyzed, INSW = Insufficient water available for sample collection, NS = not sampled

action levels, and U-235 activities are greater than the Tier II action level. The only nitrate result above Tier II is at upgradient well 99101. Downgradient wells 99301 and 99401 exhibit elevated concentrations of selenium for every sample round that groundwater has been available. The only VOC observed at a concentration greater than its Tier II action level is TCE in upgradient well 99201 (3rd quarter 2002 only) and downgradient well 99301 (all four sampling rounds to date). There has been insufficient water for any Pu/Am or metals samples from either of the two upgradient wells (99101 and 99201). There have been no Pu/Am detections above Tier II action levels at either of the downgradient wells.

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An average linear groundwater flow velocity of 290 ft/yr has been calculated for Building 991 utilizing 2nd quarter 2002 water level data. Hydraulic conductivity for the Qvf (Valley Fill Alluvium) and effective porosity values were used as described in Section 3.2 of this report.

In summary, the limited results to date for Building 991 indicate that U-isotopes, TCE, and selenium may be the analytes of interest in groundwater at Building 991. Pu/Am and PCE do not appear to be pre-D&D analytes of interest in groundwater at Building 991.

5.13 Building 559

Building 559, placed into service in 1968, is located approximately 190 feet west of Building 707 and 175 feet southwest of Building 776/777. The building contains laboratory facilities used to perform analyses of samples from production processes and products from all areas of the plant (DOE, 1992a). ChemRisk (1992) provides the following description of Building 559. The Building 559 Laboratory (the Plutonium Analytical Laboratory) was one of the four original service laboratories at Rocky Flats. The laboratory conducted analyses to determine the purity of Pu, what the impurities were and in what concentrations; and the concentrations of Pu alloys, whether in metal, liquid, or oxide form. The laboratory also analyzed gases and organics. The primary purpose of the laboratory was to sample incoming Pu site returns and feed material, and that which was recovered and/or purified and cast at the Site, for the production of weapons. Building 561, located immediately south of Building 559, houses all of the ventilation and air filtering systems associated with Building 559

The Final Sampling and Analysis Plan for the D&D Groundwater Monitoring of Building 559 (RMRS, 2001d) was submitted to the Agencies in July 2001. Building 559 is currently scheduled for demolition in mid-FY 2005. This should allow adequate time for construction of a chemical baseline for the D&D monitoring wells.

Well installation and sampling activities that took place at Building 559 during 2001 included the installation of five D&D wells; including the development and sampling of upgradient wells 56201 and 56301 and downgradient well 56901. Monitoring well 56001 could not be fully

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developed during the 4th quarter of 2001; monitoring well 56101 was dry during the 4th quarter of 2001. Figure 5-19 presents the building location and the locations of the D&D monitoring wells.

Based on the research performed in support of the Building 559 D&D SAP, the contaminants of interest associated with Building 559 are Pu and CF. The D&D analytical suite for Building 559 consists of VOCs, metals, U-isotopes, Pu/Am, nitrate, and PCBs. PCB samples have been discontinued at Building 559 because there have been no historical detections. Table 5-15 presents a summary of Building 559 D&D groundwater monitoring data collected through CY 2002. Until a baseline is established for Building 559, analytes will be discussed in terms of concentrations relative to Tier I and Tier II groundwater action levels.

Table 5-15 Historical Building 559 D&D Groundwater Monitoring Data.

Well and Location	Date	Nitrate (mg/L)	Pu Am (pCi/L)	U-233 U-235 U-238 (pCi/L)	VOCs > Tier II	
					Constituent	Concentration (ug/L)
56201 Upgradient	12/01	3.7	U 0.0237	0.334 0.189 0.152	1,1-DCE CT TCE	**8.2** **37** **20**
	5/02	3.9	0.0103 U	0.924 U 0.587	CT TCE	**34** **17.2**
	10/02	4	U 0.0223	**2.94** U **2.76**	CT TCE	**58.5** **12.5**
56301 Upgradient	12/01	2	0.0361 0.0067	**2.37** U **1.43**	1,1-DCE CT PCE TCE	**21** **44** **9.7** **16**
	5/02	2	U 0.0175	**2.54** U **1.67**	1,1-DCE CT PCE TCE	**15** **81.8** **7.42** **15.1**
	10/02	1.6	U U	**17.6** **1.03** **15**	1,1-DCE CT TCE	**9.98** **45.5** **7.67**
55901 Downgradient	12/01	5.8	U 0.0211	0.446 U 0.454	1,1-DCE CT PCE TCE	**13** **49** **5.5** **14**
	4/02	6.2	U 0.0185	**7.42** 0.411 **5.65**	1,1-DCE CT TCE	**18.6** **70.4** **13**
	10/02	6.2	U U	**4.2** 0.432 **3.56**	1,1-DCE CT TCE	**8.95** **79.8** **18.6**

Well and Location	Date	Nitrate (mg/L)	Pu Am (pCi/L)	U-233 U-235 U-238 (pCi/L)	VOCs > Tier II	
					Constituent	Concentration (ug/L)
56001 Downgradient	4/02	1.4	U U	**2.69** U **2.35**		
	10/02	NS	U 0.0066	**2.23** 0.19 **1.38**		
56101 Downgradient	4/02	1.8	INSW	**17.1** 0.602 **11**		
	10/02	3.5	U U	**16.4** .347 **10.1**		
FD-559-561 Upgradient	12/01	3.8	0.0093 0.0205	**1.35** U 0.628	1,1-DCE CT PCE TCE	**14** **100** **5.5** **270**
	5/02	3.9	U U	**1.1** U 0.755	1,1-DCE CT PCE TCE	**14.2** **99** **6.19** **204**
	10/02	3.4	U 0.0408	0.943 U 0.714	1,1-DCE CT PCE TCE	**16.2** **273** **6.21** **353**

Notes: Concentrations greater than Tier II shown in Bold, Concentrations greater than Tier I shown in Italicized Bold, U = non detect, NS = not sampled, INSW = Insufficient water available for sample collection, CT = carbon tetrachloride

Three of the new D&D monitoring wells (55901, 56201, and 56301) produced full sample suites in the 4th quarter of 2001. All five well produced two sets each of full sample suites during 2002 (except for Pu/Am at well 56101 during the 4th quarter). The results of the sampling completed to date at Building 559 indicate that Pu and CF may not be, as suggested in the SAP, the analytes of interest at Building 559. Neither Pu nor CF has been detected at concentrations above the Tier II action level, and Pu is generally non detect. Nitrate has not been detected above its Tier II action level at any well or FD-559-561. VOCs including CT; 1,1-DCE; and TCE were detected at concentrations greater than their Tier II action levels for all sample rounds at wells 56301 (upgradient) and 55901 (downgradient), and FD-559-561. PCE is the only other VOC detected at concentrations greater than the Tier II action level. There have been no detections of VOCs above Tier II action levels at downgradient wells 56001 and 56101. Each well and FD-559-561 has had at least one detection of a U-isotope above the Tier II action level. The only metal detected at a concentration greater than the Tier II action level is thallium at downgradient wells 56001 and 56101 during the 4th quarter of 2002.

An average linear groundwater flow velocity of 65 ft/yr has been calculated for Building 559 utilizing 2nd quarter 2002 water level data. Hydraulic conductivity for the Qrf and effective porosity values were used as described in Section 3.2 of this report.

In summary, based on the sampling results to date, Pu, CF, and nitrate are not pre-D&D contaminants of interest. VOCs are potentially upgradient contaminants of interest for this building, and the concentrations of VOCs seen in upgradient wells 56201 and 56301 and downgradient well 55901 are probably attributed to chemical storage areas and documented spills to the southwest of Building 559. U-isotopes are potentially a D&D contaminant of interest for this building.

5.14 Future Activities

Building D&D monitoring was initiated at RFETS to determine if building demolition might result in adverse environmental impacts to groundwater, ultimately for the purpose of providing protection to surface water should such impacts be detected. While examining the preliminary data from D&D wells, a plan was being formulated as to how contaminant data from these areas might be best used to guide future decisions related to surface water protection. The immediate answer is clear – only a few of the D&D wells contribute what might be considered "essential" Site knowledge uniquely suited for that purpose. Those few wells are the ones lying along the exterior of the IA, downgradient of buildings and upgradient of drainages. D&D wells at buildings located more interior to the IA contribute no information that is not adequately captured by other "Program" wells, located between the buildings and surface water, which are currently sampled and potentially of better construction. These Program wells are better suited to monitor the effects of significant releases in these areas.

Water Program staff will discuss discontinuation of all or a portion of this monitoring program with Agency staff and stakeholders at future IMP meetings.

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Figure 5-2
Upgradient vs Downgradient Comparison
Building 123
Well 10198 vs 10498 for Nitrate

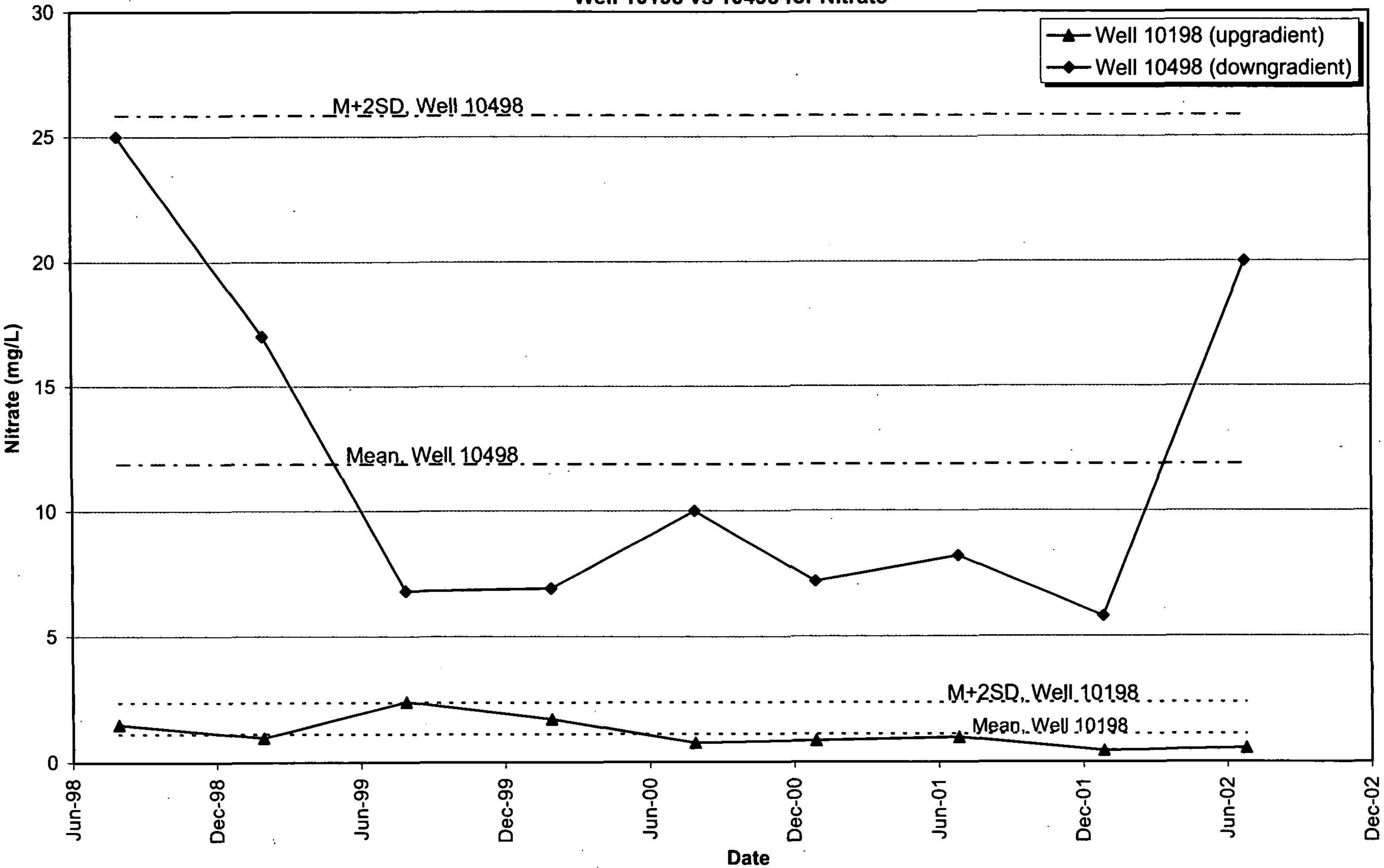

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Figure 5-3
Upgradient vs Downgradient Comparison
Building 123
Well 10198 vs 10498 for U-233/234

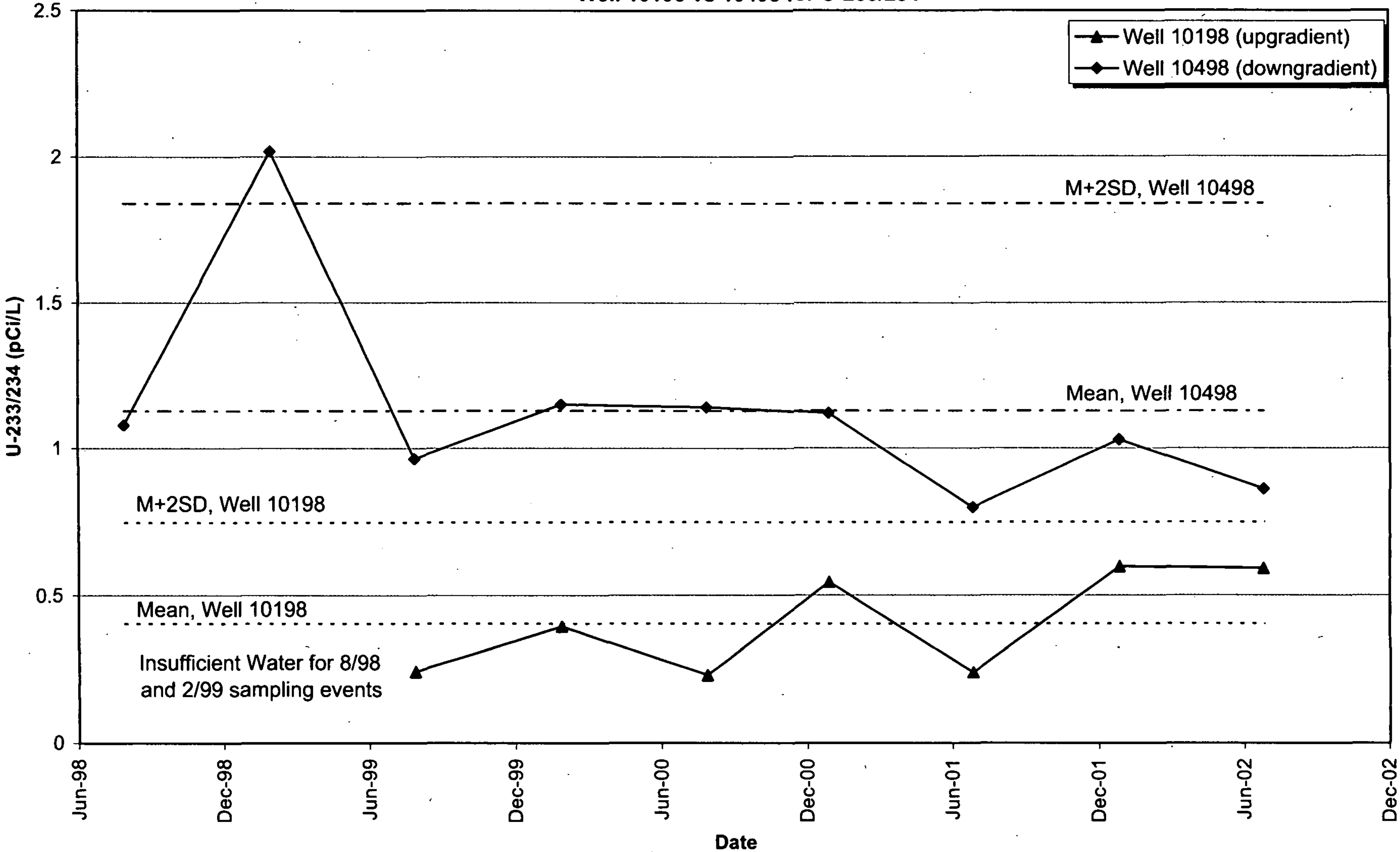

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Figure 5-4
Upgradient vs Downgradient Comparison
Building 123
Well 10098 vs 10298 for Nitrate

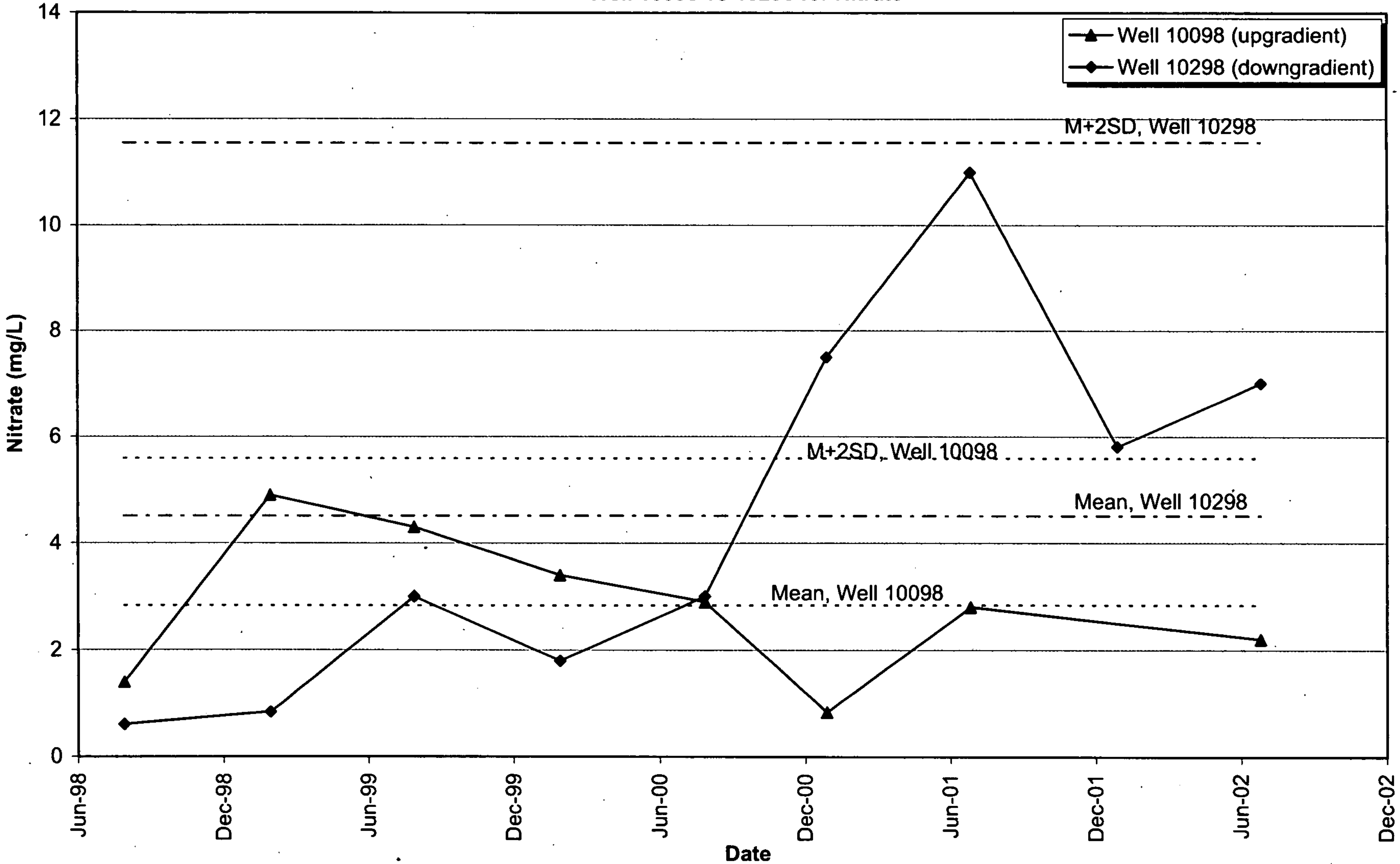

Figure 5-5
Upgradient vs Downgradient Comparison
Building 123
Well 10098 vs 10298 for U-233/234

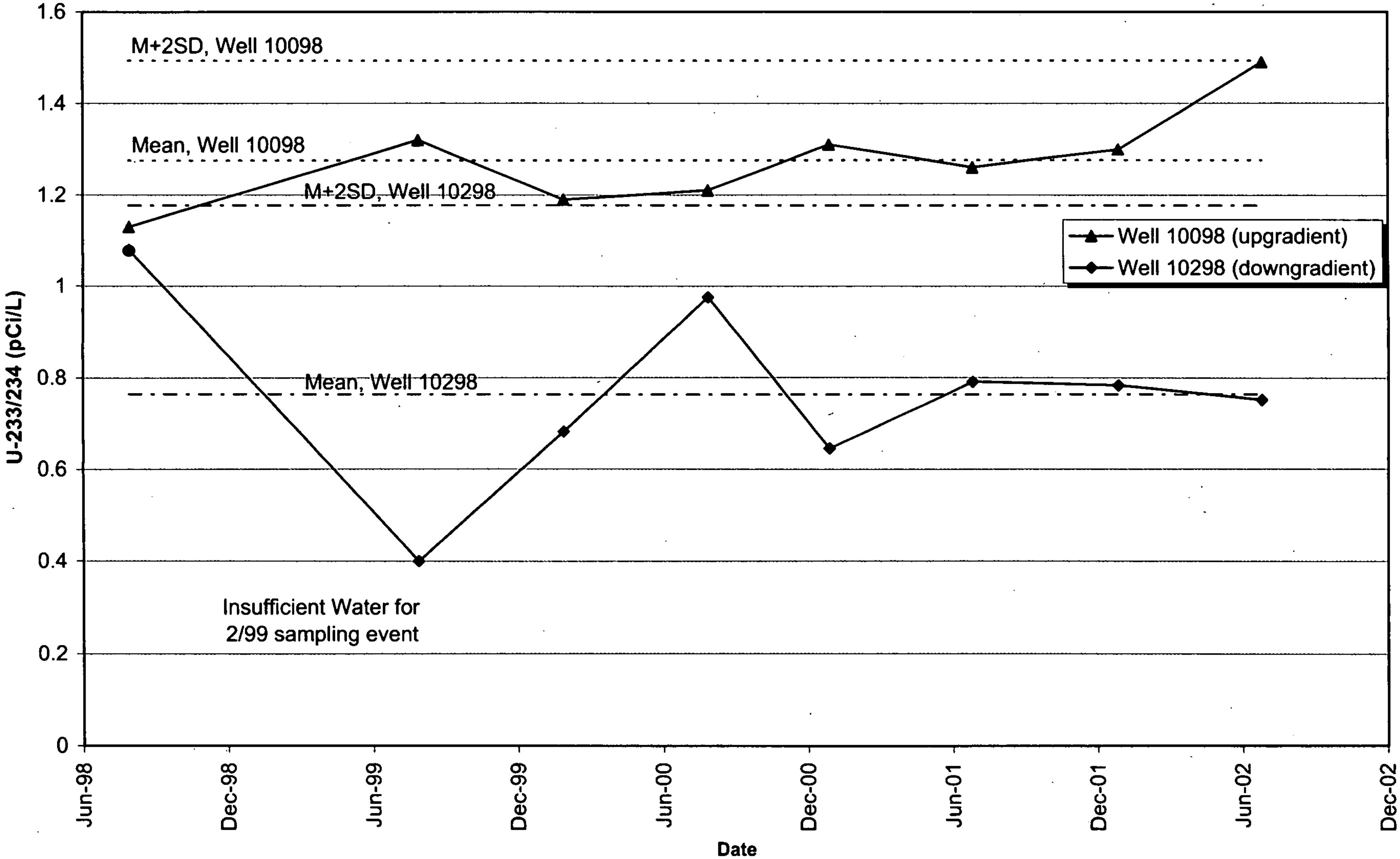

Figure 5-10
Upgradient vs Downgradient Comparison
Building 779
Well 02397 vs 02500 for TCE

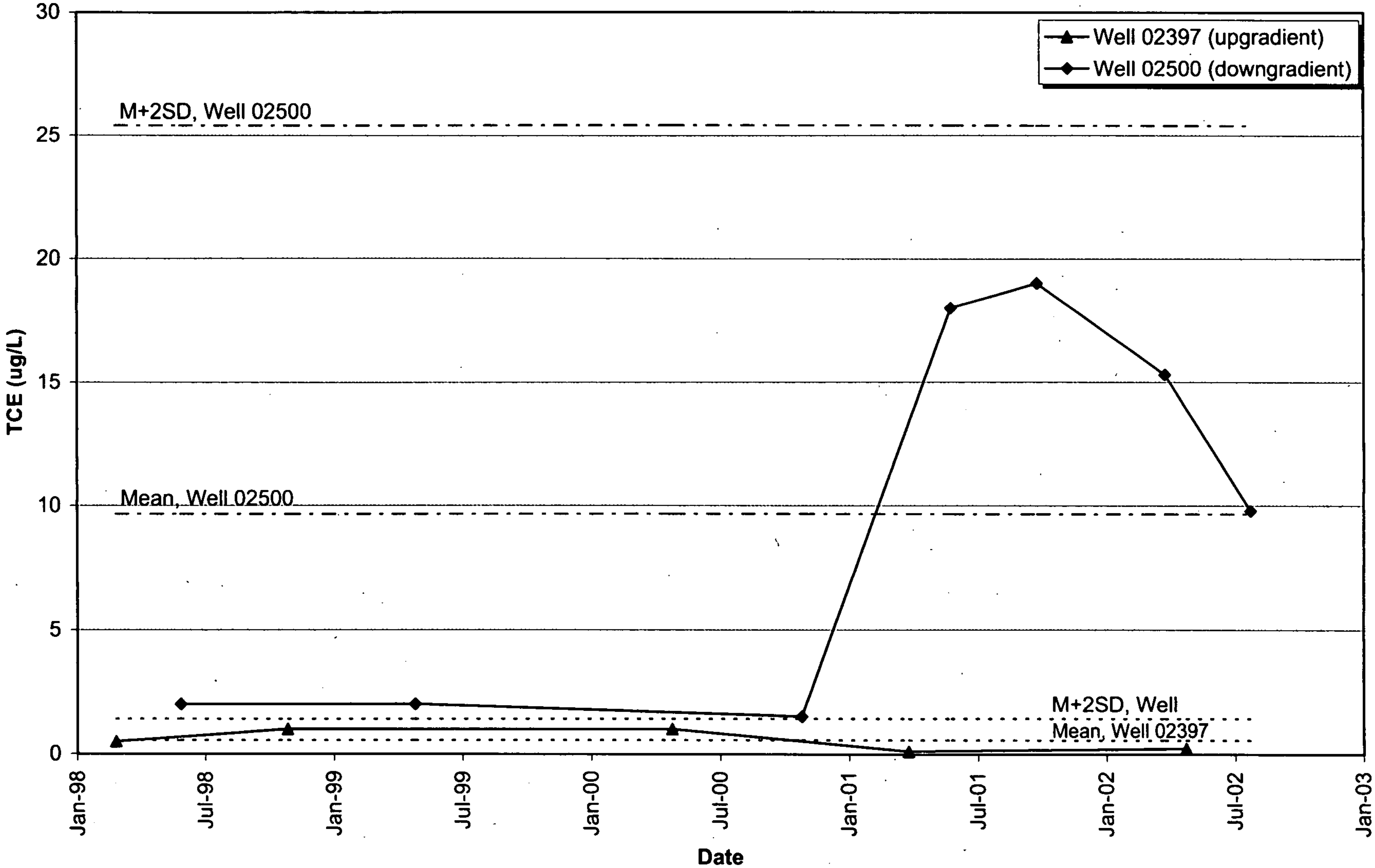

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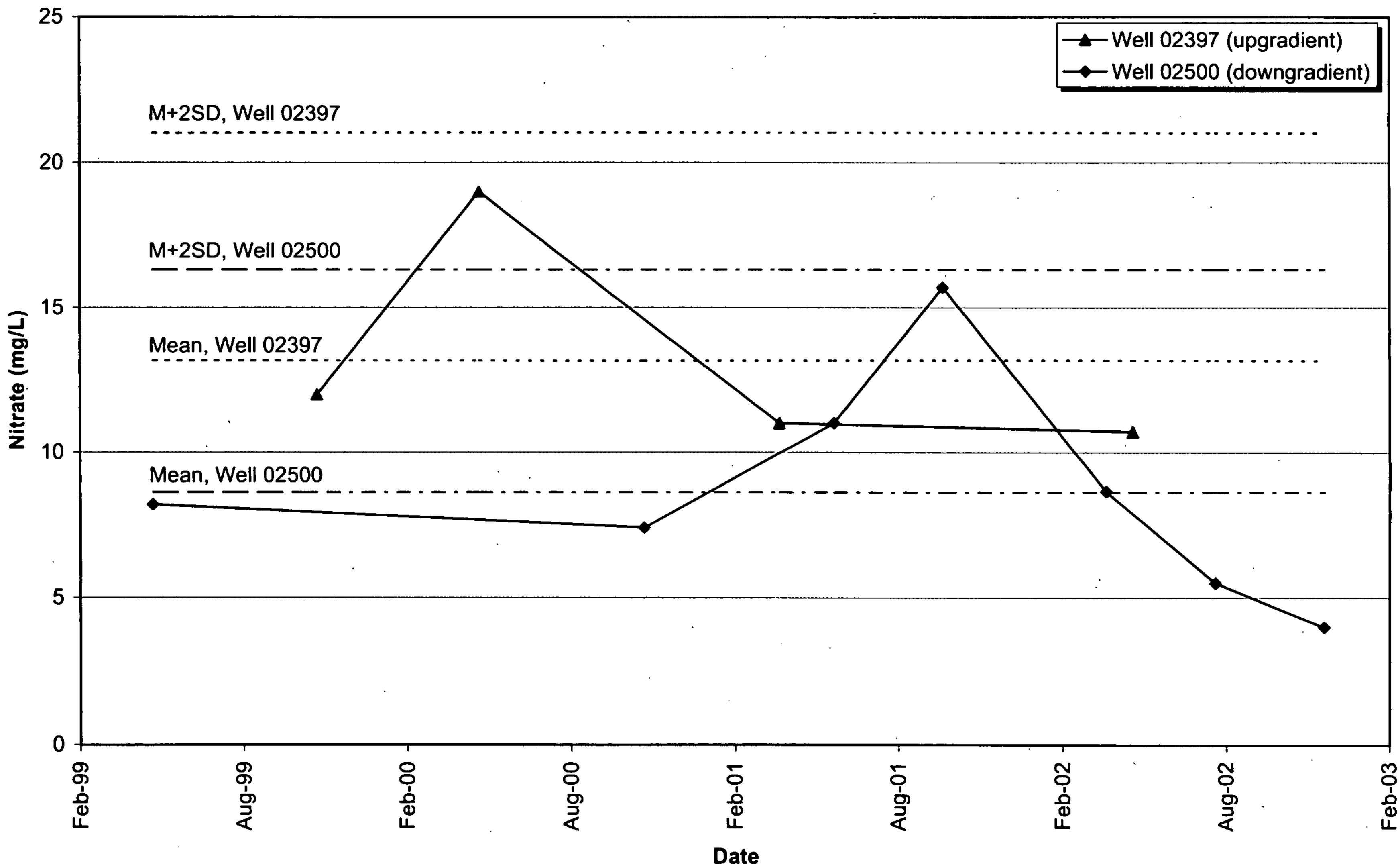
Figure 5-11
Upgradient vs Downgradient Comparison
Building 779
Well 02397 vs 02500 for Nitrate



6.0 PRESENT LANDFILL – 2002 UPDATE

This section presents the CY 2002 groundwater quality data for the Present Landfill (Landfill), previously known as OU7, which is located in the BZ north of the IA. Throughout 2002, groundwater monitoring was conducted in accordance with the requirements of the RFCA (RFCA, 1996) as set forth in the IMP (K-H, 2002e). The landfill occupies approximately 44 acres (including the Landfill and Landfill Pond) at the western end of the No Name Gulch drainage (Figure 6-1). A seep exists at the east face of the Landfill, as a result of infiltration of precipitation and the migration of groundwater through the landfill. The Landfill served as a former solid waste disposal facility for RFETS and has not been operational since 1998.

The Annual RCRA Groundwater Monitoring Reports for RFETS (DOE, 1990; 1991a, 1992d, 1993c, 1994c, 1995, and 1996a) describe groundwater data for 1989 through 1995 at the Landfill. The *Phase I RCRA Facility Investigation/Remedial Investigation Work Plan for Operable Unit 7: Present Sanitary Landfill* (DOE, 1991b) presents additional information. Subsequent groundwater monitoring activities conducted under RFCA during calendar years 1996, 1997, 1998, and 1999 are presented in annual Present Sanitary Landfill Groundwater Monitoring Reports (DOE, 1997b; 1998a, 1999, and 2000). Since 1999, the yearly data assessment for the landfill is included in the Annual RFCA Groundwater Monitoring Reports (Safe Sites 2001a; 2002b). Additional background information regarding the landfill can be found in the *Draft Interim Measure/Interim Remedial Action for Operable Unit 7 (IHSS 114) and RCRA Closure of the RFETS Present Landfill* (K-H, 2003b).

6.1 Current Present Landfill Groundwater Monitoring Program

Changes to the Site groundwater monitoring program implemented in 2002 are outlined in the IMP (K-H, 2002e), which includes the monitoring and reporting requirements for the Landfill, including well identification, sampling frequency, and analytical requirements.

The Landfill currently operates under CDPHE and EPA guidelines for solid waste disposal sites and facilities. The current groundwater monitoring program was instituted in accordance with the RFCA, as further defined in the IMP for RCRA units. RCRA interim status groundwater

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monitoring is currently conducted to detect potential releases bases on comparisons of upgradient to downgradient groundwater quality. If the mean concentration for an individual constituent in a downgradient well is statistically different from the mean concentration in an upgradient well, and the concentration in the downgradient well shows a statistically significant increase with time, then the results are reported to EPA and CDPHE. An evaluation is conducted to determine potential impacts to surface water via groundwater and monitoring continues. Reporting to CDPHE and EPA would be through the quarterly groundwater monitoring reports and during the quarterly data exchange meetings.. Consistent with the IMP, attention is given to the groundwater contaminants listed in RFCA Attachment 5 (RFCA 1996 et. al), which, if exceeded may trigger an evaluation, remedial action, and/or management action. Non-ALF constituents, such as the major cation metals sodium, potassium, calcium, and magnesium, are not reportable under RFCA, and therefore not emphasized in this report. Figure 6-1 present the locations of the eight existing RCRA wells in relation to relevant surface and subsurface features at the Landfill.

For the CY 2002 reporting period, quarterly sampling of the four upgradient RCRA wells (70193, 70393, 70493, and 5887) and four downgradient RCRA wells (4087, 52894, 52994, and B206989) was attempted to ensure compliance with RFCA. Downgradient well pair 52894/52994 was dry the entire year. Table 6-1 summarizes sampling activities and shows the hydrostratigraphic unit monitored and material screened for these wells. The limited number and position of existing wells makes it difficult to construct potentiometric surface maps and concentration isopleth maps, thus current and future reports will only assess impacts to or from the Landfill at the upgradient and downgradient Landfill boundaries.

Groundwater elevations for active wells were measured quarterly, if possible, as directed in the IMP. Quarterly groundwater samples from the RCRA wells were analyzed for tritium and U-isotopes, VOCs, metals, major anions, sulfate, fluoride, and nitrate/nitrite, in accordance with Appendix E-2 of the IMP. It is normally impossible to collect complete downgradient sample sets for each quarterly sampling period during the year. The incomplete analyte suites collected for most 2002 quarters in the downgradient RCRA wells were due to slow recharge and/or limited saturated thickness superimposed on extremely dry conditions at the Site during the 2nd half of 2001 and all of 2002.

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Table 6-1 Well Completion Information and CY 2002 Sampling Summary for Present Landfill Wells.

Well	HSU	Screened Material	Quarterly Sampling Summary			
			Q1	Q2	Q3	Q4
Upgradient Wells						
5887	Upper	Qrf	V,W,N,M,T,U	V,W,N,M,T,U	V,W,N,M,T,U	V,W,N,M,T,U
70193	Upper	WBR	V,W,N,M,T,U	V,W,N,M,T,U	V,W,N,M,T,U	V,W,N,M,T,U
70393	Upper	Qrf	V,W,N,M,T,U	V,W,N,M,T,U	V,W,N,M,T,U	V,W,N,M,T,U
70493	Upper	WBR	V,W,N,M,T,U	V,W,N,M,T,U	V,W,N,M,T,U	V,W,N,M,T,U
Downgradient Wells						
4087	Upper	Qvf	Dry	V,W,N,M,T,U	V,N	Dry
52894	Upper	Qvf	Dry	Dry	Dry	Dry
52994	Upper	WBR	Dry	Dry	Dry	Dry
B206989	Upper	WBR	W,N,M,T,U	Dry	V,W,N,M,T,U	V,W,N,U

Notes: V=volatile organic compounds; W=water quality parameters; N=nitrate/nitrite; M=metals; T=tritium; U=uranium isotopes; No sulfate samples were collected from well B206989 during 2002; WBR = weathered bedrock.

Some historical contaminants, such as semivolatile organic compounds (SVOCs), were not included in the sampling program as a result of contaminant screening conducted during the IMP DQO process and acceptance of the plan by EPA and CDPHE. Table 6-2 lists the constituents monitored for in wells within and near the Landfill.

6.2 Physical Characteristics of the Groundwater System

6.2.1 Hydrogeology of the Present Landfill

The "uppermost aquifer", described in Section 1.2.4.1 of this report, is equivalent to the UHSU. The uppermost aquifer in the vicinity of the Landfill is defined to include alluvium (Rocky Flats Alluvium and Valley Fill Alluvium), colluvium, and weathered bedrock of the Arapahoe Formation that is in direct hydraulic communication with the overlying surficial deposits. Weathered bedrock materials are generally more permeable than unweathered bedrock. Unweathered claystones are considered part of the LHSU. Bedrock wells were assigned to a

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hydrostratigraphic unit (either upper or lower) based on geological information from borehole logs, sampling results, and, where available, hydraulic conductivity measurements. In the Landfill proper, the uppermost aquifer also includes artificial fill (the Landfill wastes mixed with daily cover material).

UHSU Groundwater is present in Qrf, Qvf, Qc, artificial fill, weathered claystones, and potentially weathered sandstones in the area of the Landfill. The Qrf is 25 to 30 feet thick on the northwest, west, and southwest sides of the Landfill, and 10 to 15 feet thick on the divides north and south of the Landfill Pond. The Qc is 1 to 5 feet thick on the slopes around the Landfill Pond and below the dam. The Qvf ranges in thickness from 3 to 8 feet in the area of the Landfill and becomes thicker downstream (to the east). The thickness of artificial fill ranges from about 5 feet at the edges of the Landfill to about 45 feet near the centerline of the valley (DOE, 1996c). Weathered bedrock thickness varies considerably in the vicinity of the Landfill, ranging from approximately 4 to 35 feet, as indicated by weathered bedrock isopach mapping of the area (EG&G, 1995a).

Table 6-2 Chemical and Radiological Constituents Monitored at the Present Landfill.

Volatile Organic Compounds	Volatile Organic Compounds	Metals
1,1,1,2-Tetrachloroethane	Cis-1,2-Dichloroethene	Cadmium
1,1,1-Trichloroethane	Cis-1,3-Dichloropropene	Calcium
1,1,2,2-Tetrachloroethane	Dibromochloromethane	Chromium
1,1,2-Trichloroethane	Dibromomethane	Cobalt
1,1-Dichloroethane	Dichlorodifluoromethane	Copper
1,1-Dichloroethene	Ethylbenzene	Iron
1,1-Dichloropropene	Hexachlorobutadiene	Lead
1,2,3-Trichlorobenzene	Isopropylbenzene	Lithium
1,2,3-Trichloropropane	Methylene Chloride	Magnesium
1,2,4-Trichlorobenzene	Naphthalene	Manganese
1,2,4-Trimethylbenzene	n-Butylbenzene	Mercury

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Volatile Organic Compounds	Volatile Organic Compounds	Metals
1,2-Dibromo-3-chloropropane	n-Propylbenzene	Molybdenum
1,2-Dibromoethane	o-Chlorotoluene	Nickel
1,2-Dichlorobenzene	p-Chlorotoluene	Potassium
1,2-Dichloroethane	4-Isopropyltoluene	Selenium
1,2-Dichloropropane	sec-Butylbenzene	Silver
1,3,5-Trimethylbenzene	Styrene	Sodium
1,3-Dichlorobenzene	tert-Butylbenzene	Strontium
1,3-Dichloropropane	Tetrachloroethene	Thallium
1,4-Dichlorobenzene	Toluene	Tin
Bromobenzene	Trans-1,3-Dichloropropene	**Water Quality Parameters**
Bromochloromethane	Trichloroethene	Fluoride
Bromodichloromethane	Trichlorofluoromethane	Nitrate/Nitrite
Bromoform	Vinyl Chloride	Sulfate
Bromomethane	**Metals**	Total Dissolved Solids
Carbon Tetrachloride	Aluminum	**Radionuclides**
Chlorobenzene	Antimony	Tritium
Chloroethane	Arsenic	Uranium-233/234
Chloroform	Barium	Uranium-235
Chloromethane	Beryllium	Uranium-238

6.2.2 Groundwater Conditions

Groundwater flow patterns in the UHSU at RFETS tend to mimic the surface topography. Within the Landfill artificial fill, groundwater generally flows toward the center of the Landfill, and then east toward the Landfill Pond, although, hydrologic modeling performed by the Water Program has predicted that, within the waste, groundwater can locally flow toward the Landfill drain system (laterally outward). Outside the Landfill, groundwater generally flows eastward within saturated UHSU deposits, except within stream valleys, which function as drains for UHSU groundwater. For example, adjacent to the Landfill Pond, groundwater flows to the north and south toward the pond because of its low topographic position in the No Name Gulch drainage. Groundwater entering the pond mixes with surface water and is discharged by evaporation or is pumped to Pond A-3. To some extent, pond water may percolate downward into underlying bedrock materials and beneath or laterally through the dam.

Groundwater elevations in monitoring wells are measured at least quarterly. Historically, water levels in the surficial deposits of the UHSU are characterized by seasonal variations of as much as 10 feet. The water table elevation is generally lowest in late winter and early spring, prior to recharge by snowmelt, and highest during June and July. Groundwater elevations in UHSU weathered bedrock have shown seasonal variations of as much as 15 feet.

In the past, the average depth to groundwater ranged from 5 to 15 feet in surficial deposits, excluding artificial fill (EG&G, 1995b). Most of the well pairs within the Landfill have been abandoned in recent years in preparation of closure of the facility. Historically, within the Landfill, groundwater was found at approximately 20 feet at the western end, 16 feet in the middle, and 33 feet at the eastern end (DOE, 1996c). The depth to groundwater in weathered bedrock is generally greater than in the overlying surficial deposits because of downward vertical gradients in bedrock materials. The saturated thickness of UHSU deposits varies widely across the Landfill, with the thickest sections found in the Qrf at the western end. The thinnest saturated sections are found in Qc and Qvf deposits east of the Landfill Pond and in the Qrf along the south divide. EG&G (1995b) reported saturated thickness ranging from 0 to 20 feet for surficial deposits at the Landfill.

Nested upgradient RCRA well pair 70393/70493 is located approximately 400 feet southwest of the western edge of the groundwater intercept system. Well 70393 is screened to the base of the Qrf and well 70493 is completed in the weathered bedrock just below the alluvium/bedrock contact. The screened interval and sandpack of this well does not connect with the overlying alluvium. These RCRA wells generally maintain a water elevation within approximately one foot except for short periods after large recharge events like the one experienced at RFETS during March 2003.

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This situation varies from the scenario observed at downgradient nested RCRA well pair 4087/B206989, located approximately 250 feet east of the crest of the Landfill Pond dam. Well 4087 is screened to the base of the Qvf and well B206989 is completed in the weathered bedrock just below the alluvium/bedrock contact. The screened interval and sandpack of this well does not connect with the overlying alluvium. The head difference in these two RCRA wells at the most recent time that they both contained water (July 2002) was approximately 17 feet, with the deeper water level found in the weathered bedrock well. The fact that the water level in the alluvial well fluctuates more and is dry more often than the bedrock well, and that the alluvial well is dry at times when the weathered bedrock well appears to be recharging suggests that recharge to the weathered bedrock well may be from upgradient and/or beneath the dam; recharge to the alluvial well may largely be from precipitation.

The upgradient RCRA locations usually have ample groundwater available for sampling. Mounding immediately upgradient of the Landfill, which may be caused by infiltration from the unlined surface water diversion ditch, may be responsible for the abundant recharge to the upgradient wells. Alternately, the alluvium and weathered bedrock at the downgradient locations are frequently dry or thinly saturated because the Landfill Pond dam acts as a barrier to alluvial groundwater flow from the west, and the volume of groundwater flow beneath the Landfill and dam in weathered bedrock is relatively small. In addition, ET consumes much of the available shallow groundwater in the No Name Gulch drainage during the summer months.

6.2.3 Vertical Hydraulic Gradients

The vertical hydraulic gradient is the ratio of the differences in water levels measured concurrently in two adjacent wells with different screened intervals, and the vertical distance between the two measuring points, described here as the midpoint of each screened interval. Vertical hydraulic gradient calculations provide a means to evaluate whether groundwater flow has a potential for movement either downward or upward through geologic media.

As stated above, most of the well pairs within the Landfill have been abandoned in recent years. Consequently, current water level data from within the Landfill are unavailable. The historic vertical hydraulic gradients that were calculated for well pairs within the Landfill generally

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indicated a downward (recharging) component of flow, with values ranging from 0.022 to 1.099 ft/ft. At one well pair, 72393/72093, situated within the center of the Landfill, groundwater had a slight upward (discharging) vertical gradient that ranged from 0.020 to 0.026 ft/ft. Historical data from all the well pairs indicate that vertical hydraulic gradients generally remained constant over time.

A current (July 2002) vertical hydraulic gradient for downgradient well pair 4087/B206989 indicates a downward (recharging) component of flow at 0.686 ft/ft.

6.2.4 Average Linear Flow Velocities

The existing RCRA wells have flow boundaries between them (Landfill east face, the Landfill Pond and dam) and calculating flow velocities between them would be difficult and probably inaccurate. Historically, the average linear groundwater flow velocity was calculated for three flowpaths in UHSU surficial deposits and three flowpaths in UHSU bedrock in the vicinity of the Landfill (DOE, 1996b). The following paragraph, summarized from the 1995 RCRA Groundwater Monitoring Report (DOE, 1996a), is generally considered indicative of historic flow velocities within the Landfill.

The calculated average linear groundwater flow velocities in fill materials ranged from approximately 1 foot per year at the west end of the Landfill to approximately 160 feet per year at the eastern face of the landfill. Calculated average linear groundwater flow velocities in UHSU bedrock at the Landfill ranged from approximately 0.20 feet to 0.22 feet per year beneath the Landfill, to approximately 0.07 feet to 0.41 feet per year downgradient of the Landfill (DOE, 1996a). The calculated average linear groundwater flow velocities for UHSU bedrock in 1995 were similar to those reported in the *1994 Annual RCRA Groundwater Monitoring Report* (DOE, 1995).

6.3 Groundwater Quality at the Present Landfill

The assessment of current groundwater chemistry at the Landfill includes a discussion of the spatial distribution of groundwater constituents in and around the Landfill, and a statistical evaluation of the chemistry of downgradient groundwater with respect to upgradient groundwater, as specified in *6 CCR 1007-2, 6 CCR 1007-3,* and the IMP. Statistical comparisons between downgradient and upgradient groundwater data were made using methodology described in the *1995 Annual RCRA Groundwater Monitoring Report* (DOE, 1996a) and *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities* (EPA, 1992b).

6.3.1 Areal Distribution of Groundwater Constituents – 2002

There were only five sampling events (including four incomplete sample suites) at the downgradient RCRA monitoring wells during 2002. As discussed above, well pair 52894 (alluvial) and 52994 (weathered bedrock) produced no samples. Downgradient well pair 4087 (alluvial) produced one full sample suite in April and VOCs and nitrate in July, and B206989 (weathered bedrock) produced three partial sets of samples in January (no VOCs or sulfate), July (no sulfate), and November (no metals or sulfate).

The four upgradient RCRA monitoring wells each produced four full sample suites during 2002; one suite at each well during each quarter.

6.3.1.1 Volatile Organic Compounds in Groundwater

At downgradient RCRA wells 4087 and B206989, there were no concentrations of any VOCs above Tier II action levels from any of the sampling events at either of the two wells, and very few detections of VOCs overall.

At the upgradient RCRA locations, wells 5587, 70193, and 70493 exhibited no concentrations of VOCs above Tier II action levels from any of the sampling events and very few detections of VOCs overall. Alluvial well 70393 had concentrations of PCE; TCE; and 1,1-DCE which were greater than their Tier II action levels for all four sampling rounds (except for PCE during the 3rd quarter; 4.9 µg/L). All of the concentrations show little variation during the course of the year and hover near the Tier II action level. The VOCs at well 70393 are associated with the PU&D Yard.

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6.3.1.2 Metals in Groundwater

Downgradient RCRA alluvial well 4087 did not have any metals results above Tier II action levels during the 2nd quarter sampling event. Weathered bedrock well B206989, exhibited concentrations of selenium, lithium, and thallium that were greater than their Tier II action levels for both sampling rounds during 2002 where metals samples were collected (1st and 3rd quarters).

The only metals detections above Tier II action levels at the upgradient RCRA wells were for thallium. Alluvial well 5587 had two (1st and 3rd quarters), and weathered bedrock well 70493 had one (4th quarter). The range for the three detections was 2.2 to 6.2 µg/L; most results for thallium were non detect. There were no detections of any metals above groundwater Tier II action levels at seep SW097 during the one sampling event that occurred during 2002.

6.3.1.3 Radionuclides in Groundwater

Downgradient RCRA wells 4087 and B206989 have results above Tier II for U-233/234 and U-238 for all 2002 sampling rounds where U-isotope samples were collected. Well B206989 also exhibits results above Tier II for U-235 for two sample events. The concentrations of U-233/234 and U-238 in weathered bedrock well B206989 are about five times greater than the concentrations of these analytes in alluvial well 4087.

In contrast, three of the four upgradient RCRA wells have no results above Tier II action levels for U-isotopes and many results are non detect or estimated (J qualified) values. All of the U-233/234 and U-238 results above Tier II in the upgradient wells were from weathered bedrock well 70493. The activity concentrations of the U-233/234 and U-238 results in upgradient well 70493 are approximately 50 times lower than downgradient well B206989.

Based on ICP/MS analyses, the U-isotope activities at the Landfill have been determined to be naturally occurring (Safe Sites, 2001a). Tritium and strontium-89/90 were not detected above their Tier II action levels in any of the Landfill RCRA wells.

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6.3.1.4 Nitrate in Groundwater

Nitrate was found in downgradient weathered bedrock well B206989 at concentrations above the Tier II action level (10 mg/L) for all three sampling events. Nitrate was not found above 1 mg/L in downgradient alluvial well 4087.

At the upgradient RCRA wells, there were no detections of nitrate above the Tier II action level, although well pair 70393/70493 had detections ranging from 2 to 5 mg/L.

Tables 6-3 and 6-4 summarize the analytical data for 2002 at the Landfill RCRA wells.

6.3.2 Statistical Evaluation of Groundwater Constituents

According to the IMP, the decision logic for RCRA designated wells requires the performance of a comparison of pooled upgradient groundwater sample means to individual downgradient well sample means to evaluate potential contaminant releases from the regulated unit into the UHSU.

Table 6-3 Analytical Summary of Downgradient UHSU Weathered Bedrock Well B206989, Tier II Exceedances-2002.

Dates	Radionuclides U-233/U-235/U-238 (pCi/L)	Lithium (µg/L)	Selenium (µg/L)	Nitrate (mg/L)	Thallium (µg/L)
1/02	55.2/<Tier II/33.9	1150	259	69.4	2.4
7/02	56.6/2.07/35.1	1200	410	40.3	4.6
11/02	59.4/1.99/36.9	NS	NS	19	NS
Tier II Action Level	**1.06/1.01/0.768**	**730**	**50**	**10**	**2**

Notes: NS = not sampled; There were no Tier II exceedances for VOCs in well B206989; Downgradient well 4087 had Tier II exceedances for U-233/234 and U-238 only (see text).

Table 6-4 Analytical Summary of Upgradient UHSU Wells 70393 and 70493, Tier II Exceedances-2002.

Well	Date	VOCs PCE/TCE/1,1-DCE (µg/L)	Radionuclides U-233/U-238 (pCi/L)	Thallium (µg/L)
70393 (alluvial)	2/02	6/20/11	< Tier II	< Tier II
	5/02	6.4/21.7/12	< Tier II	< Tier II
	7/02	< Tier II/16.4/10.2	< Tier II	< Tier II
	11/02	5.2/17/9.2	< Tier II	< Tier II
70493 (weathered bedrock)	2/02	< Tier II	1.04/< Tier II	< Tier II
	5/02	< Tier II	1.12/0.833	< Tier II
	7/02	< Tier II	< Tier II	< Tier II
	10/02	< Tier II	< Tier II	2.4
Tier II Action Level		**5/5/7**	**1.06/0.768**	**2**

Notes: Upgradient wells 5887 and 70193 had Tier II exceedances, 2 each, for thallium only (see text).

This type of comparison is usually accomplished using the statistical analysis procedures described in *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities* (EPA, 1992b). The 2001 assessment of the individual downgradient well data sets indicated that the number of sample analyses in all downgradient sets (maximum three samples) were insufficient for performing nonparametric analysis (minimum four samples) on an individual well basis. The lack of samples was because of dry conditions in all of the downgradient wells during 2001. To provide adequate data for nonparametric statistical analysis, it was necessary to pool the 2001 downgradient well data for comparison to the upgradient data. Because of the continued lack of groundwater downgradient of the Landfill, this same approach to pooling downgradient well data was used during 2002.

Table 6-5 presents a sampling and detection summary for groundwater analytes that were detected at least once during 2002. Statistical comparisons were not performed for analytes with upgradient sample means that were equal to or greater than downgradient sample means; analytes with less than 30 percent quantifiable results; or analytes with less than three quantifiable results.

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VOCs were excluded from statistical analysis because groundwater upgradient of the Landfill has historically been contaminated with VOCs relative to downgradient groundwater due to the PU&D Yard; there were almost no detections of VOCs in downgradient groundwater during 2002. Data for aluminum, arsenic, barium, beryllium, cobalt, iron, lead, mercury, silver, tin, vanadium, zinc, and tritium were excluded from statistical evaluation because upgradient sample means were greater than downgradient sample means, or there were no detections for the analyte in the downgradient wells. In the case of cobalt and tin, there were no detections in either upgradient or downgradient wells.

Table 6-5 Groundwater Sample Summary for Detected Analytes in Landfill RCRA Wells – CY2002.

Parameter	Number of Samples		Number of Detections		Percent Detections (%)		Sample Mean	
	Up-Gradient	Down-Gradient	Up-Gradient	Down-Gradient	Up-Gradient	Down-Gradient	Up-Gradient	Down-Gradient
Water Quality (mg/L)								
Fluoride	16	1	9	1	56.25	100.0	0.289	2.55
Nitrate/Nitrite, as N	16	5	16	5	100.0	100.0	3.269	25.88
Sulfate	16	1	16	1	100.0	100.0	23.41	352
TDS	16	1	16	1	100.0	100.0	153.3	841
Metals (µg/L)								
Aluminum	16	3	13	3	81.25	100.0	113.5	37.0
Antimony	16	3	3	1	18.75	33.33	0.654	0.817
Arsenic	16	3	2	1	12.50	33.33	1.849	1.217
Barium	16	3	16	3	100.0	100.0	80.21	15.96
Beryllium	16	3	4	0	25.00	0.00	ND	ND
Cadmium	16	3	2	3	12.50	100.0	0.162	0.43
Calcium	16	3	16	3	100.0	100.0	24,491	336,033
Chromium	16	3	12	2	75.00	66.67	1.176	10.62
Cobalt	16	3	0	0	0.00	0.00	ND	ND
Copper	16	3	9	3	56.25	100.0	1.159	4.4
Iron	16	3	12	1	75.00	33.33	52.51	13.93
Lead	16	3	2	0	12.50	0.00	ND	ND
Lithium	16	3	13	3	81.25	100.0	11.0	826.3

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Parameter	Number of Samples		Number of Detections		Percent Detections (%)		Sample Mean[1]	
	Up-Gradient	Down-Gradient	Up-Gradient	Down-Gradient	Up-Gradient	Down-Gradient	Up-Gradient	Down-Gradient
Magnesium	16	3	16	3	100.0	100.0	5299	136,067
Manganese	16	3	14	3	87.50	100.0	2.696	15.48
Mercury	16	3	1	1	6.25	33.33	0.048	0.027
Molybdenum	16	3	10	3	62.5	100.0	2.402	4.0
Nickel	16	3	9	2	56.25	66.67	2.581	3.533
Potassium	16	3	13	3	81.25	100.0	947.8	11,029
Selenium	16	3	7	3	43.75	100.0	2.695	228.3
Silver	16	3	4	0	25.00	0.00	ND	ND
Sodium	16	3	16	3	100.0	100.0	13,440	530,333
Strontium	16	3	16	3	100.0	100.0	157.9	4236
Thallium	16	3	3	3	18.75	100.0	1.298	2.967
Tin	16	3	0	0	0.00	0.00	ND	ND
Uranium, total	16	3	0	3	0.00	100	10.87	65.9
Vanadium	16	3	7	1	43.75	33.33	1.459	0.817
Zinc	16	3	11	2	68.75	66.67	8.617	8.017
Radionuclides (pCi/L)								
Tritium	16	3	1	0	6.25	0.00	ND	ND
U-233/234	16	4	4	4	25.00	100.0	0.246	45.45
U-235	16	4	0	4	0.00	100.0	0.023	1.244
U-238	16	4	3	4	18.75	100.0	0.127	28.36
Volatile Organic Compounds								
1,1,1-TCA	16	4	5	0	31.25	0.00	ND	ND
1,1-DCE	16	4	4	0	25.00	0.00	ND	ND
Carbon tetrachloride	16	4	2	0	12.50	0.00	ND	ND
Chloroform	16	4	0	0	0.00	0.00	ND	ND
Cis-1,2-DCE	16	4	0	0	0.00	0.00	ND	ND
Methylene Chloride	16	4	2	0	12.50	0.00	ND	ND
PCE	16	4	4	0	25.00	0.00	ND	ND
TCE	16	4	8	0	50.00	0.00	ND	ND

1 = Includes non-detects at 0.5 x detection limit; ND = Not determined because all downgradient results are U qualified

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Based on EPA guidance for statistical evaluations involving two data groups (EPA, 1992a), for analytes with greater than 30 percent quantifiable results, nonparametric Mann-Whitney (also referred to as Wilcoxon Rank-Sum) testing was performed. All UHSU results (alluvial and bedrock) were grouped by analyte into upgradient and downgradient data sets to simplify analyses and provide adequate data to perform statistical testing. This approach is justifiable because all downgradient wells are closely located in a well defined, narrow drainage that defines the primary groundwater flowpath emanating from the Landfill. The reader is referred to the EPA guidance document for further description of the statistical methods and parameters used in this section.

Table 6-6 summarizes the results of statistical comparisons for wells that had downgradient analyte concentration means that were greater than upgradient analyte concentration means. Of the 23 analytes listed, statistically significant differences (at the 90 percent confidence level) in downgradient versus upgradient mean concentrations were found for all but five; antimony, chromium, manganese, nickel, and nitrate. Although it does not show a significant difference in mean downgradient versus mean upgradient concentration, nitrate is the only one of the five that exhibits a mean downgradient concentration greater than the Tier II action level.

Of the 18 analytes listed in Table 6-6 as having a statistically significant increase in downgradient versus upgradient concentration, only six, lithium, selenium, thallium, U-233/234, U-235, and U-238 have mean downgradient concentrations that are greater than Tier II action levels; there are none greater than Tier I action levels. (This list would probably include sulfate, had a sample for this analyte been collected from well B206989 during 2002; the only sulfate sample from a downgradient well, 4087, during 2002 was below Tier II; see Figures 6-10 and 6-11). Six other analytes, cadmium, copper, fluoride, molybdenum, strontium, and sulfate all exhibit statistically significant increases in downgradient versus upgradient concentrations, although the mean downgradient concentration of each analyte is below the Tier II action level. Calcium, magnesium, potassium, sodium, and TDS all show a statistically significant increase in downgradient versus upgradient mean concentrations; however, these constituents are non-hazardous and lack RFCA groundwater action levels. Total U also exhibits a statistically significant increase in downgradient versus upgradient concentration; it has no groundwater action levels.

6.3.3 Trend Plots

Analyte trend plots (16; Figures 6-2 through 6-17) were prepared for downgradient wells, either B206989 or 4087, in which there was a significant difference exhibited between downgradient and upgradient concentrations (except for five of the six analytes listed above with no groundwater action levels; the exception being TDS). Two plots each were prepared for TDS and sulfate. In addition, a trend plot was prepared for nitrate in well B206989 because the concentration of nitrate at this location is greater than the Tier II action level. Trend lines, plotted by calculation of least square regression analysis, were added to the plots.

The trend lines on the plots for downgradient wells 4087 and B206989 indicate that, in general, analyte concentrations have remained relatively constant with time. Cadmium (Figure 6-2), copper (Figure 6-3), fluoride (Figure 6-4), molybdenum (Figure 6-6), and nitrate (Figure 6-7) exhibit flat or slightly decreasing trend lines. Sulfate and TDS in well 4087 (Figures 6-10 and 6-16, respectively) exhibit concentration trends that are decreasing slightly, whereas sulfate and

Table 6-6 Comparison of Upgradient and Downgradient Groundwater Quality at the Present Landfill, CY 2002.

Analyte	Statistical Test	Confidence Level (%)	Significant Difference
Antimony	Mann-Whitney	90	No
Cadmium	Mann-Whitney	90	Yes
Calcium	Mann-Whitney	90	Yes
Chromium	Mann-Whitney	90	No
Copper	Mann-Whitney	90	Yes
Fluoride	Mann-Whitney	90	Yes
Lithium	Mann-Whitney	90	Yes
Magnesium	Mann-Whitney	90	Yes
Manganese	Mann-Whitney	90	No
Molybdenum	Mann-Whitney	90	Yes
Nickel	Mann-Whitney	90	No

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Analyte	Statistical Test	Confidence Level (%)	Significant Difference
Nitrate	Mann-Whitney	90	No
Potassium	Mann-Whitney	90	Yes
Selenium	Mann-Whitney	90	Yes
Sodium	Mann-Whitney	90	Yes
Strontium	Mann-Whitney	90	Yes
Sulfate	Mann-Whitney	90	Yes
Thallium	Mann-Whitney	90	Yes
TDS	Mann-Whitney	90	Yes
Uranium, total	Mann-Whitney	90	Yes
U-233/234	Mann-Whitney	90	Yes
U-235	Mann-Whitney	90	Yes
U-238	Mann-Whitney	90	Yes

Note: The statistical results are for analytes with downgradient sample means greater than upgradient sample means and greater than 30% sample detections.

TDS in well B206989 (Figures 6-11 and 6-17, respectively) exhibit concentration trends that are increasing. These two analytes are important because of their relevance as potential indicators of leachate contamination from landfills. Of the six analytes having a statistically significant increase in downgradient versus upgradient concentration with mean downgradient concentrations that are greater than Tier II action levels (lithium, selenium, thallium, U-233/234, U-235, and U-238), lithium (Figure 6-5) and selenium (Figure 6-8) exhibit apparent increasing trends, and thallium (Figure 6-12) and the U-isotopes (Figures 6-13 through 6-15) exhibit apparent slightly increasing trends. The current concentrations of all three U-isotopes in well B206989 are near the Site backgrounds. Strontium metal (Figure 6-9) also exhibits an apparent increasing concentration trend. It should be noted that although concentrations of lithium, selenium, thallium, and U-isotopes appear to be increasing, the trend lines were not analyzed statistically to determine if the apparent increasing trends are statistically significant.

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6.3.4 Data Interpretation

A conceptual and numeric integrated hydrologic flow model was developed by the Water Program for the Landfill and utilized in the Draft IM/IRA. Although the calibrated model assumed that the external groundwater interceptor system (GWIS) drain was operational, a sensitivity analysis was performed to evaluate how the system responded without an operational GWIS drain. Results showed that heads increased slightly external to the landfill GWIS, but in general, simulated heads reproduced observed heads reasonably well without the external drain operating. In addition, the seep discharge also increased as a result of the increased gradient towards the internal GWIS landfill drain, which preferentially drains to the former western pond area and then to the Landfill seep. Either way, simulated heads, flowpaths and seep discharge rates were similar for both cases. Therefore, the model results were generally not sensitive to whether the external drain is operational or not. Ultimately, it is likely that the external GWIS drain simply drains groundwater from areas of higher heads to areas along the GWIS where levels are lower, but never discharges into the non-perforated portion of the pipe.

Based on the model, all saturated zone flow upgradient of the Landfill seep is conceptualized as discharging to the surface at, or immediately downgradient of, the Landfill seep. The seep discharge then flows into the Landfill Pond after being treated. From the Landfill Pond, groundwater flows beneath (within the weathered bedrock) and through the dam at a slow rate because of low associated permeabilities. Groundwater from the Landfill Pond is largely constrained downstream of the dam to flow within the Valley Fill Alluvium, or weathered bedrock. From here, it mixes with lateral inflows from the northern and southern hillslope colluvium and landslide deposits and becomes subject to loss as ET. The model predicts that, based on the functionality of the Landfill trench system and associated clay barrier, groundwater on the exterior of the Landfill does not mix with groundwater on the interior of the Landfill. In addition, the hydrologic model predicts that water in the Landfill waste material is derived mostly form direct recharge of precipitation than by lateral or vertical groundwater inflow.

Results of previous hydrogeologic investigations suggest that the groundwater intercept system may not completely isolate the landfill from the surrounding groundwater. Hydraulic assessments for specific areas of the GWIS indicate that groundwater may flow into the Landfill

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on the north side where the leachate collection system may not have been completely keyed into bedrock (DOE 1996b). In addition the leachate collection trench was buried during Landfill expansion (DOE 1996b). Therefore, the clay cutoff wall no longer extends to the surface of the Landfill; this may allow groundwater to flow across the clay cutoff wall if the water table were to rise sufficiently.

Most downgradient analyte concentrations do not appear to be increasing, and upgradient versus downgradient analyte concentrations currently appear to be in a steady-state condition. This indicates that potential contaminants are not currently migrating eastward at concentrations significantly greater than they have in the past. There is still a hydraulic gradient towards the east and existing contaminant concentrations will continue to migrate to the east through the low permeability weathered bedrock. The elevated concentrations of inorganic constituents in downgradient weathered bedrock groundwater may be caused by several factors. Potential explanations include:

- Vertical and horizontal seepage of Landfill leachate from beneath the Landfill into and/or beneath the Landfill Pond and beneath and through the dam; and/or,
- Another contaminant source located upgradient of the impacted wells, which is not associated with the Landfill or Landfill Pond.

6.4 Summary

Groundwater conditions at the Landfill in 2002 are generally consistent with the results of previous monitoring. Statistical comparisons of upgradient versus downgradient UHSU groundwater at the Landfill were performed for analytes meeting the minimum evaluation criteria of >30 percent detections and at least three samples per upgradient and downgradient data set. Significant differences (at the 90 percent confidence level) in downgradient versus upgradient groundwater quality were found for 18 analytes: cadmium, calcium, copper, fluoride, lithium, magnesium, molybdenum, potassium, selenium, sodium, strontium, sulfate, thallium, TDS, total U, U-233/234, U-235, and U-238. VOCs were not evaluated statistically because they were only found in upgradient samples. The VOC contamination upgradient of the Landfill probably originates at the PU&D Yard.

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Based on results greater than Tier II action levels, it appears that groundwater immediately downgradient of the Landfill Pond has been impacted by nitrate, lithium, selenium, sulfate (historically in well B206989; no 2002 results), U-isotopes, and possibly thallium. Most of the 18 analytes for which downgradient trend plots were constructed appear to show relatively stable concentration trends, and upgradient versus downgradient analyte concentrations currently appear to be steady-state. Although contamination observed in downgradient wells B206989 and 4087 may be associated with seepage beneath or through the dam, or an unknown source, the concentration of analytes observed in these wells are relatively static.

Although the upgradient wells are important for comparison to the downgradient wells, the overriding issue is potential impacts to surface water downstream of the Landfill. Because the impacts of the Landfill or other source are observed more in well B206989, this well, at the very least, should continue to be monitored. The continued monitoring of well 4087, nested with B206989, will provide additional hydraulic and analytical data pertinent to the dynamics of the groundwater system at the Landfill. Downgradient RCRA nested wells 52894 and 52994 may provide little future information as they are dry much of the time.

Regardless of the source of groundwater contamination immediately downgradient of the Landfill Pond, it poses little or no threat to surface water because ET losses in No Name Gulch are typically high and surface water discharge along this reach does not occur every year, based on surface water data collected at station SW033, which is located along No Name Gulch just above the confluence with Walnut Creek.

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Figure 6-2
B206989 Cadmium

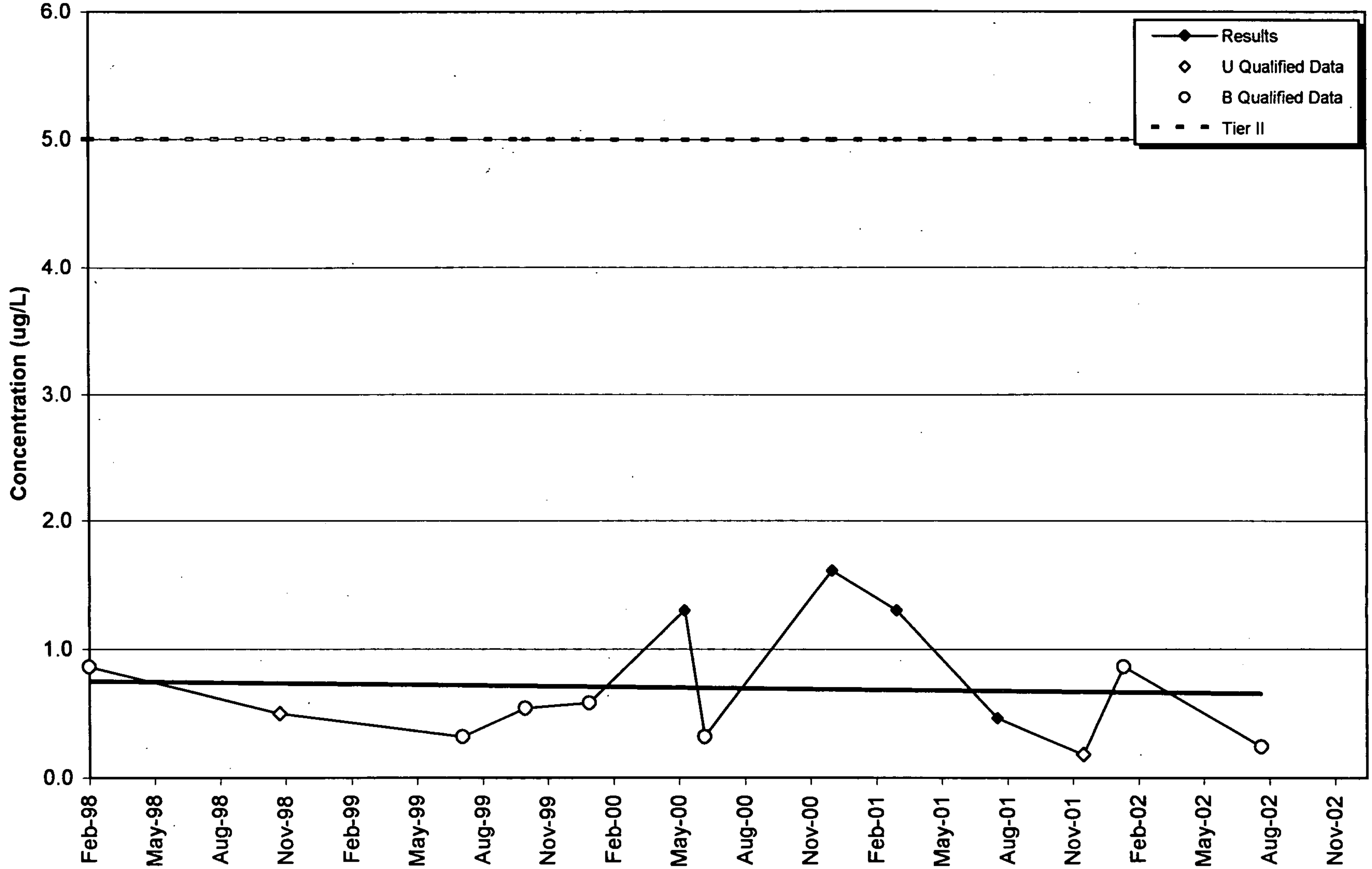

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Figure 6-3
B206989 Copper

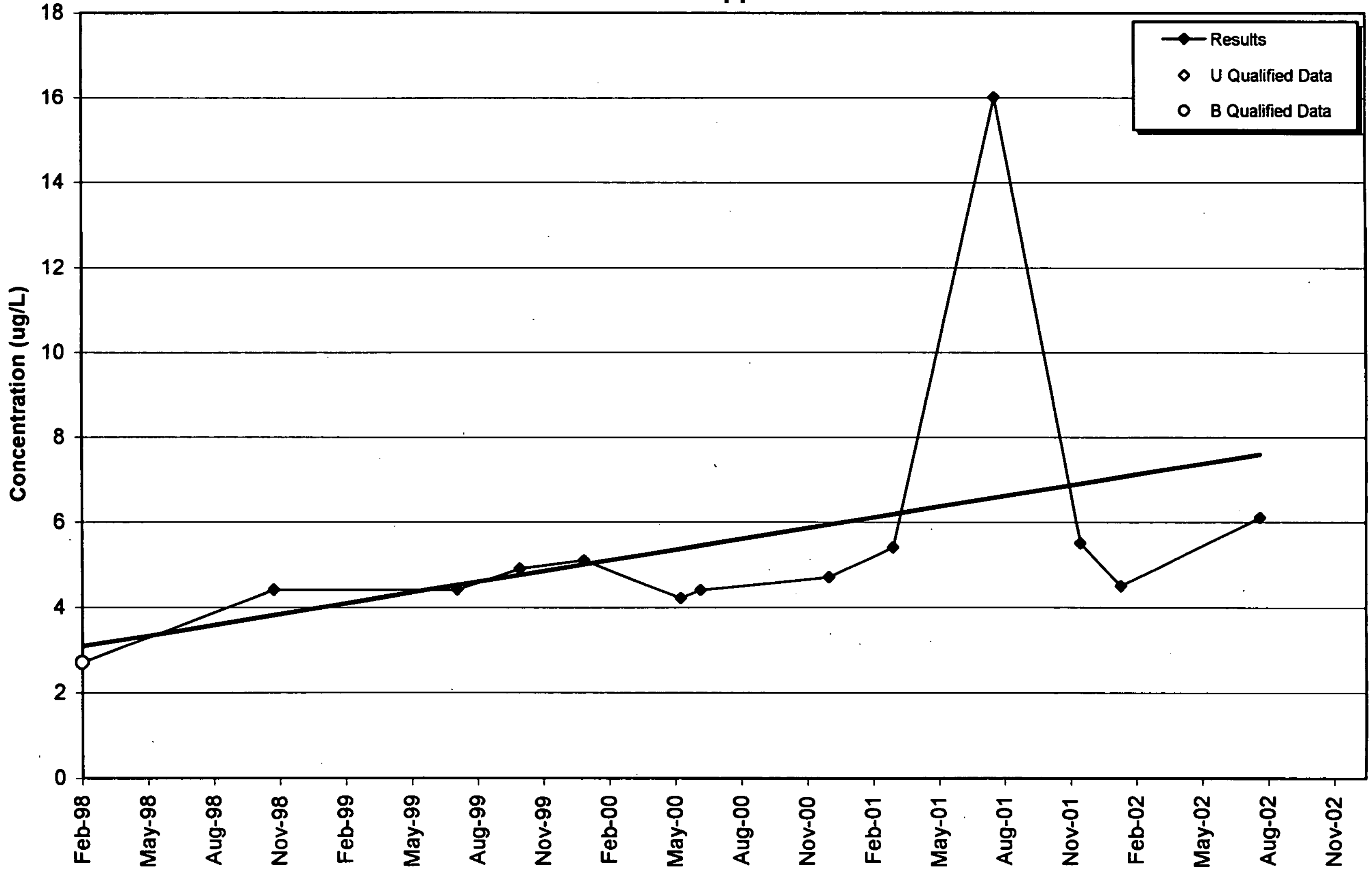

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Figure 6-4
4087 Fluoride

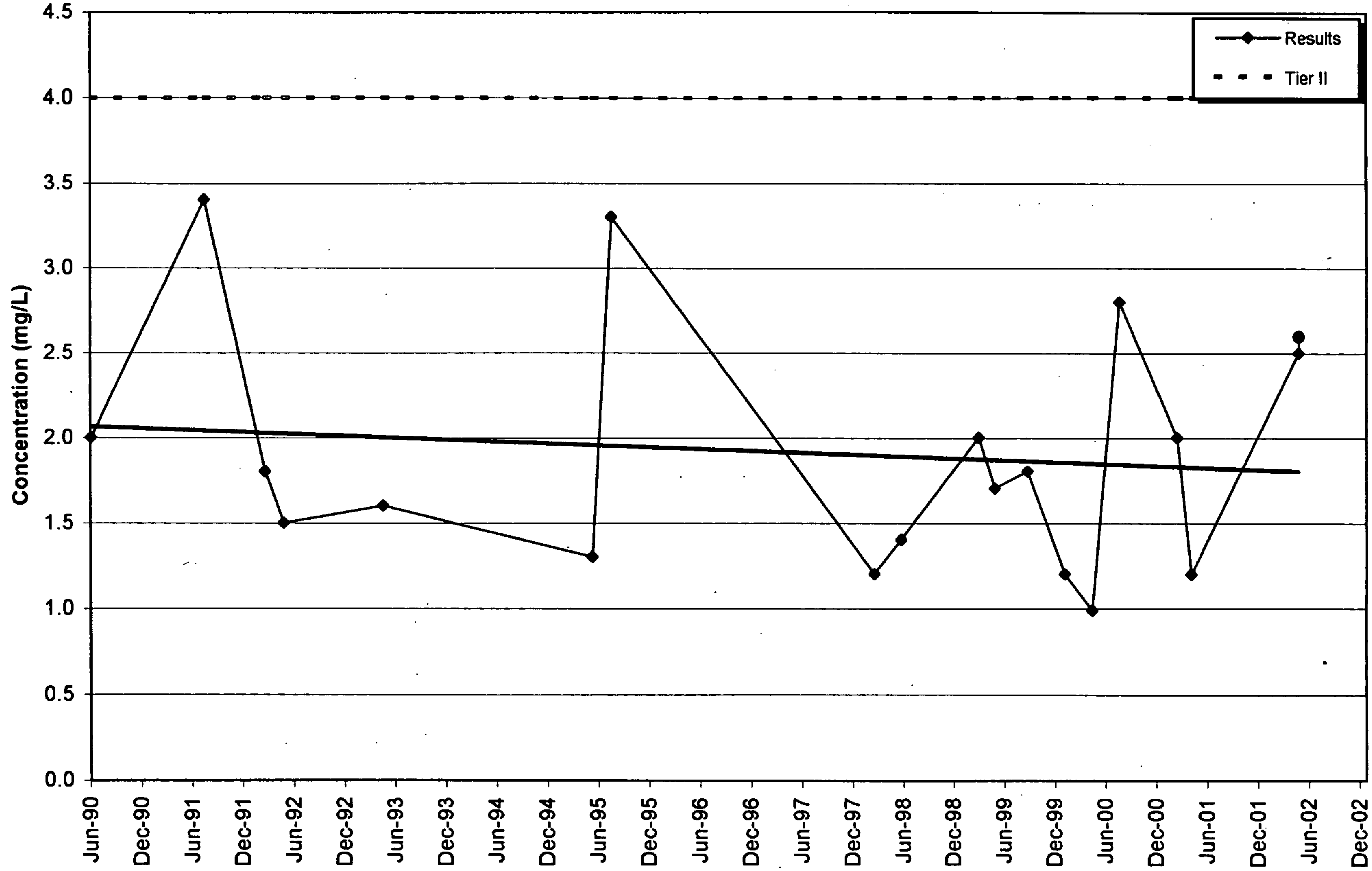

Figure 6-5
B206989 Lithium

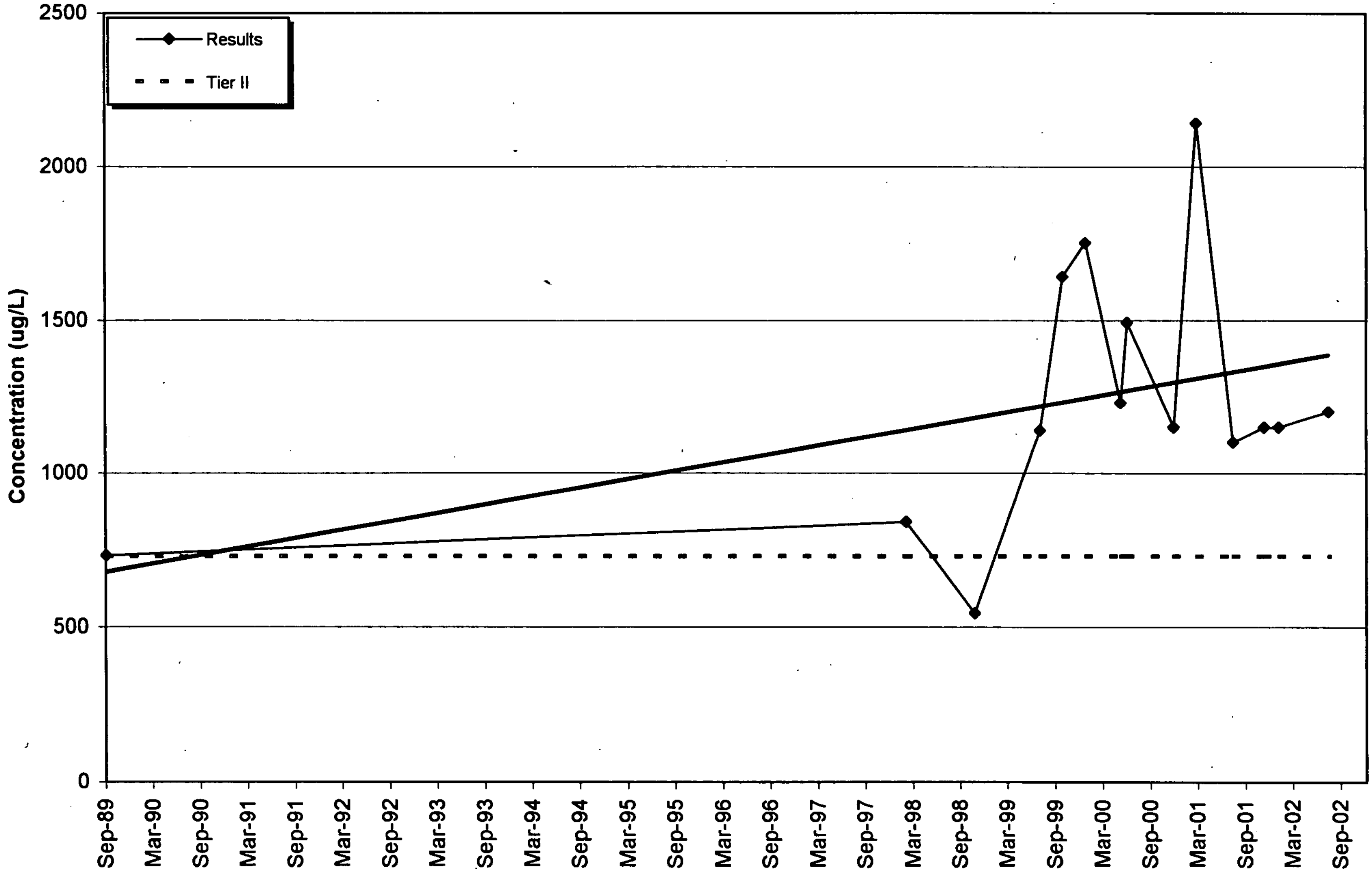

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Figure 6-6
4087 Molybdenum

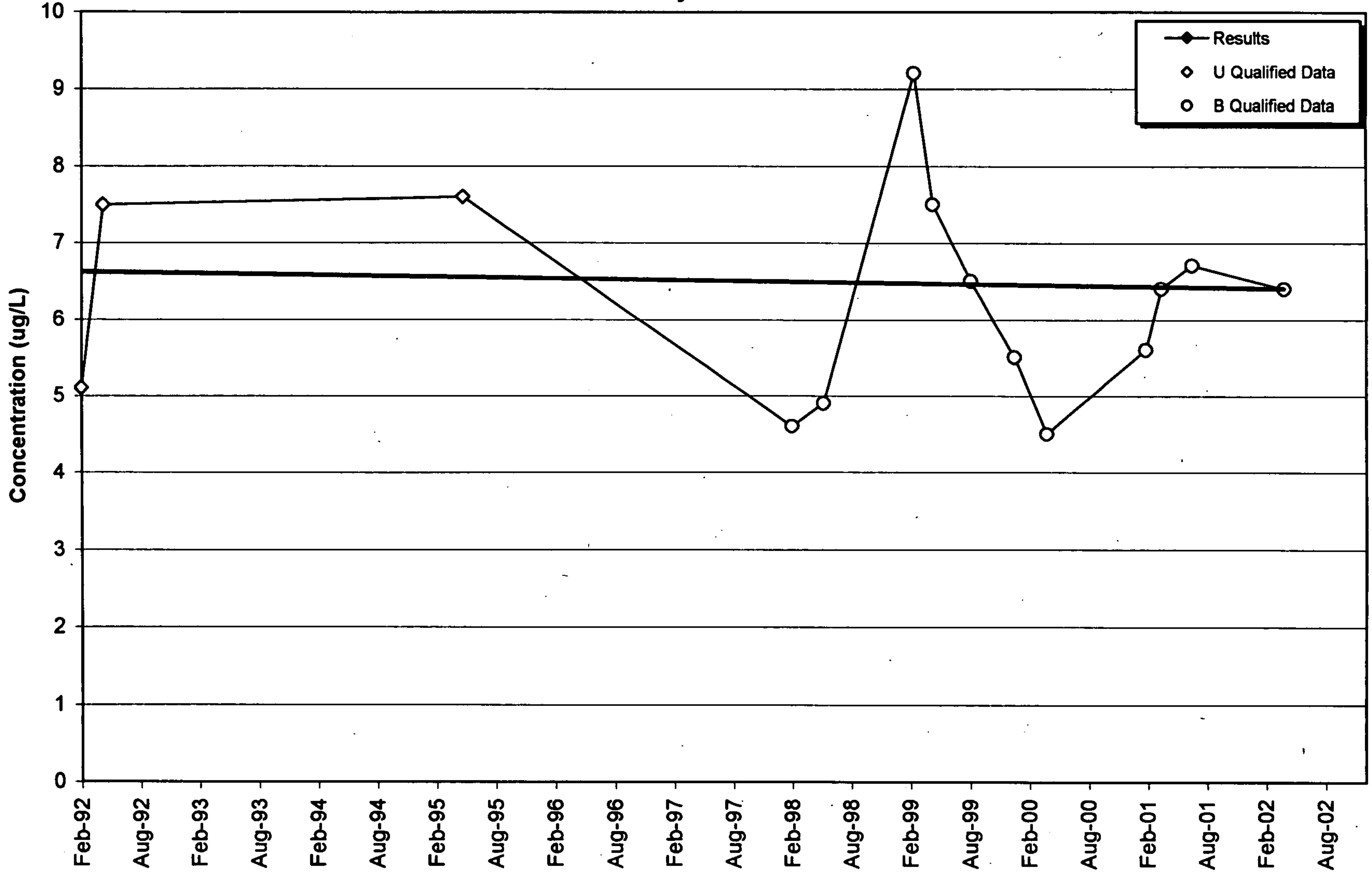

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Figure 6-7
B206989 Nitrate

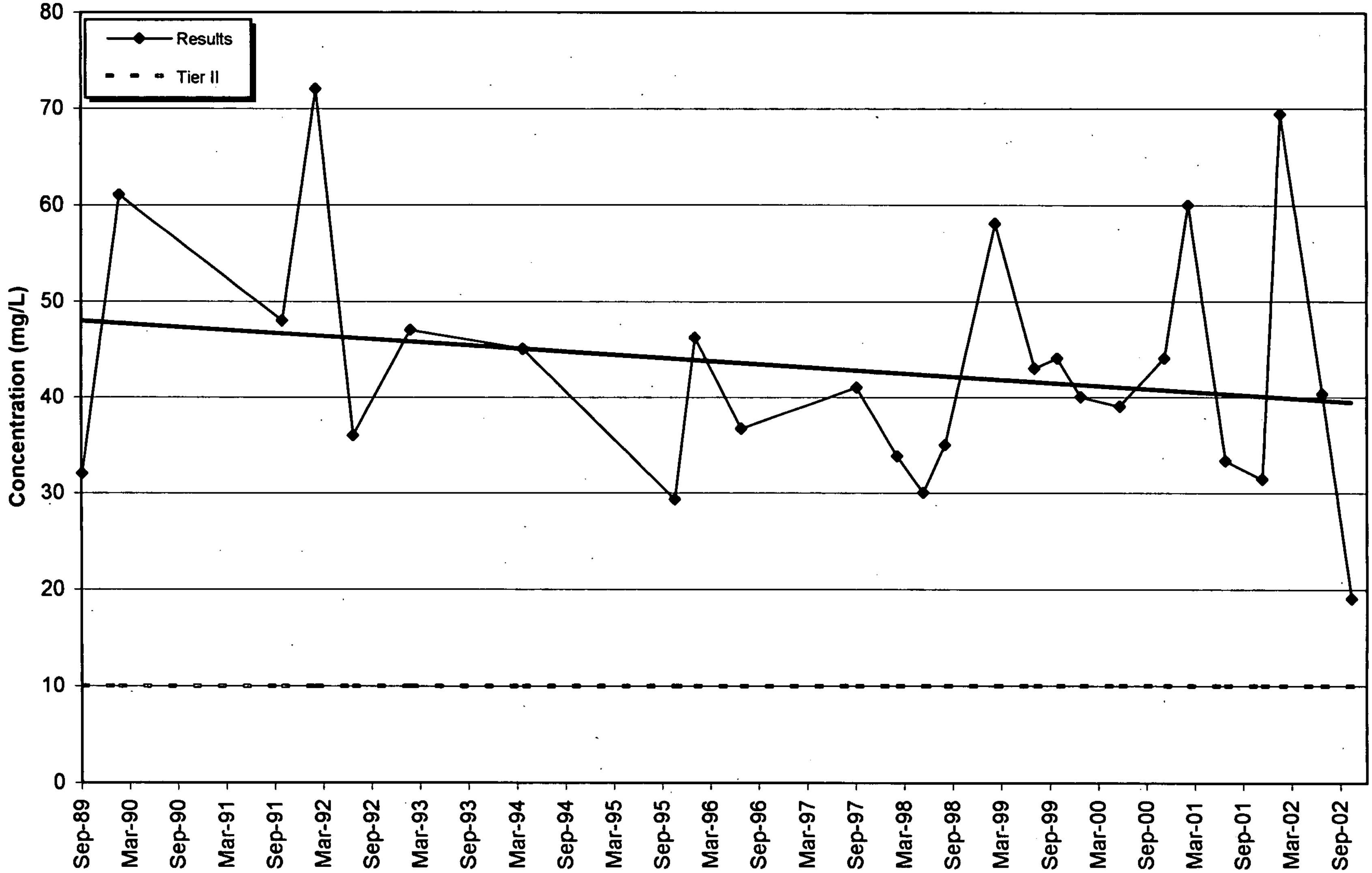

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Figure 6-8
B206989 Selenium

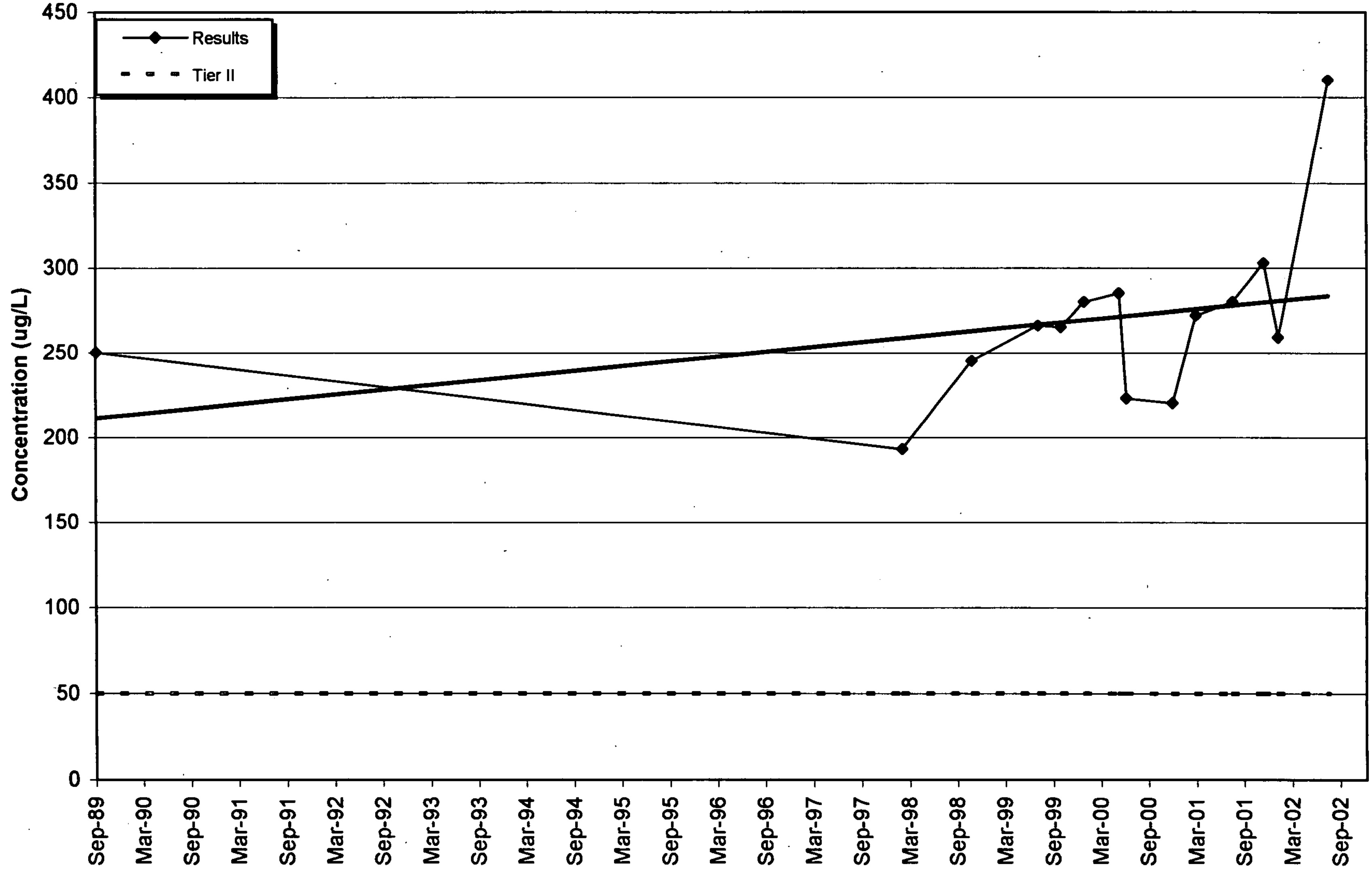

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Figure 6-9
B206989 Strontium

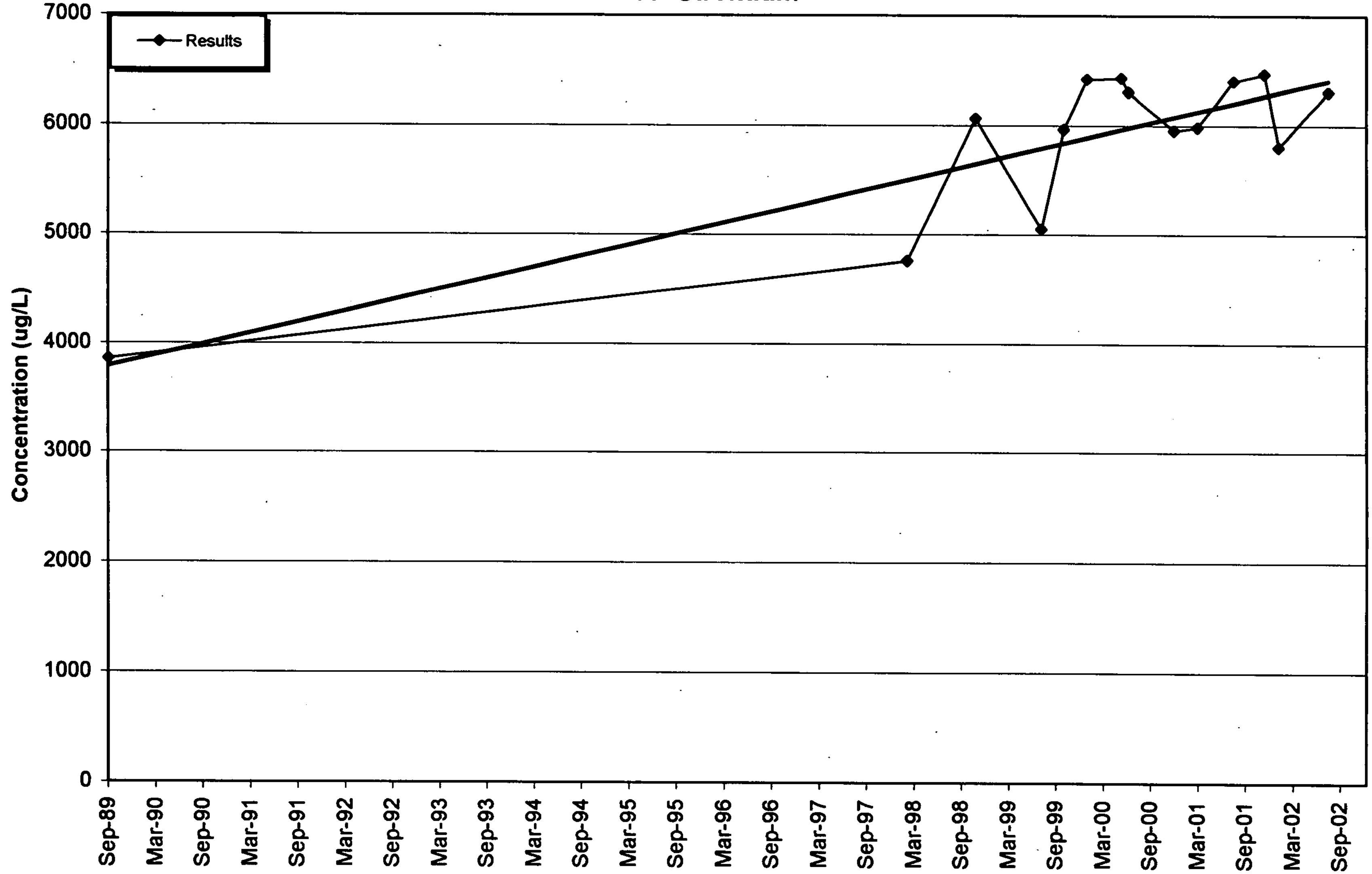

Figure 6-10
4087 Sulfate

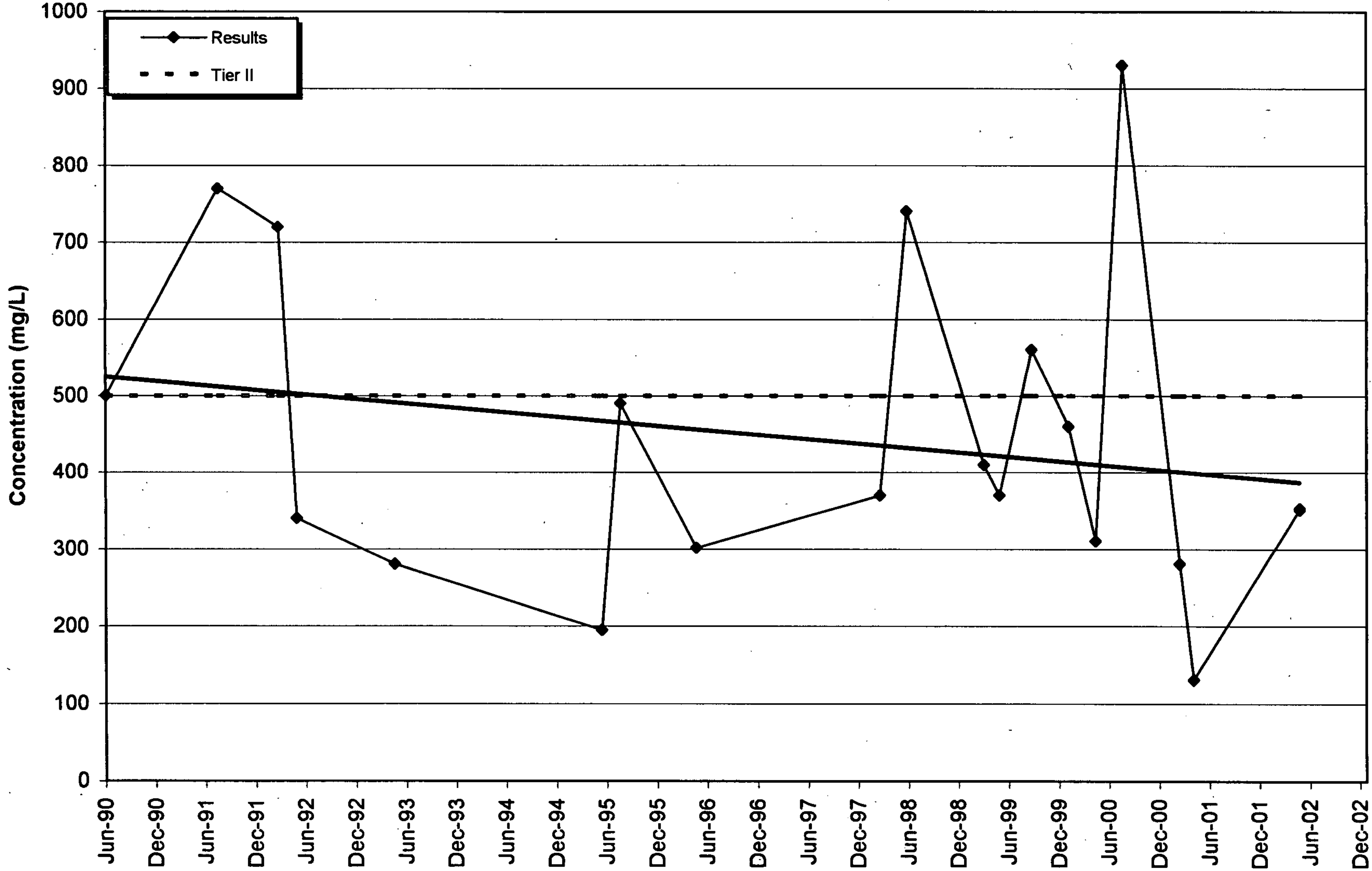

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Figure 6-11
B206989 Sulfate

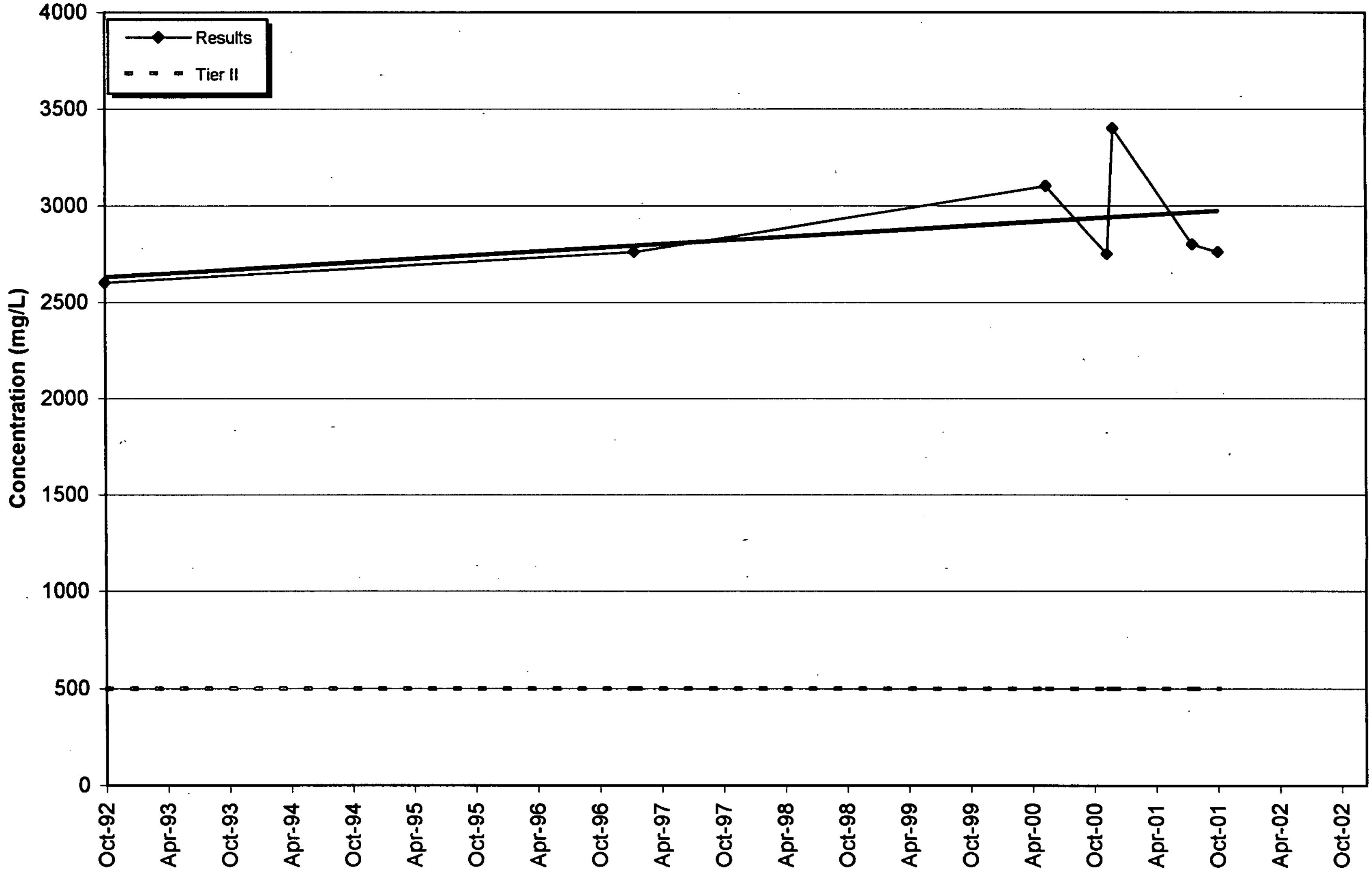

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Figure 6-12
B206989 Thallium

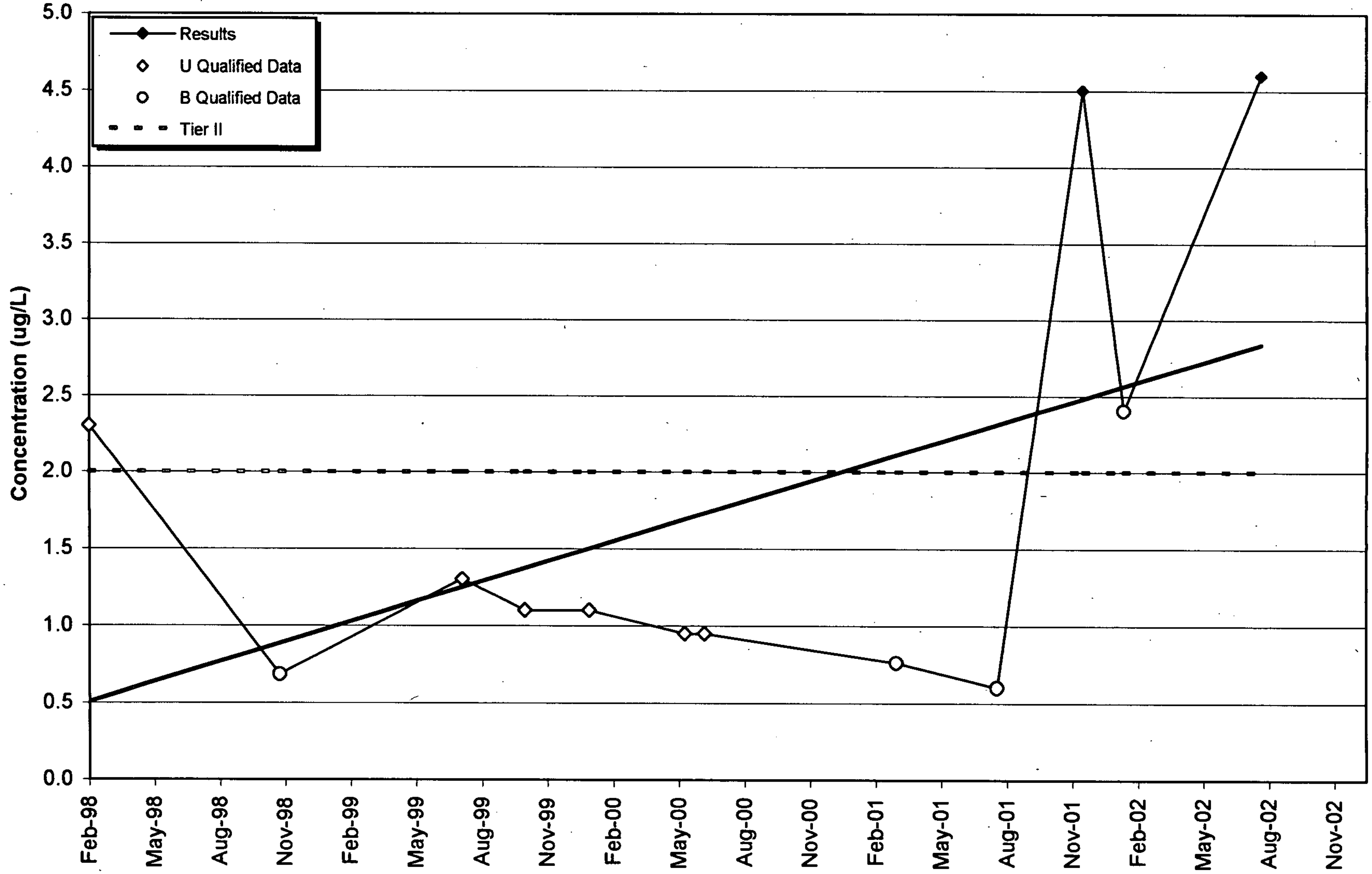

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Figure 6-13
B206989 Uranium 233/234

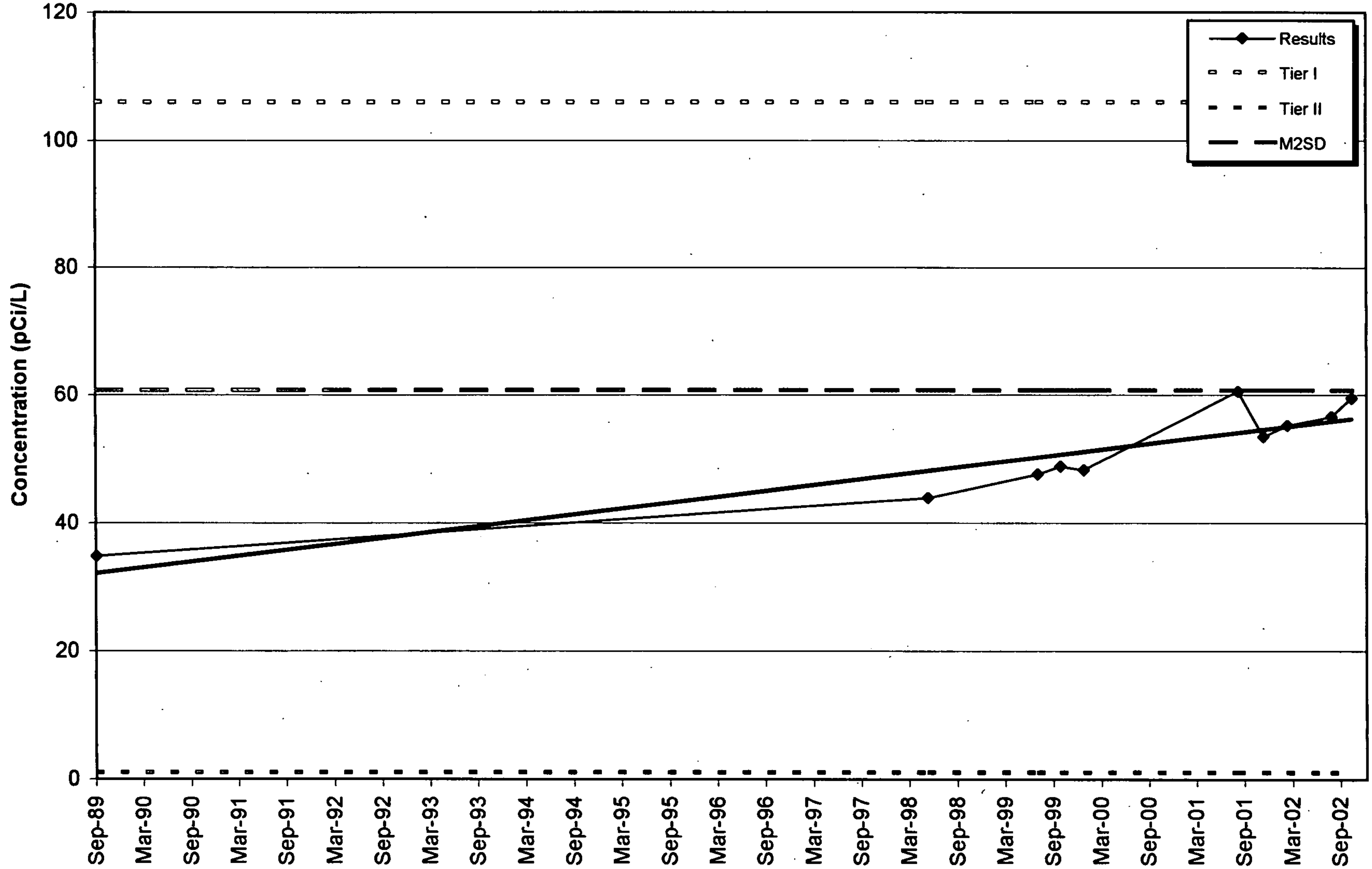

Figure 6-14
B206989 Uranium 235

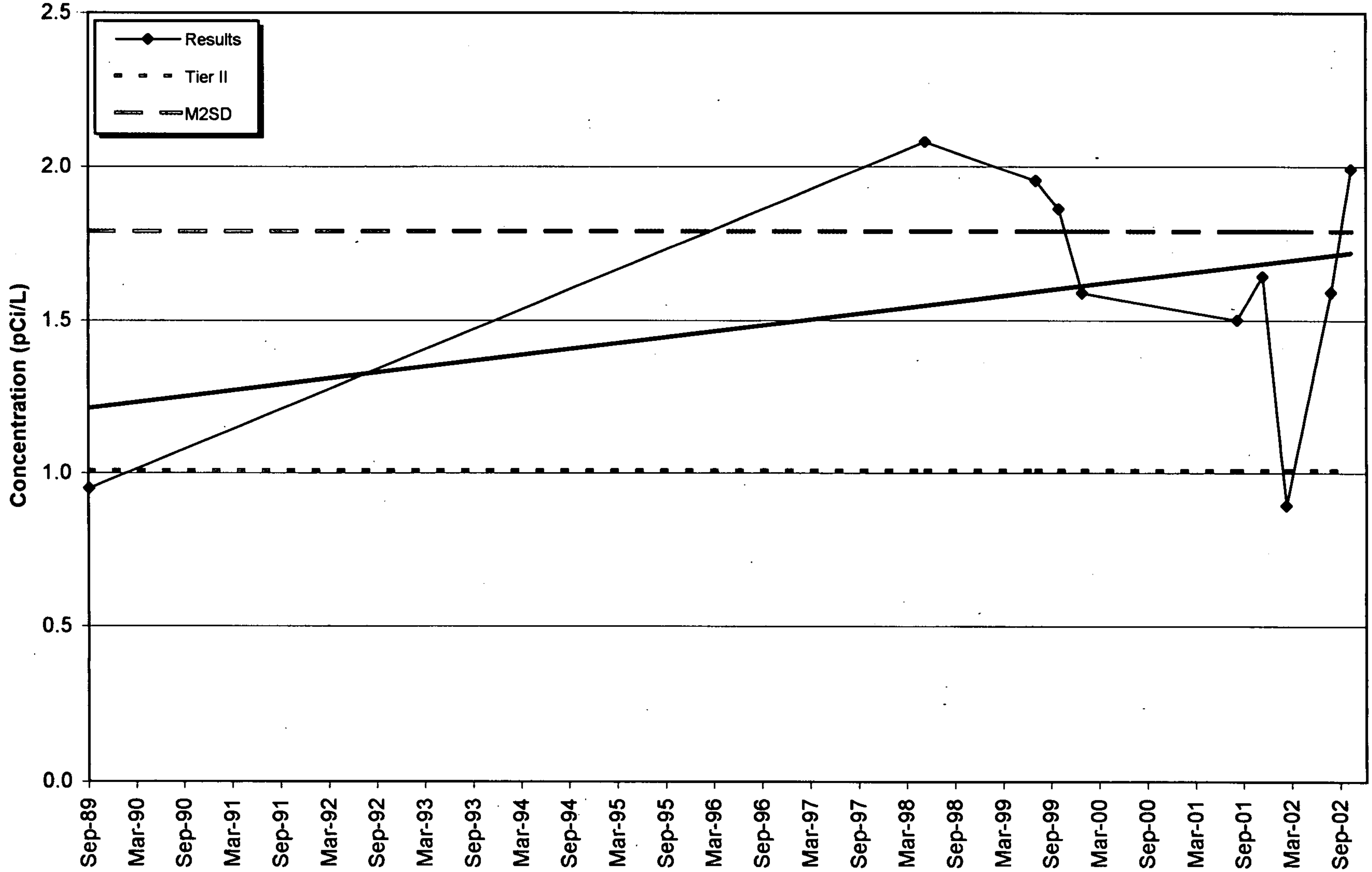

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Figure 6-15
B206989 Uranium 238

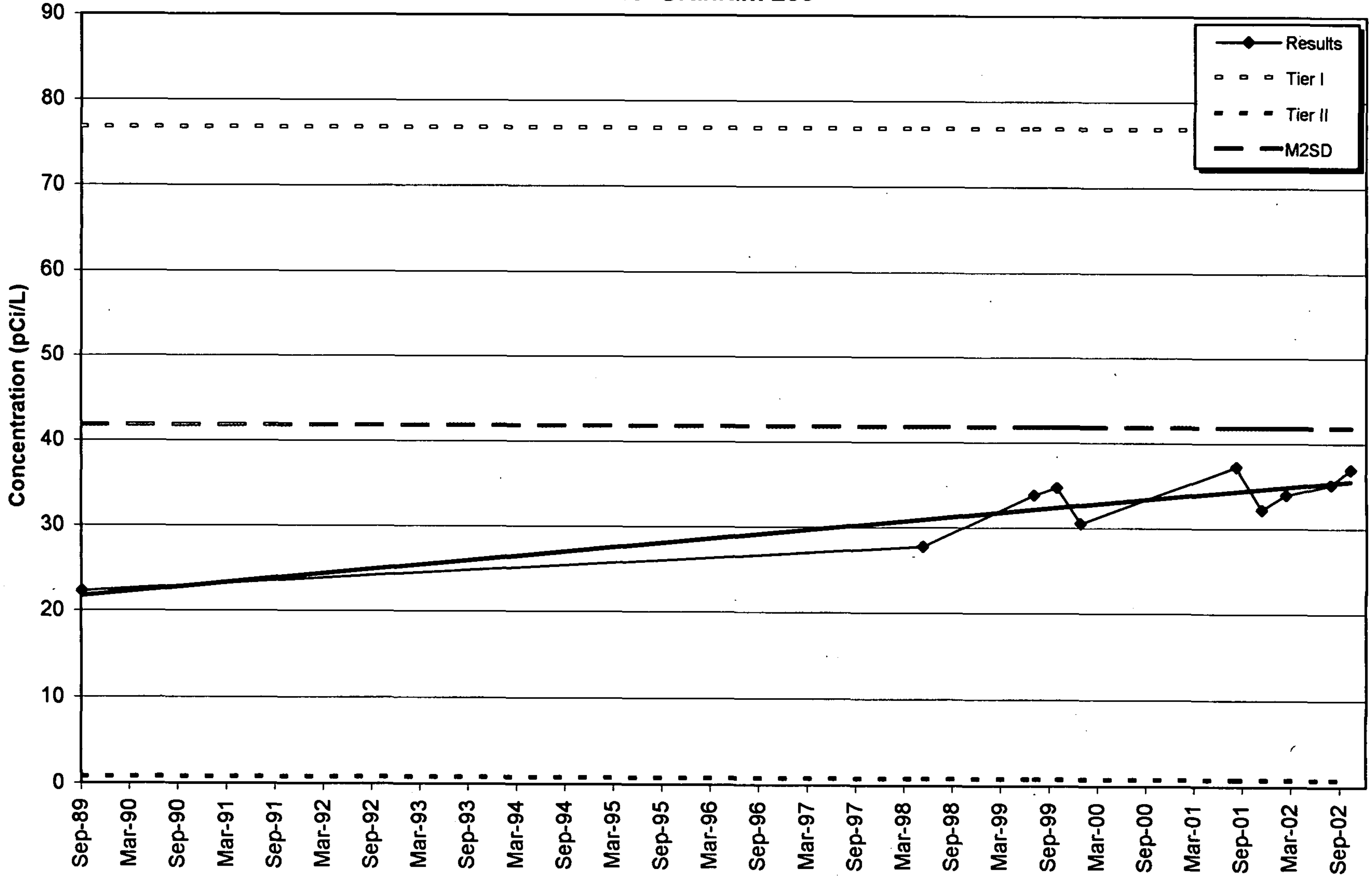

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Figure 6-16
4087 Total Dissolved Solids

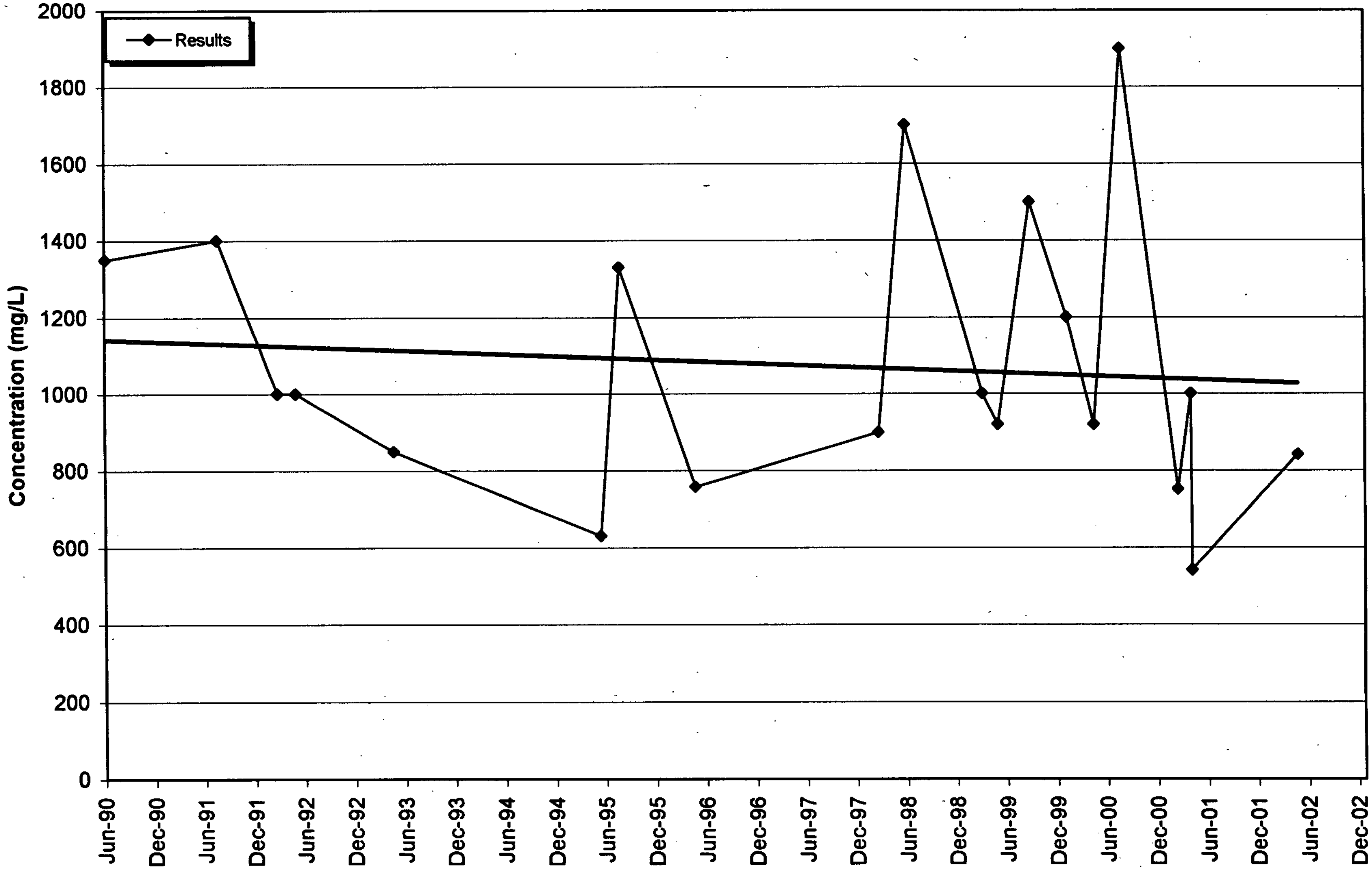

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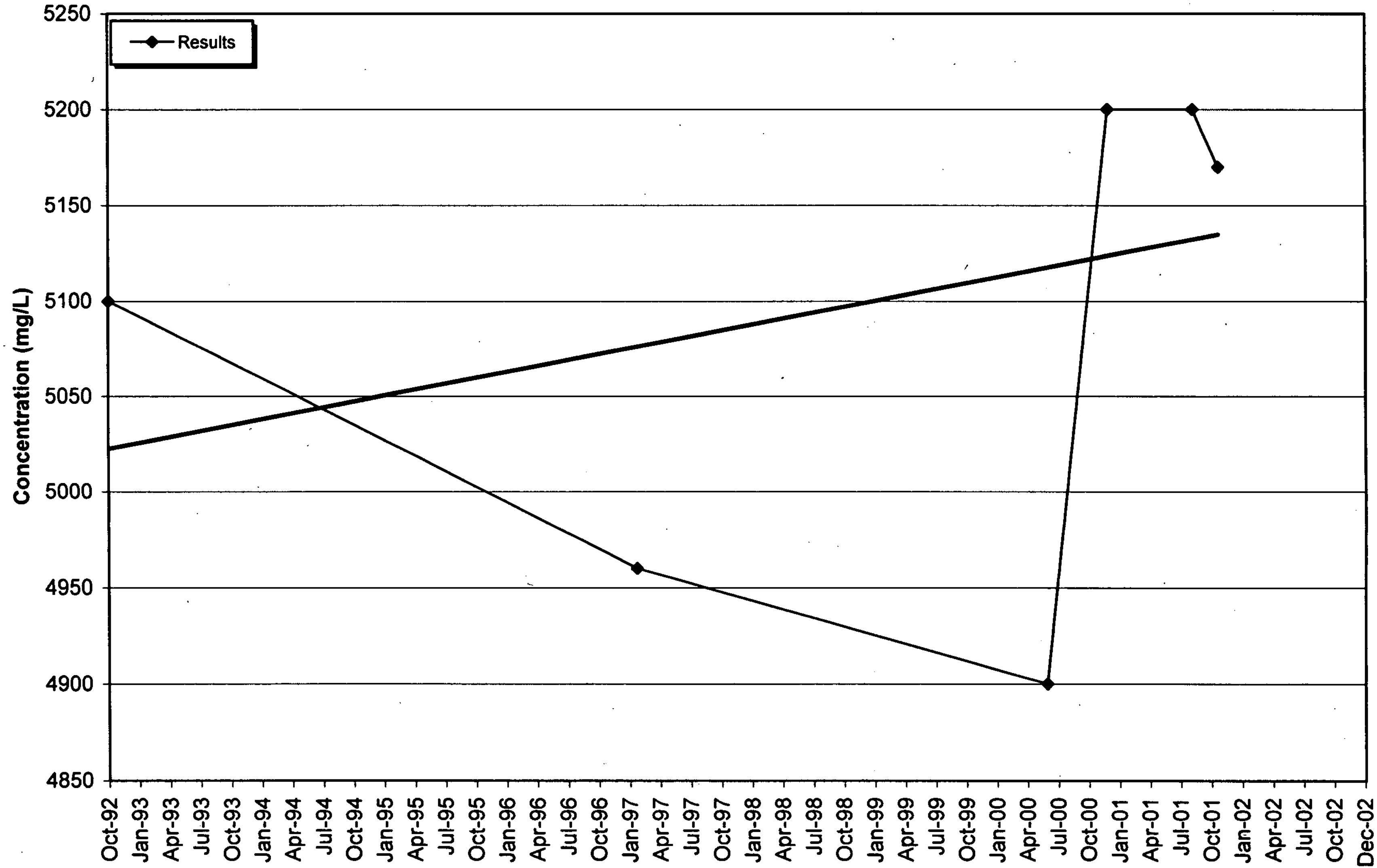
Figure 6-17
B206989 Total Dissolved Solids



7.0 BIODEGRADATION EVALUATION

Routine groundwater data were collected during 2002 to support plume degradation monitoring. During the course of reviewing and analyzing these data, the Water Program embarked on a Site-wide evaluation of VOC natural attenuation and biodegradation, instead of the analysis of plume degradation monitoring in specific areas at RFETS. This type of evaluation fits with the current concept of characterizing and remediating the entire Site instead of by specific areas (i.e., OU).

Section 7.1 provides background information regarding plume degradation monitoring. Section 7.2 has been abstracted from the November 2003 draft report, *Evaluation of Natural Attenuation and Biodegradation Potential of Chlorinated Aliphatic Hydrocarbon Compounds in Groundwater at Rocky Flats* (K-H, 2003d). A summary of this report is included in the 2002 Annual RFCA Groundwater Monitoring Report because this information may be useful to support remedial, D&D, and long-term monitoring decisions.

The PU&D Yard Plume Treatability Study was performed by the Environmental Restoration group at RFETS. For a full description of the project to date, including figures, diagrams, and tables, please review the *Annual Report for the Rocky Flats Environmental Technology Site Groundwater Plume Treatment Systems, January through December 2002* (K-H, 2003a).

7.1 Plume Degradation

Plume degradation is defined as a measured reduction in contaminant concentrations as groundwater contaminants migrate from their source. This reduction in concentration can be a result of a number of groundwater fate and transport processes including dilution, dispersion, sorption, volatilization, and biotic and abiotic transformations. Biodegradation or bioremediation describes the portion of plume degradation that is brought about by biological degradation mechanisms. Biological degradation typically involves bacteria that occur naturally in soil and groundwater. Under the right conditions these bacteria break down certain fuel hydrocarbons and certain chlorinated organic compounds.

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The main mechanism for the biological breakdown of chlorinated aliphatic hydrocarbons (CAHs) is through reductive dechlorination reactions. Under reductive dechlorination, a CAH such as CT serves as an electron acceptor, causing the compound to gain a hydrogen atom at the expense of a chlorine atom. The successive dechlorination of CT forms CF, methylene chloride (MC), and chloromethane as chlorine atoms are progressively removed from the original CT molecule.

For biodegradation to occur there must be an electron acceptor, a source of carbon to serve as an electron donor, an appropriate bacterial community, and a favorable environment for the metabolic reactions to take place. Previously, the sampling programs at IHSS 118.1, the 903 Pad/Ryan's Pit Plume, and the PU&D Yard Plume were implemented to investigate whether these processes were taking place at the Site. These investigations employed the method described by Wiedemeier et al (1996) which determines whether biodegradation is occurring to a significant degree at a site based on applying scores to certain chemical parameters.

7.1.1 Electron Donors

The main mechanism that degrades CAHs, such as CT, is reductive dechlorination. Reductive dechlorination is the substitution of hydrogen for chlorine atoms within the CAH, which causes it to progressively break down into daughter products. This process requires a source of electron donors, which is typically organic carbon. Carbon can be used either as natural carbon in the aquifer, or can be acquired from the breakdown of petroleum hydrocarbons. Total organic carbon (TOC) samples have been used to ascertain the availability of carbon in the RFETS environment, which could then serve as an energy source for reductive dechlorination.

7.1.2 Electron Acceptors

VOCs were analyzed to determine if daughter products were being formed by reductive dechlorination. In order to undergo reductive dechlorination, CAHs must be potential electron acceptors. This reaction mechanism occurs when there is a sufficient electron donor source present, the proper chemical environment exists, and there is a relative lack of competing electron acceptors. Dissolved oxygen (DO), rather than solvents, is the favored electron acceptor used by bacteria for the biodegradation process. Anaerobic bacteria cannot function at DO concentrations above 0.5 mg/L and hence, reductive dechlorination cannot occur (Wiedemeier et al, 1999). Nitrate and sulfate were analyzed because these species, along with dissolved oxygen, can compete with chlorinated solvents as electron acceptors. If high levels of nitrate and/or sulfate exist in groundwater in the vicinity of a plume source, reductive dechlorination of a parent CAH and its by-products could be retarded.

7.1.3 Metabolic By-Products

Measurement of the biodegradation metabolic by-products is a valuable indicator of the predominant microbial and chemical processes occurring during contaminant transformation. Ferric iron (Fe^{3+}) is reduced to ferrous iron (Fe^{2+}) during anaerobic biodegradation of organic compounds. Therefore, an increase in ferrous iron concentration in the source area can suggest that biodegradation is occurring. The production of hydrogen sulfide occurs during sulfate reduction and verifies that sulfate is acting as an electron acceptor during biodegradation. The presence of methane in groundwater is indicative of strongly reducing conditions. Methane can be produced through the biodegradation of petroleum hydrocarbons. The presence of methane in groundwater containing chlorinated solvents suggests that the chemistry of the groundwater is favorable for reductive dechlorination. The presence of elevated concentrations of chloride in groundwater relative to upgradient locations suggests that reductive dechlorination of organic solvents is taking place. This is because the replacement of hydrogen for chlorine in the chemical structure of the CAH during reductive dechlorination releases chlorine in the process.

7.2 Evaluation of Natural Attenuation and Biodegradation Potential

The draft report *Evaluation of Natural Attenuation and Biodegradation Potential of Chlorinated Aliphatic Hydrocarbon Compounds in Groundwater at Rocky Flats* (K-H, 2003d) presents evidence of the extent of natural attenuation processes reducing CAH constituents in groundwater at RFETS. This report uses available groundwater quality data to estimate several CAH attenuation or degradation rate constants. The report also uses a number of geochemical lines of evidence regarding the extent of biodegradation at RFETS.

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A site-specific conceptual model was developed for natural attenuation processes. This model views biodegradation at RFETS as occurring within small "islands", in which anoxic conditions are locally maintained to support reductive dechlorination (the main process of biodegradation) of relatively oxidized CAHs like CT, PCE, and TCE. These "islands" of biodegradation are surrounded by a "sea" of oxidizing groundwater that probably does not support reductive dechlorination. The mean concentration of DO in shallow groundwater at RFETS is relatively high at 5.7 mg/L. Biodegradation should be halted by these oxidizing conditions, although vinyl chloride (VC) may be rapidly oxidized under these conditions.

Under oxidizing or reducing conditions, the solvent 1,1,1-TCA undergoes rapid hydrolysis (half-life 0.5 to 1.7 years) to acetic acid. Thus, 1,1,1-TCA has the best chance for rapid remediation of the primary solvents used at RFETS.

Fuel spills and detectable benzene, toluene, ethyl benzene, and xylenes (BTEX), spatially associated with some CAH plumes, provide an organic substrate for bacterial growth and help produce locally anoxic conditions ("at the islands") through microbial respiration. The lathe coolant used at RFETS would be particularly amenable to biodegradation since the hydraulic oils in the coolant provide a substrate for bacteria and reducing conditions that support reductive dechlorination of the CAHs.

The rates and spatial distributions of CAH compounds undergoing natural attenuation in groundwater at RFETS have been evaluated using various "lines of evidence" suggested by published technical literature. These lines of evidence include estimation of biodegradation rate constants, bulk attenuation rate constants, point attenuation rate constants, and overall mass removal of CAHs from groundwater in terms of moles per year.

Several hundred two dimensional charts were prepared to interpret water quality data for:

- Determination of attenuation rate constants;
- Interpretation of redox environments suitable for biodegradation;
- Visualization of the extent of natural attenuation of CAHs through elapsed time; and

- Interpretation of the attenuation of CAH concentrations with groundwater migration distance along a contaminant plume.

The Wiedemeier scores ranking system is a screening tool used to quickly assess the extent of biodegradation in the subsurface. This system is based on the concept that biodegradation will cause predictable changes in groundwater chemistry (EPA, 1998). If most of the relevant water quality parameters have been measured, then their concentrations can be compared against this scoring system, which assigns points to certain chemical parameters. The points for all parameters are summed to produce a Wiedemeier score for each well.

RFETS groundwater analytical data for field parameters and laboratory-generated concentrations were scored under the Wiedemeier system. Wiedemeier scores for 579 monitoring wells at RFETS ranged from a minimum of –3 points to a maximum of +22 points, with a mean of 3.0 points, and a standard deviation of 3.4 points. The M2SD was 9.8. If the data are normally distributed, about 98 percent of the wells at RFETS should have Wiedemeier scores below 10 points, indicating limited to no evidence of biodegradation at the Site.

Based on presently available data, well 33502 is the only well at RFETS exhibiting strong evidence of biodegradation. Well 33502, located on Sage Avenue just north of Building 335, had a Wiedemeier score of 22. This location is known for its elevated VC concentration, reaching 1200 µg/L during February, 2003. The Tier I groundwater action level for VC is 200 µg/L.

Only one other well, 1986, had adequate evidence of biodegradation, with a Wiedemeier score of 19. Well 1986 is located about 1500 feet northeast of well 33502 in the unnamed drainage between Buildings 371/374 and 771. All other Site wells had Wiedemeier scores of 14 points or less:

- 125 wells fell in the category of limited evidence of biodegradation (6 to 14 points); and
- 349 wells had inadequate evidence of biodegradation (1 to 5 points).

No positive evidence of biodegradation was found for hundreds of other wells and foundation drain outfalls at RFETS.

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Approximately 170 charts were prepared in which the natural log of contaminant concentration (ln C) was plotted against contaminant migration distance (D) using data from wells located along a groundwater flowpath from a CAH source area. Each chart shows the trend in detected concentrations of a single CAH compound, carried by groundwater through multiple wells located along the flowpath, during a restricted time period.

These ln C versus D plots were prepared to determine bulk attenuation rate constants (K_b) for individual CAHs in each of seven areas of interest in or near the IA. Bulk attenuation rate constants are useful for two purposes. First, they can be used to predict the future extent, or size of a plume and whether it should grow, shrink, or remain at steady state. Second, for steady-state plumes, the same data used to compute K_b values can be used to estimate biodegradation rate constants.

Natural attenuation processes are widely believed to *decrease* contaminant concentrations during groundwater migration along a flowpath from a contaminant source area. Looking at the RFETS results, 103 of the plots had regression lines with negative slopes (positive K_b rates) indicating that the concentrations of CAHs were, indeed, naturally attenuating during contaminant migration. However, another 64 of the ln C versus D plots exhibited positive slopes (negative K_b rates) indicating that the concentrations of some contaminants in groundwater were actually *increasing* through time at RFETS. The most likely explanation for this increasing trend is that the plotted plume segments with positive slopes are showing only the rising limb of increasing daughter product concentrations. If more complete groundwater monitoring data were available along the full extent of the central flowpath of each CAH plume, then the daughter concentrations should peak and then attenuate with distance in accordance with the conceptual model.

Plumes that are predicted to shrink are attenuating faster, at an average bulk attenuation half life of 7.5 years. Plumes predicted to grow are attenuating slower, with average bulk attenuation half lives of 19.8 years. The half life of steady-state plumes averaged 15.1 years. A wide range of predicted decay times (durations) was found for CAH compounds to attenuate in concentration and reach a Tier II action level. Positive decay durations ranged from one year to more than 1200 years to attenuate to Tier II.

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Biodegradation rates have been computed for the attenuation of CAHs in groundwater at RFETS. This was done using the one-dimensional (1D) method of Buscheck and Alcantar (1995), with the recognition that this method likely overestimates the true biodegradation rate (Zhang and Heathcote, 2003). Lack of data concerning the dimensions and exact location of contaminant source areas precludes the application of more sophisticated methods.

The 1D method requires that the plume be at steady state during the time period, otherwise the computed rate constant will be a less reliable approximation of the biodegradation rate. Thirty-five biodegradation rate constants were computed for plumes of individual CAH compounds that were predicted to remain at steady state. The mean biodegradation half lives for specific CAH chemicals in groundwater at RFETS are: 1,1,1-TCA, 15.9 years; 1,1-DCA, 30.3 years; 1,1-DCE, 3.0 years; CF, 0.8 years; cis-1,2-DCE, 10.4 years; MC, 8.1 years; PCE, 10.8 years; and TCE, 22.4 years.

For comparison, biodegradation rate statistics have been compiled from published field and laboratory biodegradation rate investigations (Aronson and Howard, 1997). All of the mean biodegradation rates at RFETS are less than 1 per year except for CF at 2.65 per year. The mean biodegradation rates for the non-RFETS sites are much faster. For example, the non-RFETS CF mean is 29.2 per year, 11 times faster than at RFETS. The non-RFETS PCE rate is 9.86, about 143 times faster than the mean rate at RFETS. The non-RFETS TCE rate is 4.02, about 12 times faster than the RFETS mean rate. Assuming that 1,2-DCA decays at a similar rate to 1,1-DCA, then the non-RFETS mean rate is 2.78, about 9 times faster than 1,1-DCA decays at RFETS. Finally, comparing the estimated biodegradation rate of 0.163 per year for CT at RFETS, to the published studies mean of 124 per year, we find the published mean is 760 times faster than biodegradation at RFETS.

In summary, biodegradation rates for CAH compounds in groundwater at RFETS are at or near the low end of published biodegradation rate constants. Worse yet, biodegradation rate constants computed from the 1D method of Buscheck and Alcantar (1995) are believed to *overestimate* the true rate constant by up to 65 percent in comparison to a more rigorous 3D method (Zhang and Heathcote, 2003). Thus, the true biodegradation rates at RFETS are likely to be even slower than those reported here. These slow rates may mean that Monitored Natural Attenuation is not a practical groundwater remedial option for RFETS.

Another line of evidence demonstrating natural attenuation of the CAH plumes in groundwater at RFETS is to look for decreases in CAH chemical mass (or number of molecules in moles) over time. The approach taken here was to compute total moles of CAH compounds per liter of water collected from these wells during two widely separated time periods, 1992-1993 and 2002-2003. Possible seasonal effects on concentration were reduced by averaging the concentrations within each two year period. If natural attenuation is occurring, large molar decreases should be observed during the more recent period.

A total of 122 wells had sufficient data to compare CAH abundance over the decade. Total moles of CAHs decreased during the decade at 91 monitoring wells; evidence of natural attenuation at those wells. The average molar decrease at these wells was 14.0 μMoles/L per well. The remaining 31 wells showed *no evidence of attenuation*, but instead showed increases in CAH mass. The average molar increase was relatively small at 3.5 μMoles/L per well. If the molar changes at all 122 wells are summed, the net change is an overall loss of 1,169 μMoles, or 9.58 μMoles/L per well. This is evidence that, on a sitewide basis, CAH plumes at RFETS are undergoing natural attenuation. The overall decline is actually a rate, 9.58 μMoles/L per decade at each well. Therefore, the RFETS average "molar attenuation rate" is 0.958 μMole/ liter/ year for CAH compounds as a group in groundwater.

The ratios of the cis and trans stereoisomers of 1,2-DCE have been used in published literature as a qualitative indicator of biodegradation. This usage is based on the fact that the manmade solvent is a mixture of cis- and trans-1,2-DCE. In contrast, biodegradation processes produce mainly cis-1,2-DCE (EPA, 1998). The cis/trans ratio is typically greater than 25 to 1 in groundwater where biodegradation is actively proceeding. The cis/trans ratio was computed for each well and sampling event at RFETS with detections for both isomers. Although some wells have low ratios, most wells had high ratios between 26 and 684. This is taken as evidence of biodegradation in these areas.

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Extensive sampling and analysis of groundwater by the Snapshot Sampling Project (Snapshot), completed in August 2003, generated data that provide a current picture of the distribution of CAH chemicals in groundwater at RFETS. The Snapshot data indicate that six CAH analyte plumes presently remain in groundwater at RFETS at concentrations exceeding Tier I groundwater action levels; CT, CF, PCE, TCE, VC, and 1,1-DCE. Section 8.0 includes four individual analyte plume maps (CT, PCE, TCE, and VC) that show the spatial distribution of the concentrations of these CAH compounds in Site groundwater during the period of 2001-2003.

In summary, the report *Evaluation of Natural Attenuation and Biodegradation Potential of Chlorinated Aliphatic Hydrocarbon Compounds in Groundwater at Rocky Flats* (K-H, 2003d) has analyzed various lines of evidence bearing on the extent and rates of natural attenuation processes operating in groundwater at RFETS. The overall conclusion is that biodegradation of chlorinated solvent compounds dissolved in groundwater is taking place in local portions of the IA and East Trenches. However, the biodegradation rates are very slow, and are near the low end of the range of rates published for other industrial sites. These slow rates may mean that Monitored Natural Attenuation is not a practical groundwater remedial option for RFETS.

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8.0 WELL ABANDONMENT AND REPLACEMENT PROGRAM

Over 1,400 monitoring wells have been installed at RFETS to characterize groundwater quality. The WARP abandons unnecessary, damaged, and temporary wells and installs replacement or new wells as needed. Replacement wells are installed to replace damaged or temporary wells in areas requiring continued monitoring and new wells are installed in areas lacking data. The objective of the WARP is to maintain and provide a streamlined, functional monitoring well network. This section presents a summary discussion of the WARP activities performed in 2002, beginning with well abandonments and concluding with well installations.

8.1 Program Planning

The *Well Abandonment and Replacement Program Work Plan: FY 2002 through Site Closure* (Work Plan; K-H, 2002g) was written to support the current objectives of the WARP. This document provides the overall requirements of the WARP, while incorporating Site well abandonment and well installation standard operating procedures (SOPs). Specific well abandonments and installations are implemented through addenda to this Work Plan.

Because of the changing configuration of the Site, the need to plan the WARP around closure projects, and our evolving understanding of groundwater contamination and its sources, a single, well-specific Work Plan was not feasible. As the Site approaches closure, removal of buildings and characterization and remediation activities produce new data, particularly regarding potential sources of groundwater contamination. These activities may also cause damage to or require the abandonment of wells.

Instead, the Work Plan (K-H, 2002g) is designed to provide general guidance, while each year's specific scope is outlined in one or more Work Plan Addenda (WPA). The dynamic nature of D&D activities at the Site caused three WPAs to be issued in FY02:

- The Fiscal Year 2002 Well Abandonment and Replacement Program Work Plan Addendum (K-H, 2002h) specified the abandonment of 75 wells and the installation of 5 wells;

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- The Calendar Year 2002 Well Abandonment and Replacement Program Work Plan Addendum for the Solar Evaporation Ponds (K-H, 2002i) specified the abandonment of 12 wells and the installation of 5 wells; and
- The Calendar Year 2002 Well Abandonment and Replacement Program Work Plan Addendum for Additional Well Abandonments (K-H, 2002j) specified the abandonment of 2 wells.

In addition to wells abandoned via the WPAs issued for the 2002 WARP (89 wells), the Fiscal and CY03 WARP WPA (K-H, 2002k) was issued in CY02. The FY03 WPA scheduled the abandonment of a total of 332 wells, piezometers, well points, and boreholes. Of those, 12 were abandoned in CY02. Therefore, during 2002, a total of 101 wells were abandoned.

Gas vents around the unused landfill in the northwest BZ, several inclinometers around the demolished Modular Storage Tanks, and miscellaneous other below ground installations were also abandoned during 2002. These installations were abandoned to support Site closure. However, because they do not represent monitoring wells, piezometers, well points, or boreholes, they are not discussed further.

8.2 Well Abandonments

The 2002 WARP focused on abandoning wells in several areas, including the western BZ (particularly in and around the West Spray Field [WSF]), the Rock Creek drainage, the 903 Pad/Lip Area, the former SEPs, and along the IA North Perimeter Road.

Several wells that were abandoned in 2002 were in the routine IMP monitoring program. Some wells were in the 2001 IMP and removed, and some were in the 2002 IMP until they were abandoned during 2002. Most of these "Program" wells were only used for the collection of water level data, however, groundwater analytical data were collected at three wells as specified in the 2002 IMP. Of these, two wells (20998, 21098) were replaced prior to being abandoned and a third (P209489) was not replaced, though a new well (79202) was installed nearby in a more appropriate location. Three other wells were abandoned and replaced during 2002 (4486, 41199, and 37401) that were damaged during D&D.

Plate 1 shows all abandoned wells. Wells abandoned in 2002 are highlighted in red. Table 8-1 summarizes the wells abandoned in 2002.

Most wells were abandoned in place. For LHSU wells, this required the entire length of the casing to be filled with cement grout per the requirements of the Office of the State Engineer. For UHSU wells, the procedure involved measuring the water level, comparing it with the depth of the top of the screen, and filling the well with filter pack sand to the higher of the two elevations. Bentonite, either in granular form or as grout slurry, was used to fill the rest of the well. For all wells, the well casing was cut at least three feet bgs and well components above three feet bgs (well casing, protective and/or surface isolation casing, well pad) were removed. Clean soil was used to backfill the remaining depression and was seeded with a native grass mix.

One well, 5086, was overdrilled. This involved removing the surface protection and using hollow-stem augers to drill out the casing and annular materials. The resulting borehole was then filled with grout slurry, topped with clean soil, and seeded with a native grass mix.

A number of other wells were physically removed (pulled). Some wells that were pulled were shallow (generally less than ten feet deep); it was more efficient to use a forklift to pull the well out of the ground than to backfill the well casing and cut it off below grade. Other wells that were pulled were small diameter; temporary wells or well points generally less than 0.75 inch in diameter. Many of these were removed by hand. For wells that were pulled, the resulting hole was filled with hydrated granular bentonite.

8.3 Well Installations

Eleven new wells (the ten described above in the WPAs and 33502) were installed and four wells were replaced during 2002. Two piezometers were installed as part of a geotechnical evaluation to support a proposed slurry wall upgradient of the Original Landfill. New wells provide monitoring for remedial actions or closed facilities. Well replacements were required to either address damage caused during D&D or other closure activities, or to replace temporary wells.

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Table 8-1 Wells Abandoned in 2002.

Well	Location and Rationale for Abandonment
2002 WARP Scope	
50194	WSF; Top priority for DOE (refers to an abandonment at the request of DOE)
50994	WSF; Top priority for DOE
B411289	WSF; Top priority for DOE (2001 Program well, water levels only)
B111189	WSF; Top priority for DOE (2001 Program well, water levels only)
B410589	WSF; Top priority for DOE (2001 Program well, water levels only)
B411389	WSF; Top priority for DOE
50394	WSF; Top priority for DOE
50894	WSF; Top priority for DOE
51794	WSF; Top priority for DOE
5086	WSF; Top priority for DOE
50794	WSF; Top priority for DOE
4886	WSF; Not useful LHSU well
51594	WSF; Not useful perched well (2002 Program well, water levels only)
50494	WSF; Not useful perched well (2002 Program well, water levels only)
51694	WSF; Not useful
46392	NE of WSF in west BZ; Not useful
63695	NE of WSF in west BZ; Not useful, small well
5186	West BZ; Not viable, screen too long
5286	West BZ; Not useful UHSU bedrock well
50294	West BZ; Not useful perched well
4686	West of New Landfill; Not useful LHSU well
03192	West border of New Landfill; Not useful
03092	SE of New Landfill; Not useful
TH19	East of New Landfill; Not useful, long screen
TH21	ENE of New Landfill; Not useful, long screen
B405689	Far southwest BZ; Not useful, shallow screen
B400489	Far southwest BZ; Not useful, long screen
B405789	Far southwest BZ; Not useful
B400189	Southwest BZ; Not useful, long screen

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Well	Location and Rationale for Abandonment
B400089	Southwest BZ; Not useful, small diameter
B400289	Southwest BZ; Not useful
0790	Southwest BZ; Not useful
0690	Southwest BZ; Not useful
0590	Southwest BZ; Not useful
5386	Southwest BZ; Not useful
52493	Southwest BZ; Not useful, poor completion
63795	Rock Creek: Land deeded to Fish and Wildlife (2001 Program well, water
63895	Rock Creek: Land deeded to Fish and Wildlife (2001 Program well, water
B102289	Rock Creek: Land deeded to Fish and Wildlife (2001 Program well, water
B102389	Rock Creek: Land deeded to Fish and Wildlife (2001 Program well, water
B202489	Rock Creek: Land deeded to Fish and Wildlife
B202589	Rock Creek: Land deeded to Fish and Wildlife
B205589	Rock Creek: Land deeded to Fish and Wildlife
B201189	Rock Creek: Land deeded to Fish and Wildlife
B201589	Rock Creek: Land deeded to Fish and Wildlife
21197	N. Perimeter Rd: No longer needed, threatened by traffic
21297	N. Perimeter Rd: Destroyed, no longer needed, threatened by traffic
21397	N. Perimeter Rd: Destroyed, no longer needed, threatened by traffic
21497	N. Perimeter Rd: No longer needed, threatened by traffic
21597	N. Perimeter Rd: No longer needed, threatened by traffic
21697	N. Perimeter Rd: No longer needed, threatened by traffic
21797	N. Perimeter Rd: Destroyed, no longer needed, threatened by traffic
21897	N. Perimeter Rd: Destroyed, no longer needed, threatened by traffic
21997	N. Perimeter Rd: No longer needed, threatened by traffic
22097	N. Perimeter Rd: No longer needed, threatened by traffic
22197	N. Perimeter Rd: No longer needed, threatened by traffic
22297	N. Perimeter Rd: No longer needed, threatened by traffic
22397	N. Perimeter Rd: Destroyed, no longer needed, threatened by traffic
22497	N. Perimeter Rd: Destroyed, no longer needed, threatened by traffic
P114589	West IA: Not viable, damaged

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Well	Location and Rationale for Abandonment
20998	West of B771 (2002 Program well for analytical sampling, replaced)
21098	West of B771 (2002 Program well for analytical sampling, replaced)
2987	On South Interceptor Ditch; Not viable, pump stuck in well (2001 Program Well)
1587	903 Pad area; Not needed for Performance Monitoring, remedial activities (2002 Program well, water levels only)
1687	903 Pad area; Not needed for Performance Monitoring, remedial activities
06591	903 Pad area; Not needed for Performance Monitoring, remedial activities
06691	903 Pad area; Not needed for Performance Monitoring, remedial activities
06791	903 Pad area; Not needed for Performance Monitoring, remedial activities
06891	903 Pad area; Not needed for Performance Monitoring, remedial activities
06991	903 Pad area; Not needed for Performance Monitoring, remedial activities (2002 Program well, water levels only)
07191	903 Pad area; Not needed for Performance Monitoring, remedial activities
08891	903 Pad area; Not needed for Performance Monitoring, remedial activities
09091	903 Pad area; Not needed for Performance Monitoring, remedial activities
13091	903 Pad area; Not needed for Performance Monitoring, remedial activities (2002 Program well, water levels only)
13191	903 Pad area; Not needed for Performance Monitoring, remedial activities
13291	903 Pad area; Not needed for Performance Monitoring, remedial activities
50199	903 Pad area; Not needed for Performance Monitoring, remedial activities
41693	Between SEPs; Closure activity
P209089	Between SEPs; Closure activity
43993	Between SEPs; Closure activity
43893	South of SEPs; Closure activity
P209489	North of SEPs; Closure activity (2002 Program well for analytical sampling; new well 79202 is more properly located)
23795	North of SEPs; Not needed, temporary well point
05093	East of SEPs; Closure activity
2786	East of SEPs; Closure activity
05393	East of SEPs; Closure activity
05193	East of SEPs; Closure activity (2002 Program well, water levels only)

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Well	Location and Rationale for Abandonment
26095	South of SEPs; Not needed, temporary well point
3887	South of SEPs; Closure activity
2003 WARP Scope	
308-P-1	Piezometer supporting Material Storage Tanks; Closure activity
308-P-2	Piezometer supporting Material Storage Tanks; Closure activity
308-P-3	Piezometer supporting Material Storage Tanks; Closure activity
26995	Well point in Solar Pond Plume area; Not needed, temporary well point
27095	Well point in Solar Pond Plume area; Not needed, temporary well point
28095	Well point in Solar Pond Plume area; Not needed, temporary well point
28195	Well point in Solar Pond Plume area; Not needed, temporary well point
27795	Well point in Solar Pond Plume area; Not needed, temporary well point
27995	Well point in Solar Pond Plume area; Not needed, temporary well point
30495	Well point in Solar Pond Plume area; Not needed, temporary well point
30695	Well point in Solar Pond Plume area; Not needed, temporary well point
28895	Well point in Solar Pond Plume area; Not needed, temporary well point
Abandoned and Replaced Due To Damage	
4486	Damaged during removal of B442, replaced with well 44202
41199	Damaged during removal of B886, replaced with well 41102

Wells were also installed in 2002 to support the IA Plume groundwater investigation. This activity, implemented through the *Sampling and Analysis Plan for Groundwater Monitoring of the Industrial Area Plume* (RMRS, 2001f), involved the installation of 14 wells. This investigation was discussed in the *2001 Annual RFCA Groundwater Monitoring Report* (Safe Sites, 2002b).

Table 8-2 identifies 2002 WARP well installations and provides summary construction information and installation rationale. The wells are discussed below.

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Table 8-2 Well Installations During 2002.

Well	Reason for Installation	Casing Total Depth	Screened Interval	Top of Bedrock
11502 *	Supports Original Landfill slurry wall project	49.3	17-47	19.0
11602 *	Supports Original Landfill slurry wall project	49.7	17.4-47.4	8.0
20902	Replaces temporary well 20998 (B771 D&D well)	18.0	5.77-15.77	4.0
21002	Replaces temporary well 21098 (IHSS 118.1 Plume Extent Well)	24.0	6.72-21.72	18.2
30002	Monitors for PU&D Yard Plume contaminants at the northern edge of South Walnut Creek	16.5	4.4-16.4	0.6
33502	Monitors contamination in the buried drainage south of B371/374	39.4	4.06-39.22	39.0
41102	Replaces well 41199 (D&D well), destroyed during demolition of B886	20.5	5.31-20.4	NM
44202	Replaces well 4486 (water level monitoring), destroyed during demolition of B442	30.4	5.4-30.3	NM
71102 *	Supports Solar Ponds Plume Treatment System	34.0	23.81-33.9	22
71202 *	Supports Solar Ponds Plume Treatment System	34.0	26.99-33.9	25.3
79102	Supports former SEPs source area monitoring	34.0	6.73-31.74	6.4
79202	Supports former SEPs source area monitoring	35.0	7.72-32.73	2.8
79302	Supports former SEPs source area monitoring	30.0	7.78-27.75	4.8
79402	Supports former SEPs source area monitoring	18.0	5.75-15.75	6.7
79502	Supports former SEPs source area monitoring	24.0	6.75-21.75	8.0
90402	Supports Performance Monitoring of the 903 Pad source removal project	20.0	7.74-17.74	13.7
90502	Supports Performance Monitoring of the 903 Pad source removal project	18.0	5.75-15.75	12.8

* = Installed as a piezometer, but can be used as a well if necessary. All measurements in feet bgs.

NM = Not measured. Core was not collected during installation of this well; refer to original well log for bedrock depth.

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8.3.1 Original Landfill

Piezometers 11502 and 11602 were installed to support a geotechnical evaluation for the potential installation of a slurry wall upgradient of the Original Landfill to minimize groundwater flow into the landfill. In addition, the piezometers were located to provide a potential replacement for well P314289, which is typically dry, and to add a new well between well P314289 and well P416889, should one be needed during closure. Water level data have been collected from these piezometers; they were not sampled in 2002. The installation of the piezometers and data evaluation was performed by ER.

8.3.2 Building 771/IHSS 118.1 Well Replacements

Replacements for temporary wells 20998 and 21098 were needed for long-term monitoring. These wells, constructed of 0.75-inch diameter PVC, were frequently dry or only provided enough water for partial samples. Wells 20902 and 21002 were installed as replacements for wells 20998 and 21098, respectively, and were constructed of two-inch diameter PVC. Both wells were successfully sampled in 2002.

8.3.3 PU&D Yard Plume

Well 30002 was installed downgradient of the southeastern lobe of the PU&D Yard Plume. This plume contains VOCs exceeding Tier II action levels. Existing wells in the North Walnut Creek drainage, most of which have been abandoned, were too shallow and unable to provide groundwater samples that would confirm whether VOCs from this plume are impacting surface water. Well 30002 was installed deeper than the wells described above; however, it has also been dry, and did not provide any samples during 2002.

8.3.4 Buried Drainage South of Buildings 371/374

Before the construction of B371/B374, an unnamed tributary to North Walnut Creek flowed to the northeast from the vicinity of B116 to the main channel of North Walnut Creek. During the

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construction of the B371/B374 cluster, a portion of the drainage located generally south of B371/B374 was filled and constructed over.

Characterization efforts for IHSS Group 300-1 (in the vicinity of the former B335) included the Geoprobing® of a location, reported in a 1994 investigation, to contain DNAPL or sludge with 100,000 µg/L PCE, and other VOCs and SVOCs. The depth of the DNAPL or sludge was estimated to be four to ten feet bgs. In 2002, well 33502 was constructed near this location. Soil sampling was performed from the surface to a depth of 10.5 feet bgs. Below that depth, the borehole was cored but no samples were collected for analysis because the cutting shoe was obstructed by a hard object (possibly a cobble) that was pushed to the total depth of the borehole (40 feet bgs). Soil samples from this location did not produce any substances similar to those reported in the 1994 investigation (DOE, 2003).

8.3.5 Solar Evaporation Ponds

Two piezometers and five wells were installed to support various activities related to the SEPs. Two piezometers, 71102 and 71202, were installed downgradient of the SPPTS collection trench to determine whether groundwater bypasses the treatment system via seepage through the trench bottom. They monitor water level only. Section 4.2 of this report and the *Annual Report for the Rocky Flats Environmental Technology Site Groundwater Plume Treatment Systems, January through December 2002* (K-H, 2003a) provide details regarding the SPPTS and results of 2002 sampling.

The SEPs were closed in 2002. The berms were demolished and the area was regraded. To support this activity, all wells installed within or immediately adjacent to the berms were abandoned in advance of closure activities. Subsequently, five new wells were installed that, together with two pre-existing wells, monitor the northern and eastern sides of the SEPs accelerated action area. These wells were installed to monitor potential changes in groundwater quality following the closure of the SEPs. These wells were sampled in 2002.

8.3.6 903 Pad

Two wells were installed to support the 903 Pad remediation project. Well 90502 was installed upgradient (west) of the 903 Pad, and well 90402 was installed southeast of the 903 Pad. These wells were dry in 2002 and were not sampled. To support the remediation project, all wells within and many wells adjacent to the 903 Pad were abandoned before remediation activities began. Selected wells were retained which, with the two newly-installed wells, will comprise the performance monitoring network for the 903 Pad.

8.4 Future Activities

Future WARP activities will continue to move toward Site closure by abandoning unnecessary and poorly constructed monitoring wells, LHSU monitoring wells, and replacing monitoring wells that are damaged during closure activities. The 2003 WARP will focus on abandoning wells and well points around the former SEPs, unnecessary wells in the IA and BZ, and LHSU wells. The 2003 effort will increase the number of abandonments, relative to 2002, with approximately 330 wells projected to be abandoned. Approximately 15 wells are projected to be installed in 2003. Results of the 2003 WARP will be reported in the 2003 Annual RFCA Groundwater Monitoring Report.

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THIS TARGET SHEET REPRESENTS AN OVER-SIZED MAP / PLATE FOR THIS DOCUMENT:
(Ref: RFETS-2002-RFCA-GWMR)

Final 2002 Annual RFCA Groundwater Monitoring Report

February 2004

Plate 1:

Well Location, Installation, and Abandonment Map

January 28, 2004

CERCLA Administrative Record Document, SW-A-004879

U.S. DEPARTEMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

GOLDEN, COLORADO

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THIS TARGET SHEET REPRESENTS AN
OVER-SIZED MAP / PLATE FOR THIS DOCUMENT:
(Ref: RFETS-2002-RFCA-GWMR)

Final 2002 Annual RFCA Groundwater Monitoring Report

February 2004

Plate 2:

Sitewide Potentiometric Surface Second Quarter 2002

January 26, 2004

CERCLA Administrative Record Document, SW-A-004879

U.S. DEPARTEMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

GOLDEN, COLORADO

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THIS TARGET SHEET REPRESENTS AN OVER-SIZED MAP / PLATE FOR THIS DOCUMENT:
(Ref: RFETS-2002-RFCA-GWMR)

Final 2002 Annual RFCA Groundwater Monitoring Report

February 2004

Plate 3:

Sitewide Potentiometric Surface Fourth Quarter 2002

January 26, 2004

CERCLA Administrative Record Document, SW-A-004879

U.S. DEPARTEMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

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THIS TARGET SHEET REPRESENTS AN OVER-SIZED MAP / PLATE FOR THIS DOCUMENT:
(Ref: RFETS-2002-RFCA-GWMR)

Final 2002 Annual RFCA Groundwater Monitoring Report

February 2004

Plate 4:

Real Time Groundwater Monitoring Location Hydrographs with Precipitation Data

January 27, 2004

CERCLA Administrative Record Document, SW-A-004879

U.S. DEPARTEMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

GOLDEN, COLORADO

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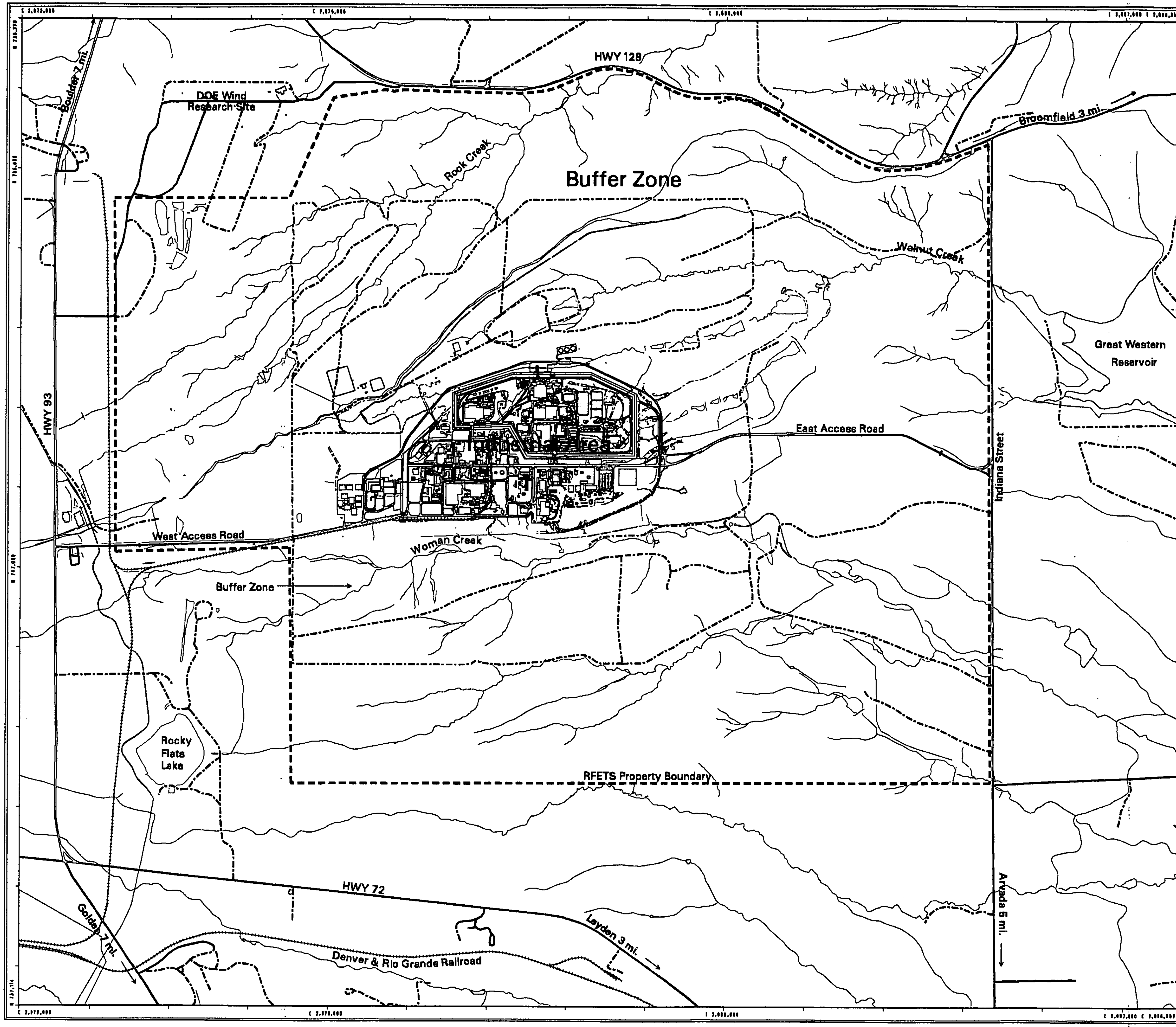

Figure 1-2

Rocky Flats Environmental Technology Site Map

2001 Annual RFCA Groundwater Monitoring Report

EXPLANATION

Standard Map Features

- Buildings and other structures
- Demolished buildings and Other Structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats Environmental Technology Site boundary
- Heavy duty paved roads
- Medium duty paved roads
- Light duty paved roads
- Dirt roads
- Railroads

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Scale = 1 : 26980
1 inch represents approximately 2248 feet

500 0 1000 2000 ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

Prepared by: CH2MHILL

Prepared for: KAISER-HILL COMPANY

February 02, 2004

NT_Svr w:/projects/rfcafy02/projects/02-0781/fig1-2.aml

30

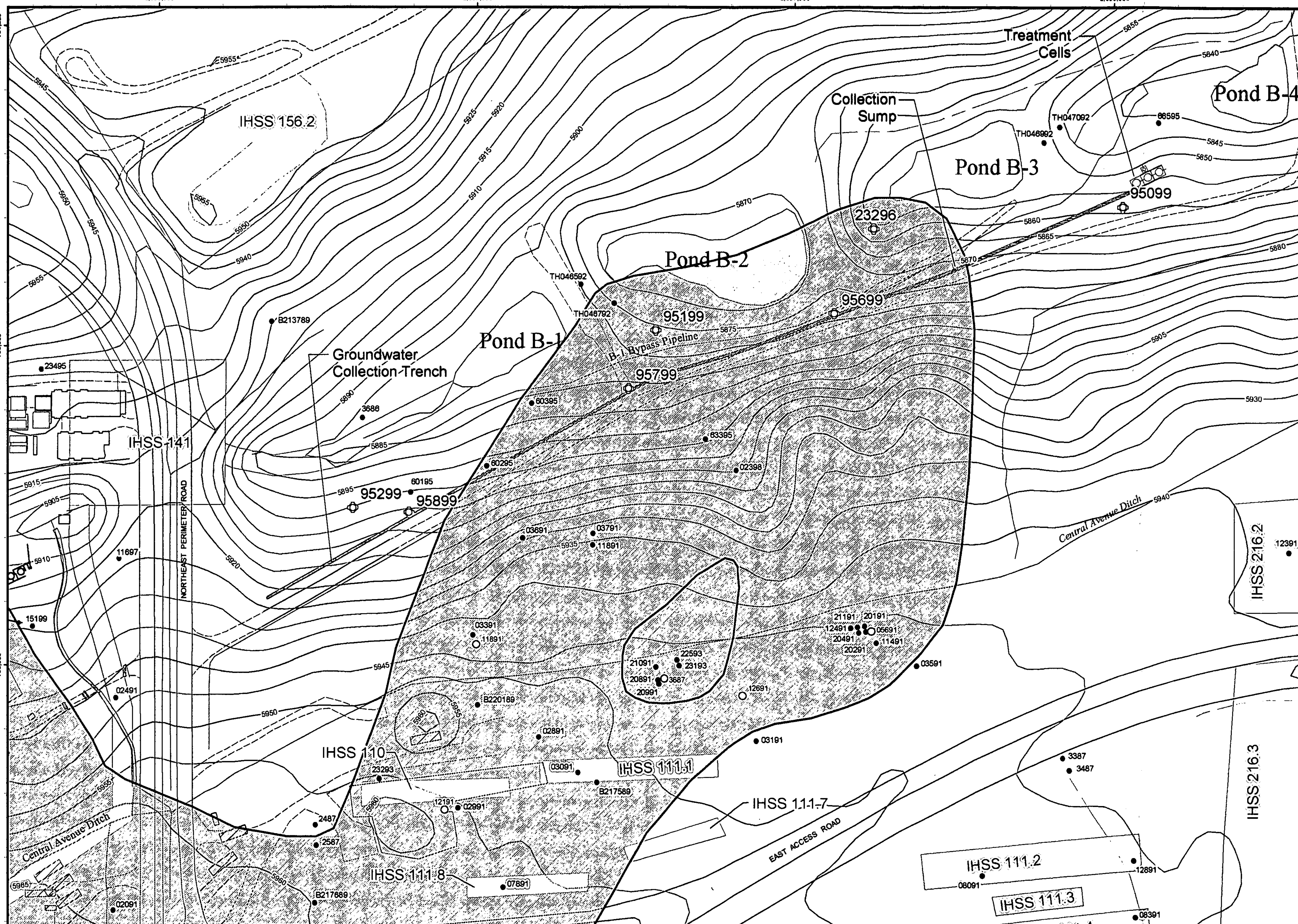

Figure 4-8

East Trenches Plume Treatment System Locations

2002 Annual RFCA Groundwater Monitoring Report

Explanation

- Flow Monitoring Well
- T3/T4 Performance Monitoring Well
- East Trenches Plume Treatment Flow Monitoring Well
- East Trenches Plume Treatment Performance Monitoring Well
- Influent pipe
- Collection trench
- Selected IHSS
- Trichloroethene Groundwater Plume (greater than or equal to 100 X MCL)
- Trichloroethene Groundwater Plume (concentration greater than or equal to MCL)

Standard Map Features

- Building or other structure
- Building - underground structure
- Basement, pit, or tunnel
- Demolished building
- Lake or pond
- Stream, ditch, or other drainage feature
- Fence or other barrier
- Topographic Contour (5-Foot)
- Topographic Contour (20-foot)
- Topographic Contour (25-foot)
- Topographic Contour (100-foot)
- Topographic Contour (500-foot)
- Paved road
- Dirt road

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

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N

Scale = 1 : 1800
1 inch represents 150 feet

75 0 75

Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone Datum: NAD27

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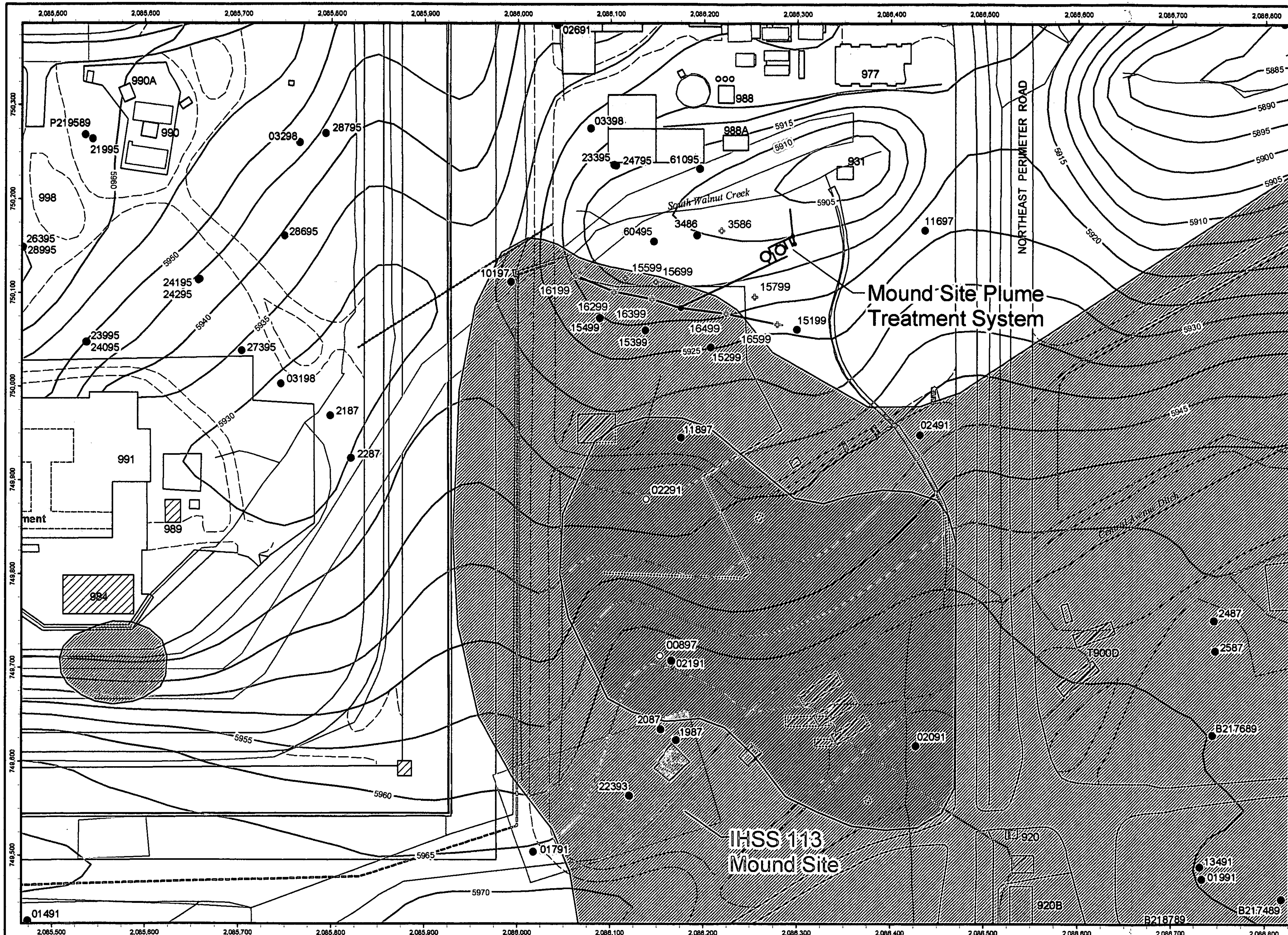
Figure 4-34

Mound Site Plume Area and Accelerated Action Area 2002 Annual RFCA Groundwater Monitoring Report



EXPLANATION

Groundwater Well Type

- Mound Treatment System Performance Monitoring Well
- Inline Treatment System Flow Monitoring Well
- Mound Source Removal Performance Monitoring Well
- Flow Monitoring Well
- Tetrachloroethene Groundwater Plume (greater than or equal to 100 X MCL)
- Tetrachloroethene Groundwater Plume (concentration greater than or equal to MCL)
- Surveyed Location of Excavated area at the Mound Site Accelerated Action Area
- Selected IHSS Boundaries
- Approximate Location of Collection Trench
- Approximate Location of 72" Storm Sewer
- Large Diameter Culvert

Standard Map Features

- Building or other structure
- Demolished building
- Building - underground structure
- Basement, pit, or tunnel
- Lake or pond
- Stream, ditch, or other drainage feature
- Fence or other barrier
- Topographic contour (5-foot)
- Topographic contour (20-foot)
- Topographic contour (25-foot)
- Topographic contour (100-foot)
- Paved road
- Dirt road

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N

Scale = 1 :1200
1 inch represents 100 feet

50 0 50 100

Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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Rocky Flats Environmental Technology Site

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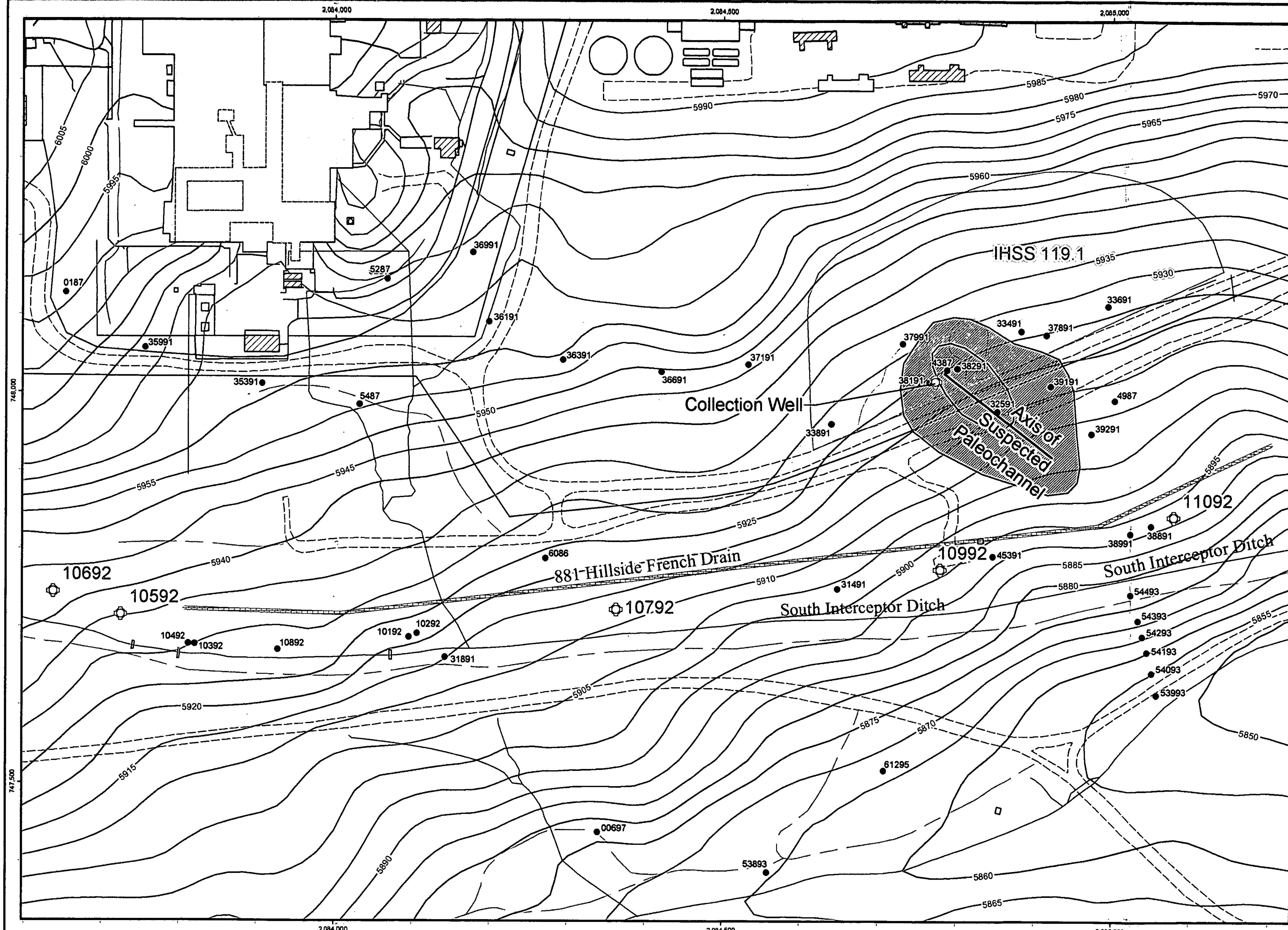

Figure 4-46

881 Hillside Area

2002 Annual RFCA Groundwater Monitoring Report

Explanation

- Flow Monitoring Well
- Performance Monitoring Well
- French Drain System
- IHSS 119.1
- Trichloroethene Groundwater Plume (greater than or equal to 100 X MCL)
- Trichloroethene Groundwater Plume (concentration greater than or equal to MCL)

Standard Map Features

- Building or other structure
- Building - underground structure
- Basement, pit, or tunnel
- Demolished building
- Lake or pond
- Stream, ditch, or other drainage feature
- Fence or other barrier
- Topographic Contour (5-Foot)
- Topographic Contour (20-foot)
- Topographic Contour (25-foot)
- Topographic Contour (100-foot)
- Topographic Contour (500-foot)
- Paved road
- Dirt road

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95 Topographic contours were derived from digital elevation model (DLM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DLM data to create 5-foot contours. The DLM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at 10 meter resolution. DEM post processing performed by MK, winter 1997.

DATA SOURCES:

Borehole and Groundwater Well data - Approved by John Boylan (URS, 303-966-5182)

Individual Hazardous Substance Site (IHSS) data - Approved by Nick Demos (SSOC, 303-966-4605)

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N

Scale = 1:1440
1 inch represents 120 feet
60 0 60
Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone Datum: NAD27

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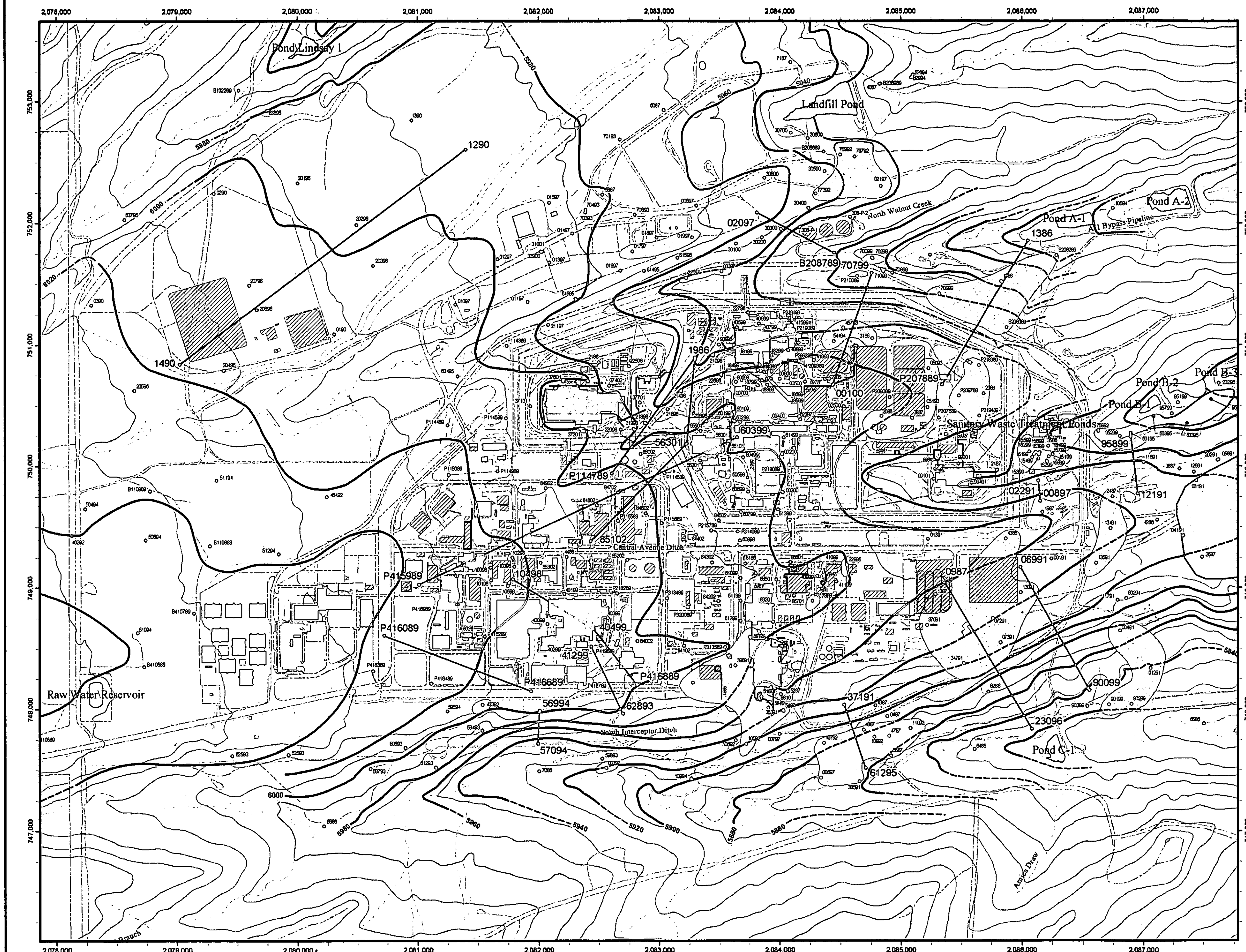
Figure 2-1

Linear Flow Velocity Well Pairs

2002 Annual RFCA Groundwater Monitoring Report



EXPLANATION

- Paired Groundwater Well used to measure flow velocity
- Groundwater Monitoring Well with Water Level Elevation
- Dry Groundwater Monitoring Well
- 2nd Quarter 2002 Data Water Level Contour (20 Foot Interval)
- Dashed where inferred
- Foundation Drain
- Approximate current extent of Unsaturated Alluvium

Standard Map Features

- Building or other structure
- Demolished building or other structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt Road
- Trail
- Fence or other barrier
- 500-foot Topographic Contour
- 100-foot Topographic Contour
- 20-foot Topographic Contour

DATA SOURCE BASE FEATURES:

Buildings, fences, hydrography, roads, and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95 Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at -10 meter resolution. DEM post-processing performed by MK, Winter 1997.

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N

Scale = 1 : 9600
1 inch represents 800 feet

400 0 400 800

Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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Figure 2-2

Water Level Change Map
2001 vs 2002
Second Quarter

2002 Annual RFCA
Groundwater Monitoring Report

Legend

- Dry Well - 2nd quarter both years
- Monitoring well with water level data for 2nd quarter both years
- Area without Groundwater Elevation Data
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt Road
- Trail
- Fence

2001 to 2002 change in saturated thickness (ft)

- -6.333 to -5
- -4.999 to -1
- -0.999 to -0.5
- -0.499 to 0.5
- 0.501 to 1
- 1.001 to 5

Scale = 1 : 12000
1 inch represents 1000 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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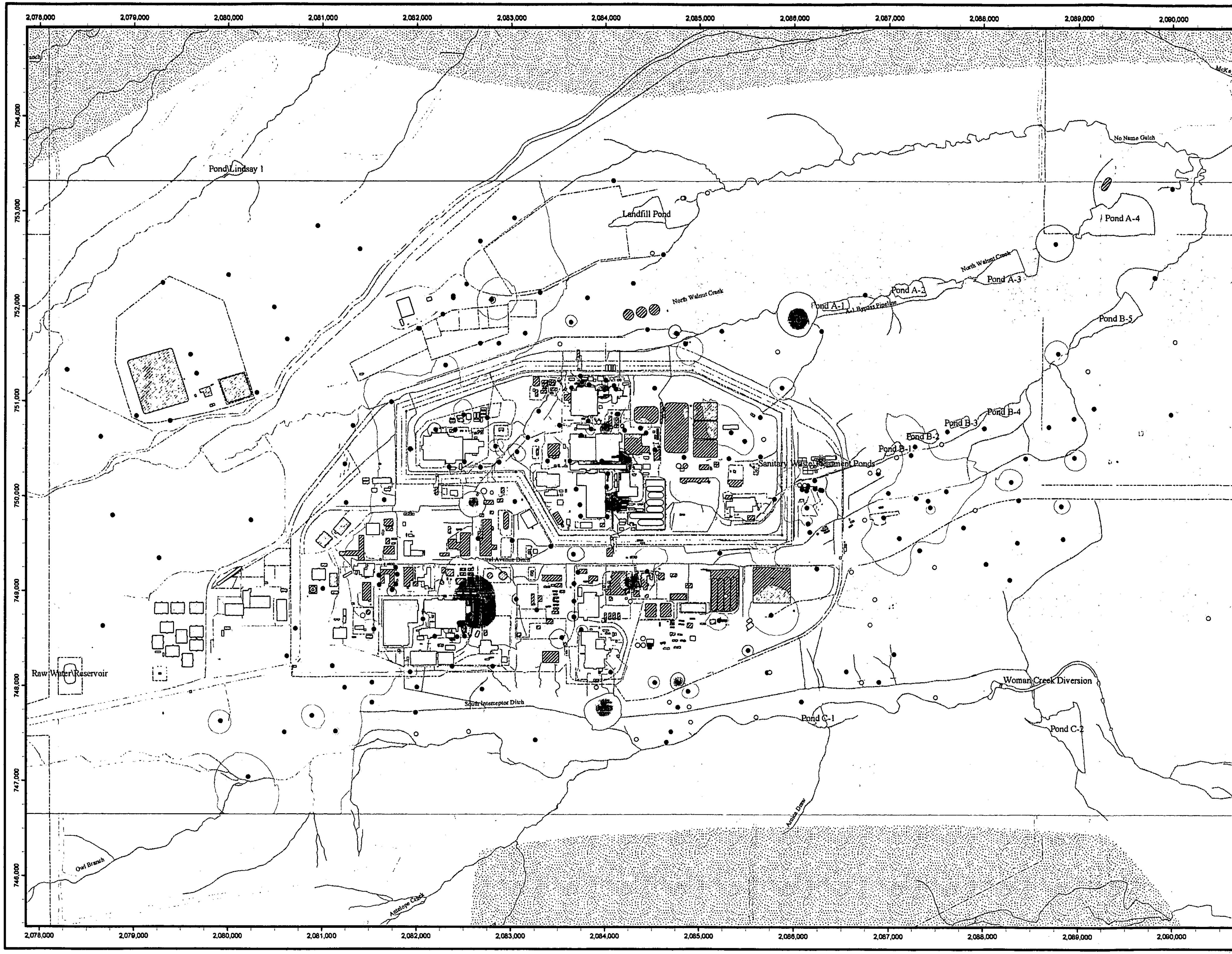

Figure 2-3

Water Level Change Map
2001 vs 2002
Fourth Quarter

2002 Annual RFCA
Groundwater Monitoring Report

Legend

- Dry Well - 4th quarter both years
- Monitoring well with water level data for 4th quarter both years
- Area without Groundwater Elevation Data
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt Road
- Trail
- Fence

2001 to 2002 change in saturated thickness (ft)

- -5.165 to -5
- -4.999 to -1
- -0.999 to -0.5
- -0.499 to 0.5
- 0.501 to 1
- 1.001 to 5

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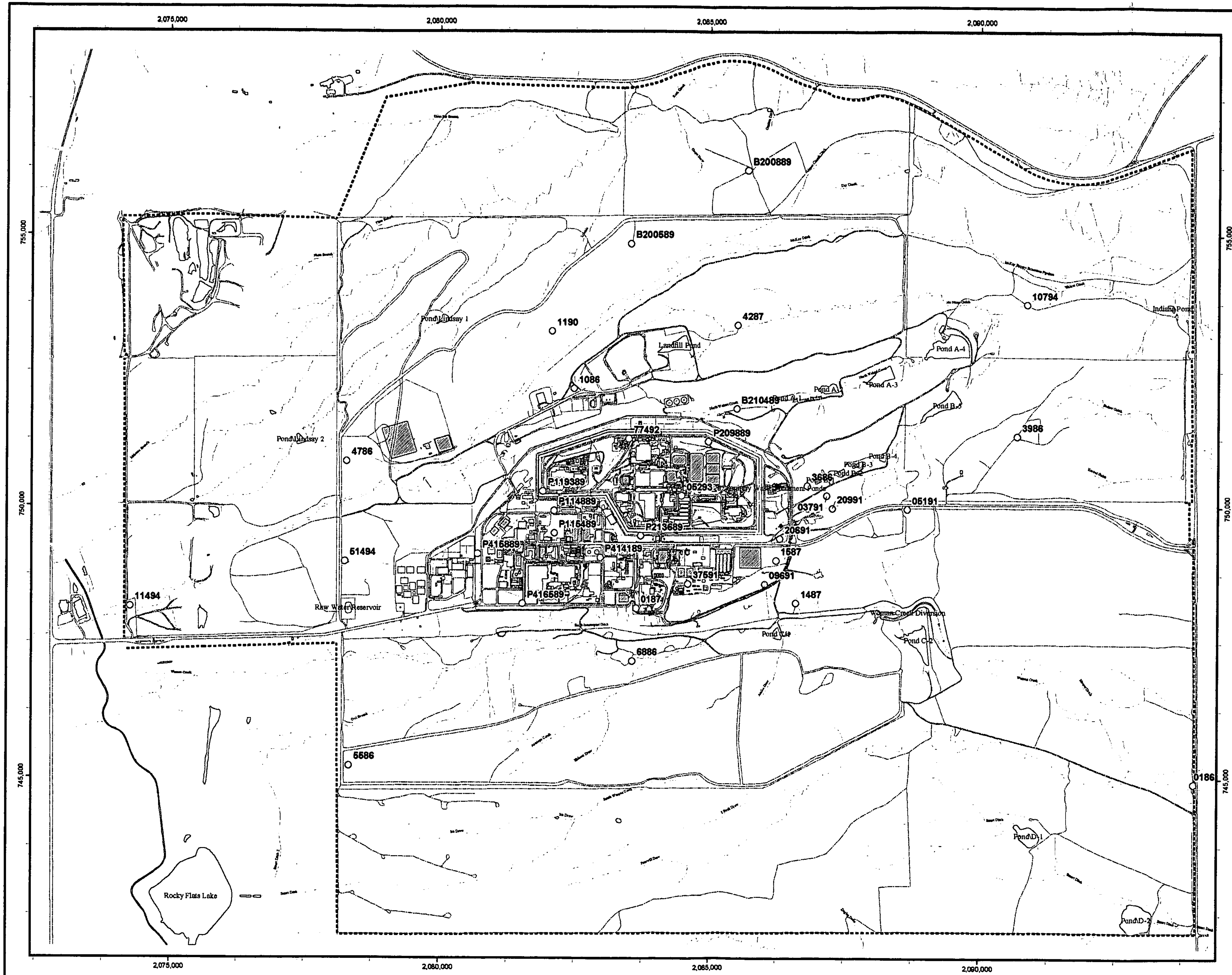

Figure 2-4

Real Time Groundwater Monitoring Well Locations

2002 Annual RFCA Groundwater Monitoring Report

EXPLANATION

- Groundwater well with real time water level monitoring
- Real time monitoring location abandoned during 2002
- Real time monitoring location added during 2002

Standard Map Features

- Building or other structure
- Demolished building
- Lake or pond
- Stream, ditch, or other drainage feature
- Fence or other barrier
- Rocky Flats Environmental Technology Site boundary
- Paved road
- Dirt Road

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads, and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

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N

Scale = 1 : 21600
1 inch represents 1800 feet

600 0 600 1,200 1,800

Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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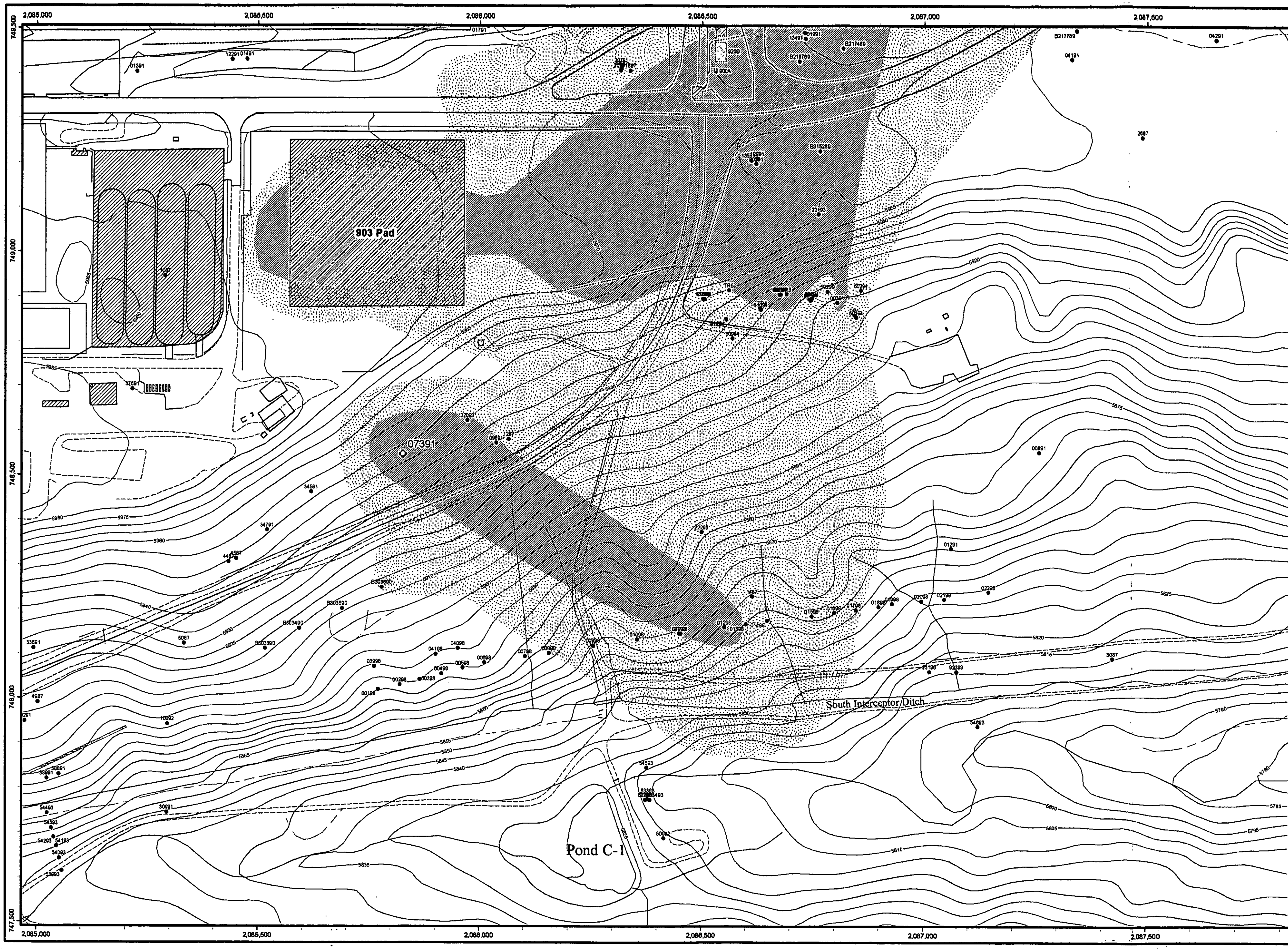

Figure 4-1

Ryan's Pit
Area Location Map
2002 Annual RFCA
Groundwater Monitoring Report

Explanation

- ● Flow Monitoring Well
- ⌖ Ryan's Pit Performance Monitoring Well

Composite Plume Key

- Composite Trichloroethene and Carbon Tetrachloride Groundwater Plume (greater than or equal to 100 X MCL)
- Composite Trichloroethene and Carbon Tetrachloride Groundwater Plume (concentration greater than or equal to MCL)

Standard Map Features

- Building or other structure
- Building - underground structure
- Basement, pit, or tunnel
- Demolished building
- Lake or pond
- Stream, ditch, or other drainage feature
- Fence or other barrier
- Topographic Contour (5-Foot)
- Topographic Contour (20-foot)
- Topographic Contour (25-foot)
- Topographic Contour (100-foot)
- Topographic Contour (500-foot)
- Paved road
- Dirt road

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95 Topographic contours were derived from digital elevation model (DLM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DLM data to create 5-foot contours. The DLM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at 10 meter resolution. DEM post processing performed by MK, winter 1997.

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N

Scale = 1 : 2520
1 inch represents 210 feet
105 0 105
Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone Datum: NAD27

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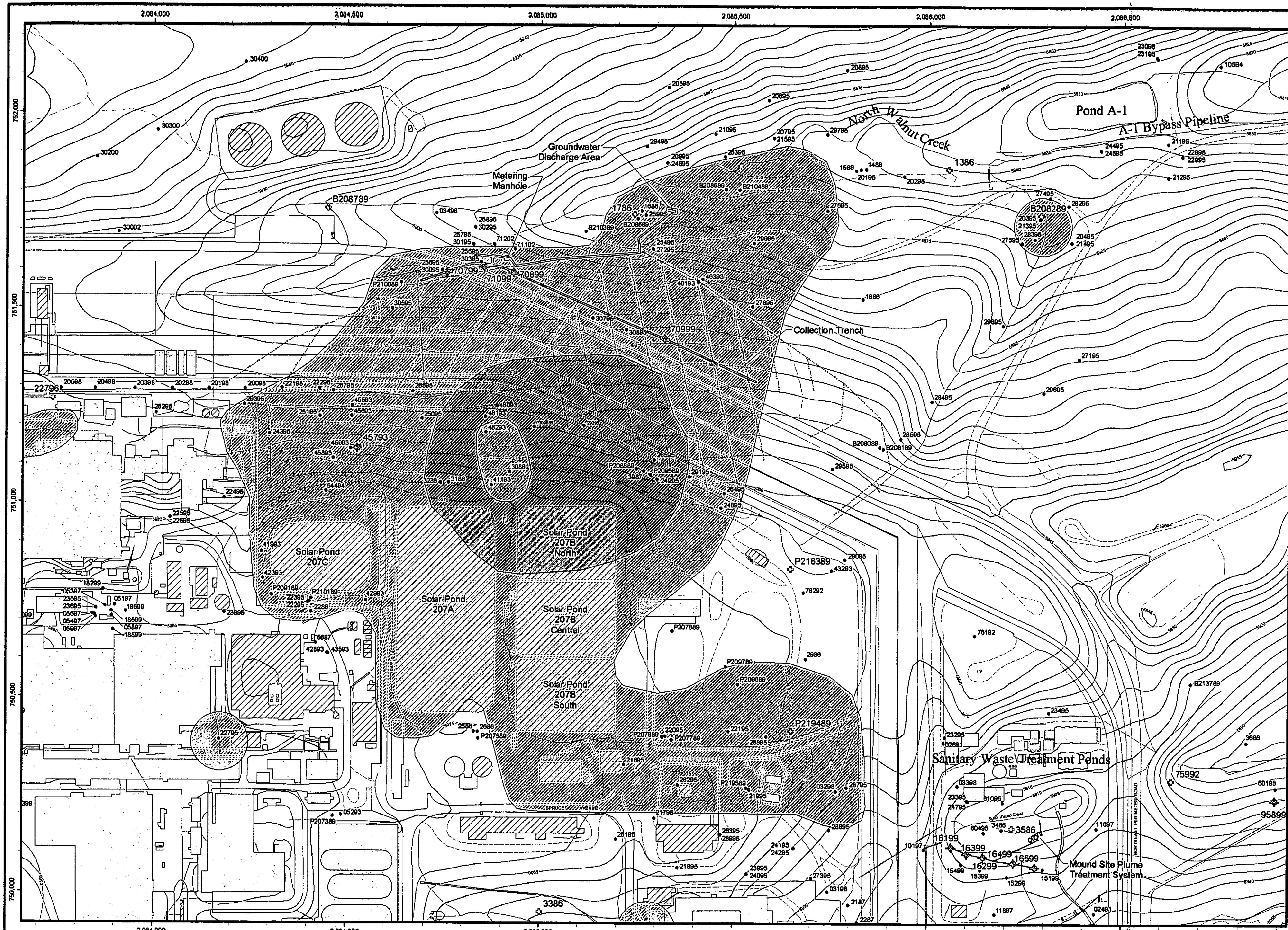

Figure 4-65

Solar Ponds Plume Treatment System Locations and Nitrate Plume

2002 Annual RFCA Groundwater Monitoring Report

Explanation

- Other Flow Monitoring Well
- In Trench Piezometer Location
- Plume Treatment System Monitoing Well
- Old Interceptor Trench System
- New Interceptor Trench System (Installed 1999)
- Tier II Nitrate Plume (10 mg/l)
- Tier I Nitrate Plume (1000 mg/l)

Standard Map Features

- Building or other structure
- Building - underground structure
- Basement, pit, or tunnel
- Demolished building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Fence or other barrier
- Topographic Contour (5-Foot)
- Topographic Contour (20-foot)
- Topographic Contour (25-foot)
- Topographic Contour (100-foot)
- Topographic Contour (500-foot)
- Paved road
- Dirt road

DATA SOURCE BASE FEATURES:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 2-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

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N

Scale = 1 :2880
1 inch represents 240 feet

120 0 120 240

Scale In Feet

State Plane Coordinate Projection
Colorado Central Zone Datum: NAD27

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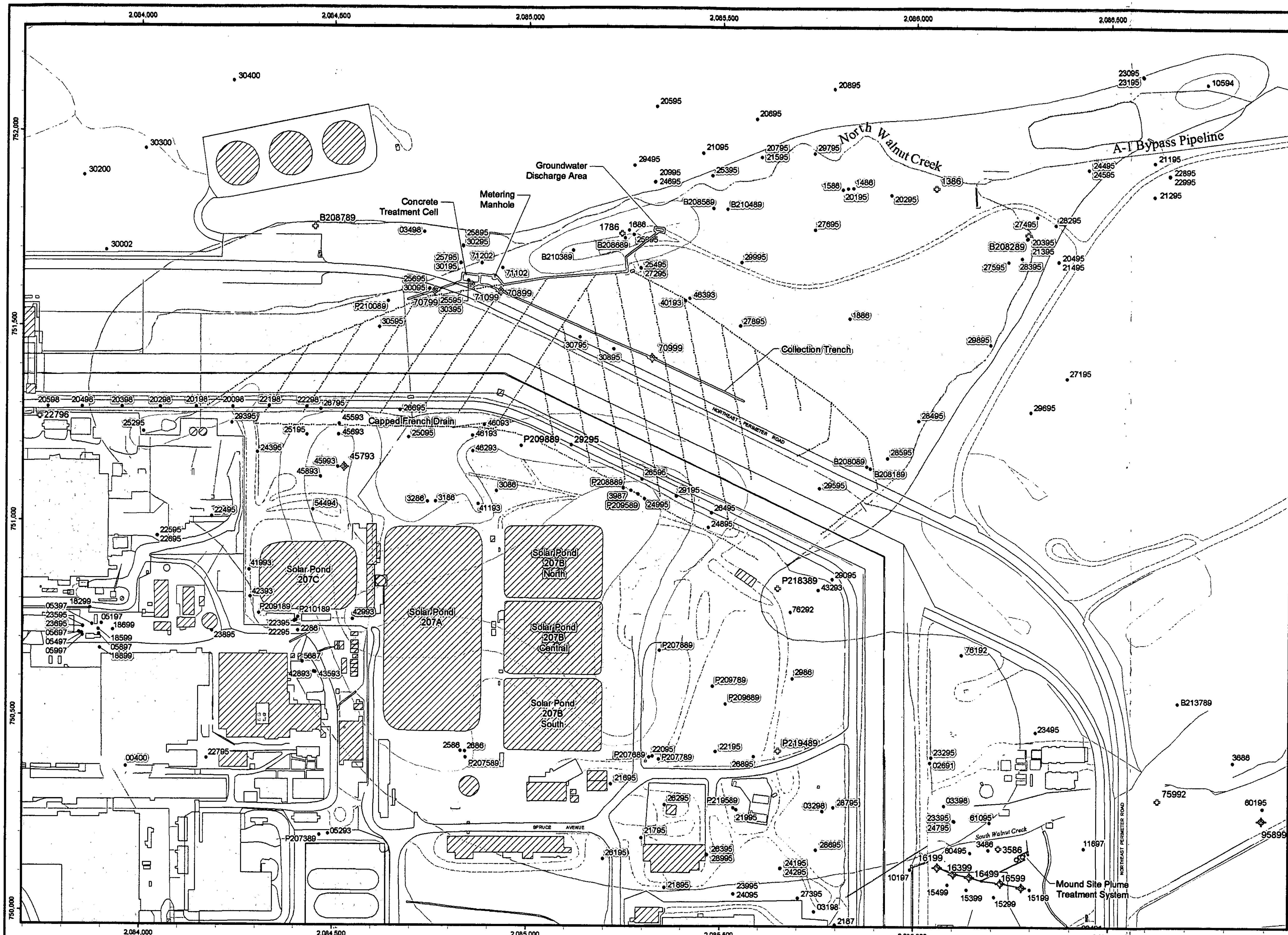

Figure 4-66

Solar Ponds Plume Treatment System Locations and Filtered Uranium Plume

2002 Annual RFCA Groundwater Monitoring Report

Explanation

- Other Flow Monitoring Well
- In Trench Piezometer Location
- Plume Treatment System Monitoring Well
- Old Interceptor Trench System
- New Interceptor Trench System (Installed 1999)

Uranium Plume Values

- => 2.847 < 50.0 pCi/L (2001-2002)
- => 50 < 104.29 pCi/L (2001-2002)
- => 104.29 < 284.7 pCi/L (2001-2002)
- => 284.7 pCi/L (2001-2002)

NOTE:
Activities shown on this figure are a combination of naturally occuring and anthropogenic U-isotopes.

Standard Map Features

- Building or other structure
- Building - underground structure
- Basement, pit, or tunnel
- Demolished building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Fence or other barrier
- Topographic Contour (5-Foot)
- Topographic Contour (20-foot)
- Topographic Contour (25-foot)
- Topographic Contour (100-foot)
- Topographic Contour (500-foot)
- Paved road
- Dirt road

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

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N

Scale = 1 : 2880
1 inch represents 240 feet

120 0 120

Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone Datum: NAD27

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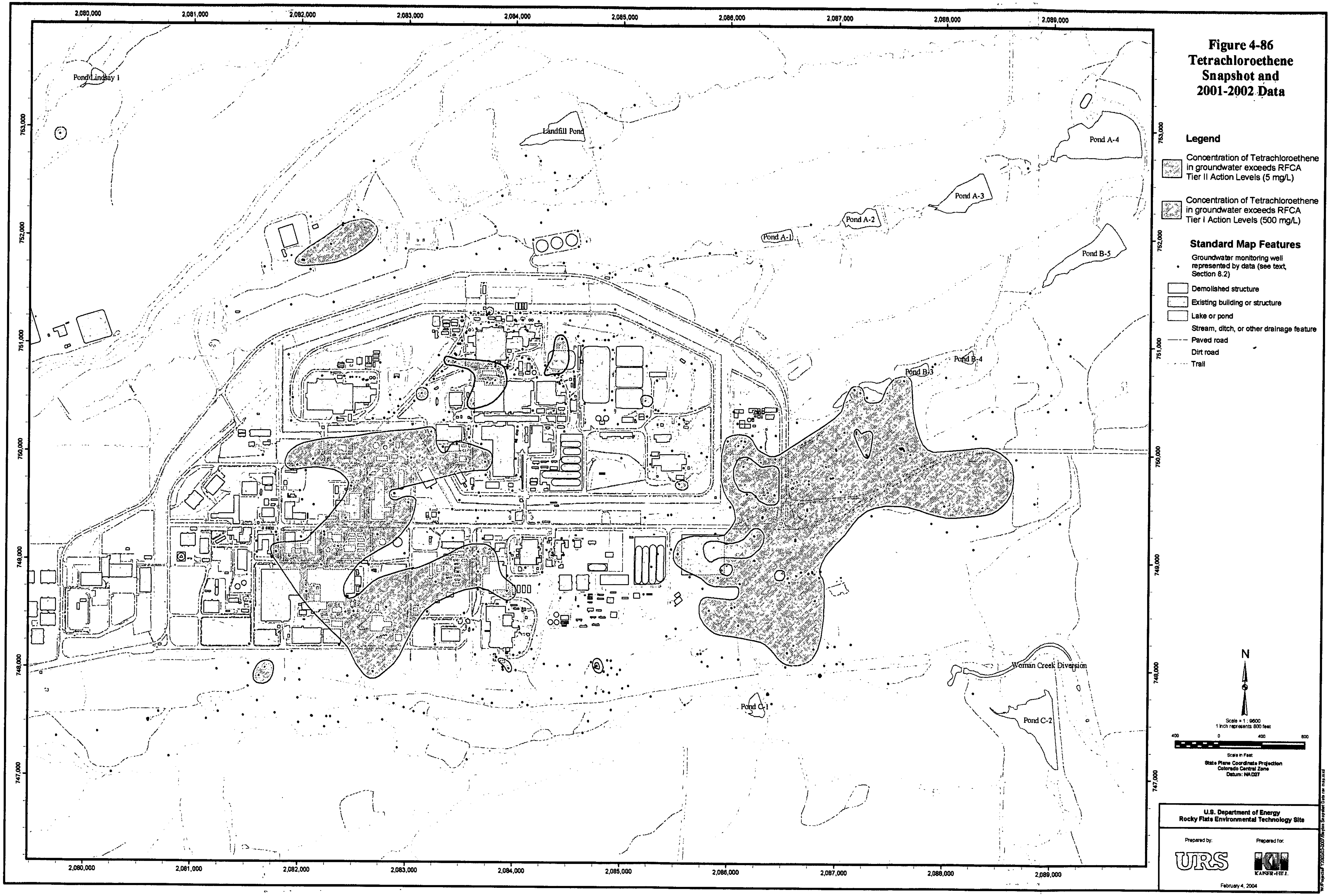
Figure 4-86
Tetrachloroethene
Snapshot and
2001-2002 Data
Legend
Concentration of Tetrachloroethene in groundwater exceeds RFCA Tier II Action Levels (5 mg/L)
Concentration of Tetrachloroethene in groundwater exceeds RFCA Tier I Action Levels (500 mg/L)
Standard Map Features
Groundwater monitoring well represented by data (see text, Section 8.2)
Demolished structure
Existing building or structure
Lake or pond
Stream, ditch, or other drainage feature
Paved road
Dirt road
Trail
N
Scale = 1 : 9600
1 inch represents 800 feet
Scale in Feet
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27
U.S. Department of Energy
Rocky Flats Environmental Technology Site
Prepared by:
Prepared for:
URS
February 4, 2004
Pond Lindsay 1
Landfill Pond
Pond A-1
Pond A-2
Pond A-3
Pond A-4
Pond B-3
Pond B-4
Pond B-5
Pond C-1
Pond C-2
Woman Creek Diversion
2,080,000
2,081,000
2,082,000
2,083,000
2,084,000
2,085,000
2,086,000
2,087,000
2,088,000
2,089,000
753,000
752,000
751,000
750,000
749,000
748,000
747,000

180

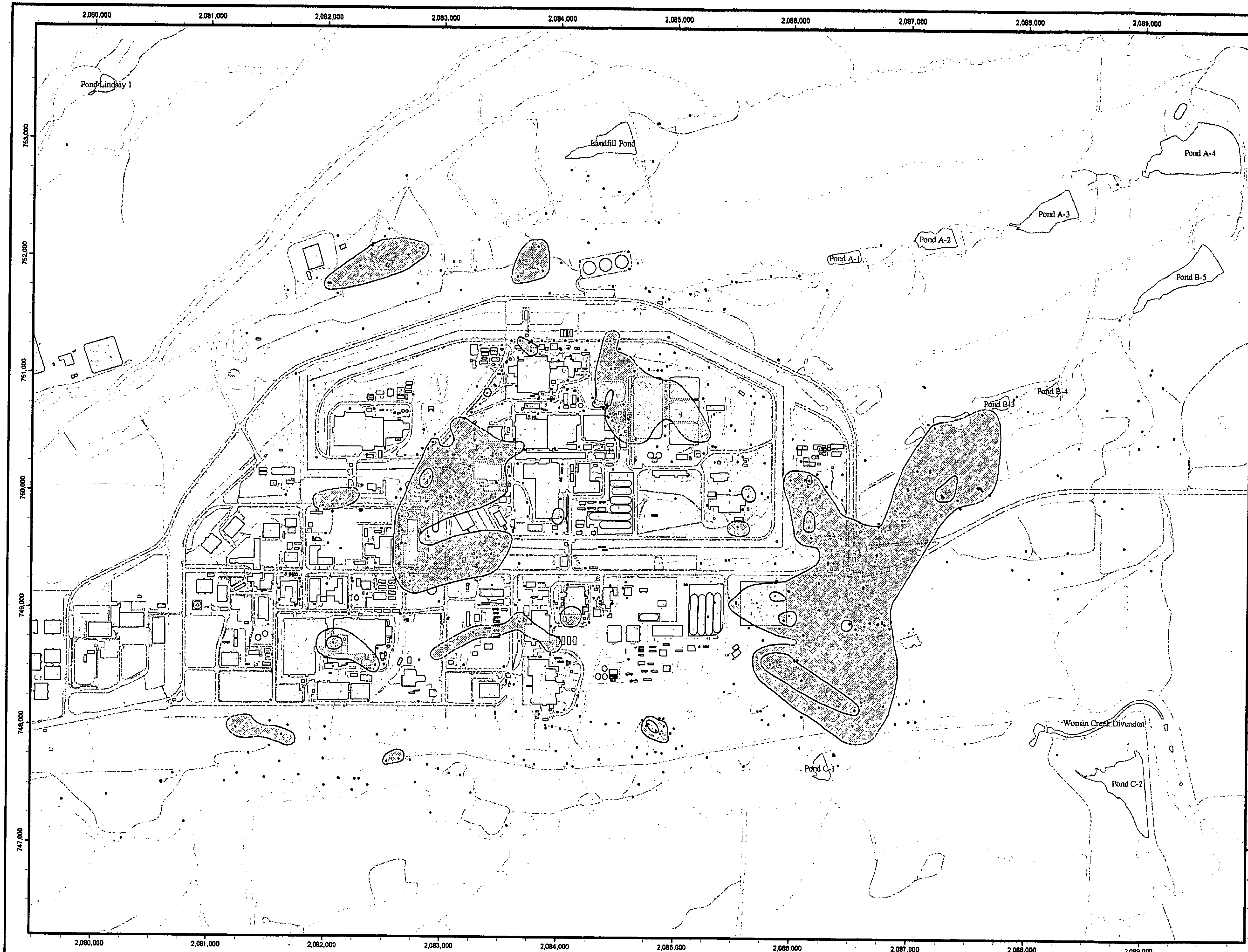

Figure 4-87
Trichloroethene Snapshot and 2001-2002 Data

Legend

Concentration of Trichloroethene in groundwater exceeds RFCA Tier II Action Levels (5 mg/L)

Concentration of Trichloroethene in groundwater exceeds RFCA Tier I Action Levels (500 mg/L)

Standard Map Features

- Groundwater monitoring well represented by data (see text, Section 8.2)
- Demolished structure
- Existing building or structure
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail

N

Scale = 1 : 9600
1 inch represents 800 feet

400 0 400 800

Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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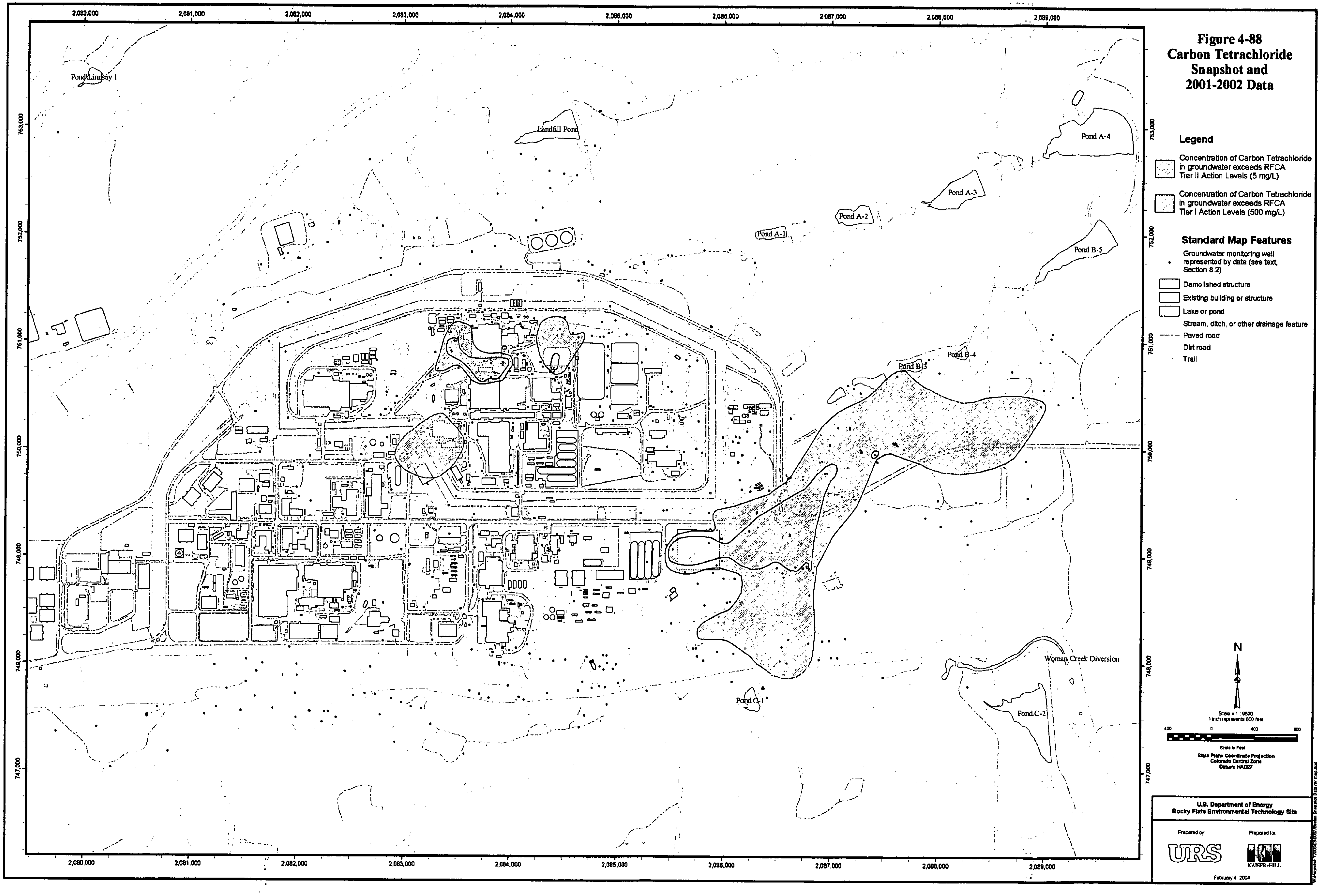
Figure 4-88
Carbon Tetrachloride
Snapshot and
2001-2002 Data
Legend
Concentration of Carbon Tetrachloride in groundwater exceeds RFCA Tier II Action Levels (5 mg/L)
Concentration of Carbon Tetrachloride in groundwater exceeds RFCA Tier I Action Levels (500 mg/L)
Standard Map Features
Groundwater monitoring well represented by data (see text, Section 8.2)
Demolished structure
Existing building or structure
Lake or pond
Stream, ditch, or other drainage feature
Paved road
Dirt road
Trail
Pond Lindsay 1
Landfill Pond
Pond A-1
Pond A-2
Pond A-3
Pond A-4
Pond B-3
Pond B-4
Pond B-5
Pond C-1
Pond C-2
Woman Creek Diversion
2,080,000
2,081,000
2,082,000
2,083,000
2,084,000
2,085,000
2,086,000
2,087,000
2,088,000
2,089,000
753,000
752,000
751,000
750,000
749,000
748,000
747,000
N
Scale = 1 : 9600
1 inch represents 800 feet
400 0 400 800
Scale in Feet
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27
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February 4, 2004

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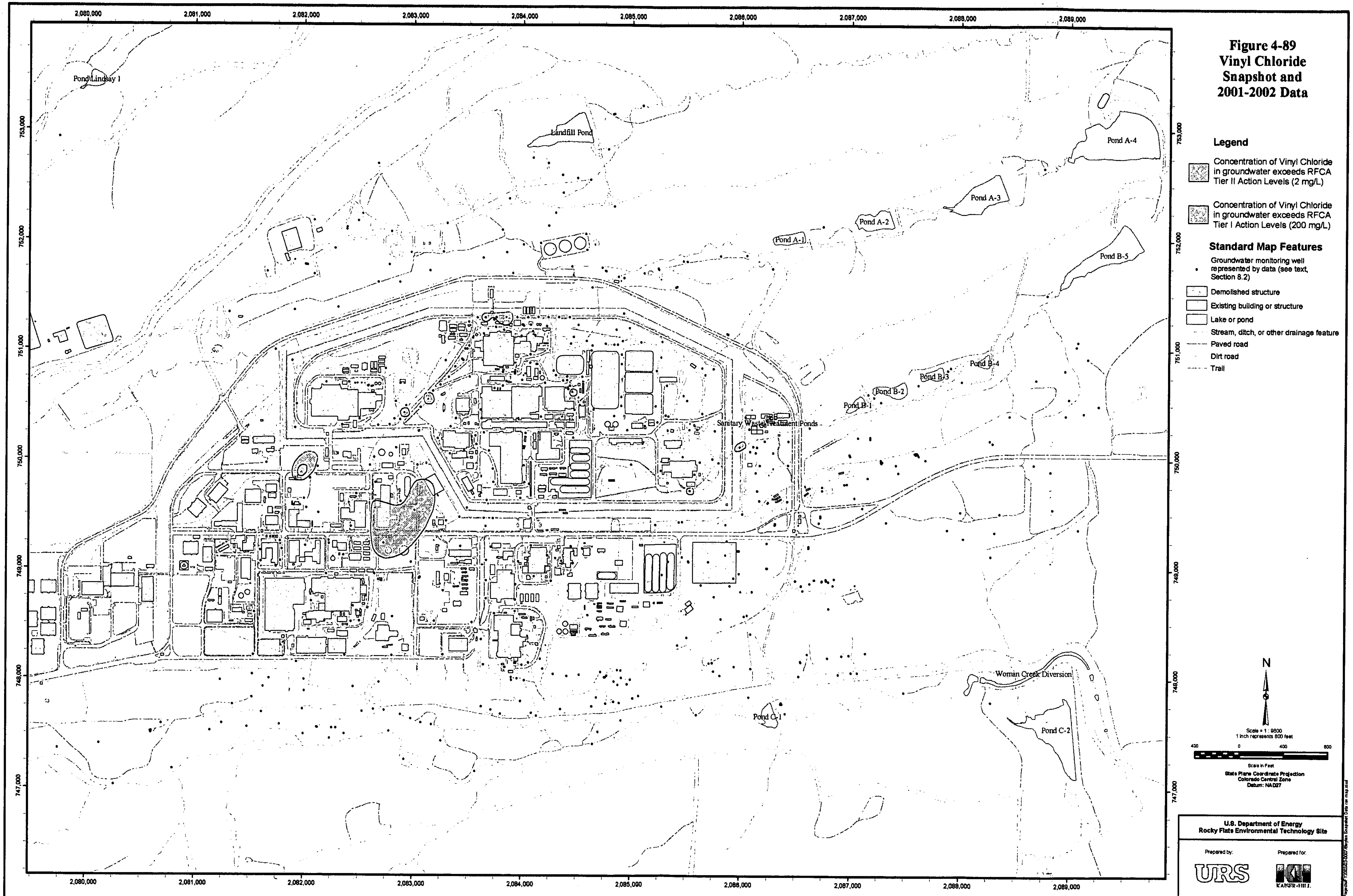

**Figure 4-89
Vinyl Chloride
Snapshot and
2001-2002 Data**

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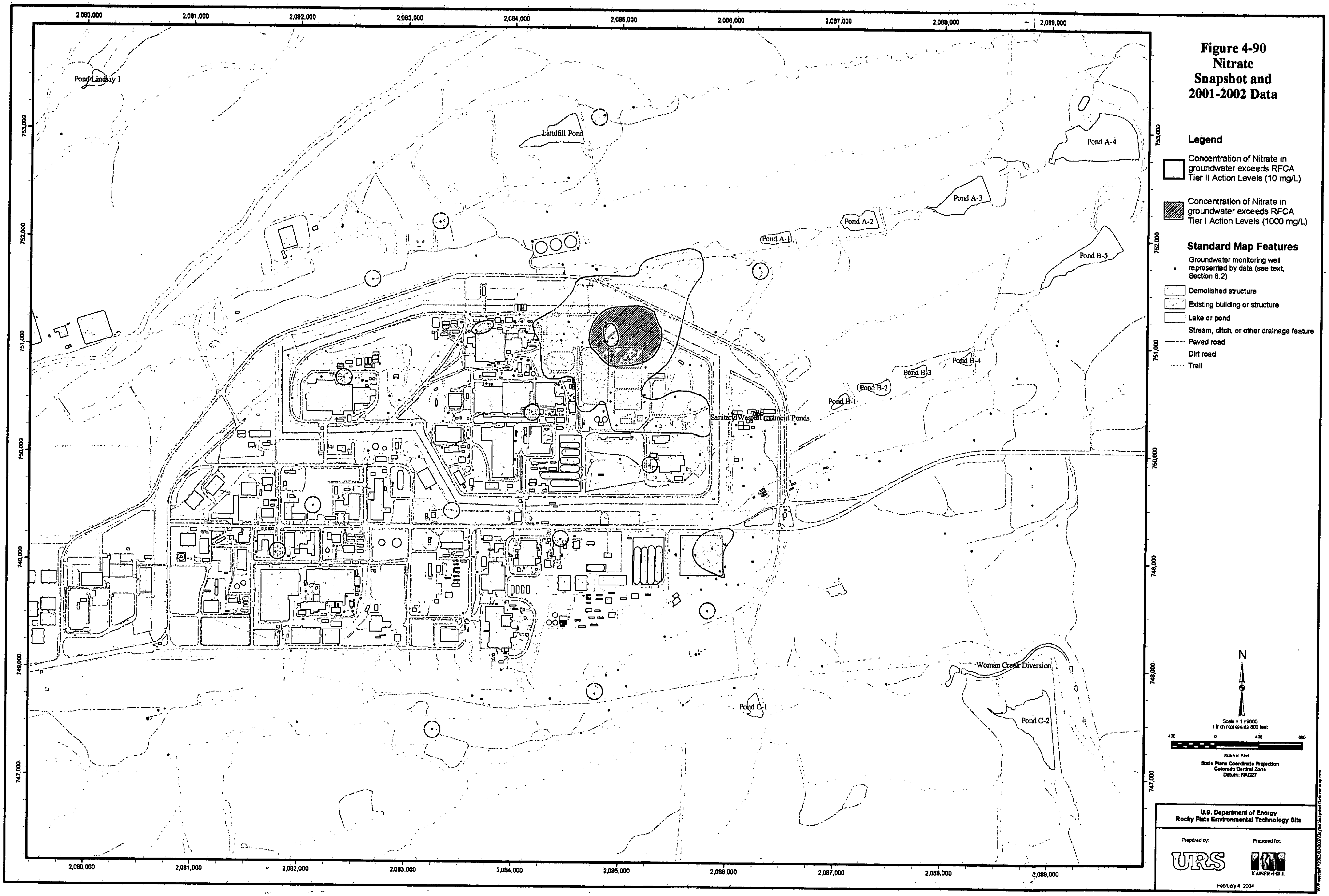
Figure 4-90 Nitrate Snapshot and 2001-2002 Data



184

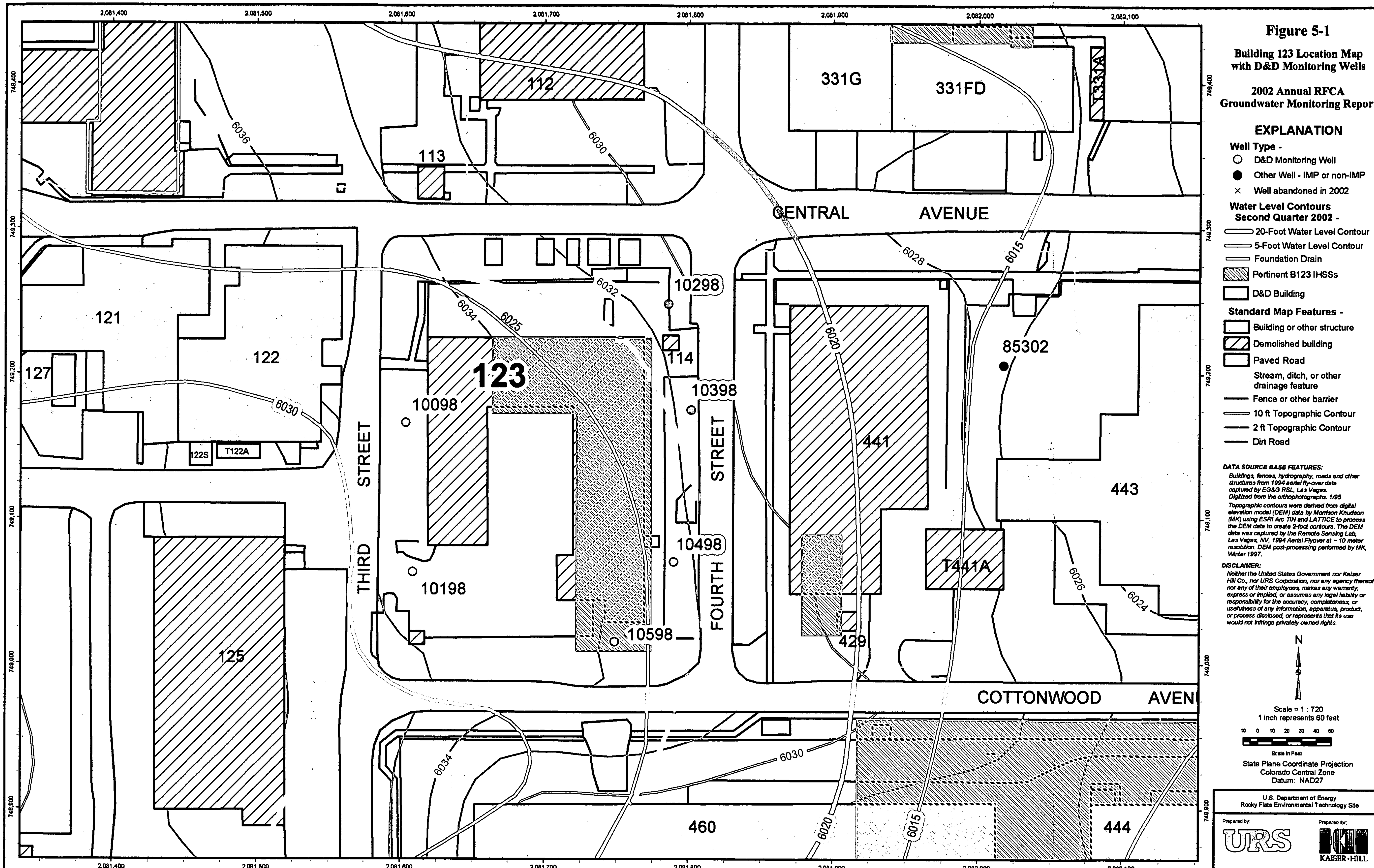


Figure 5-1

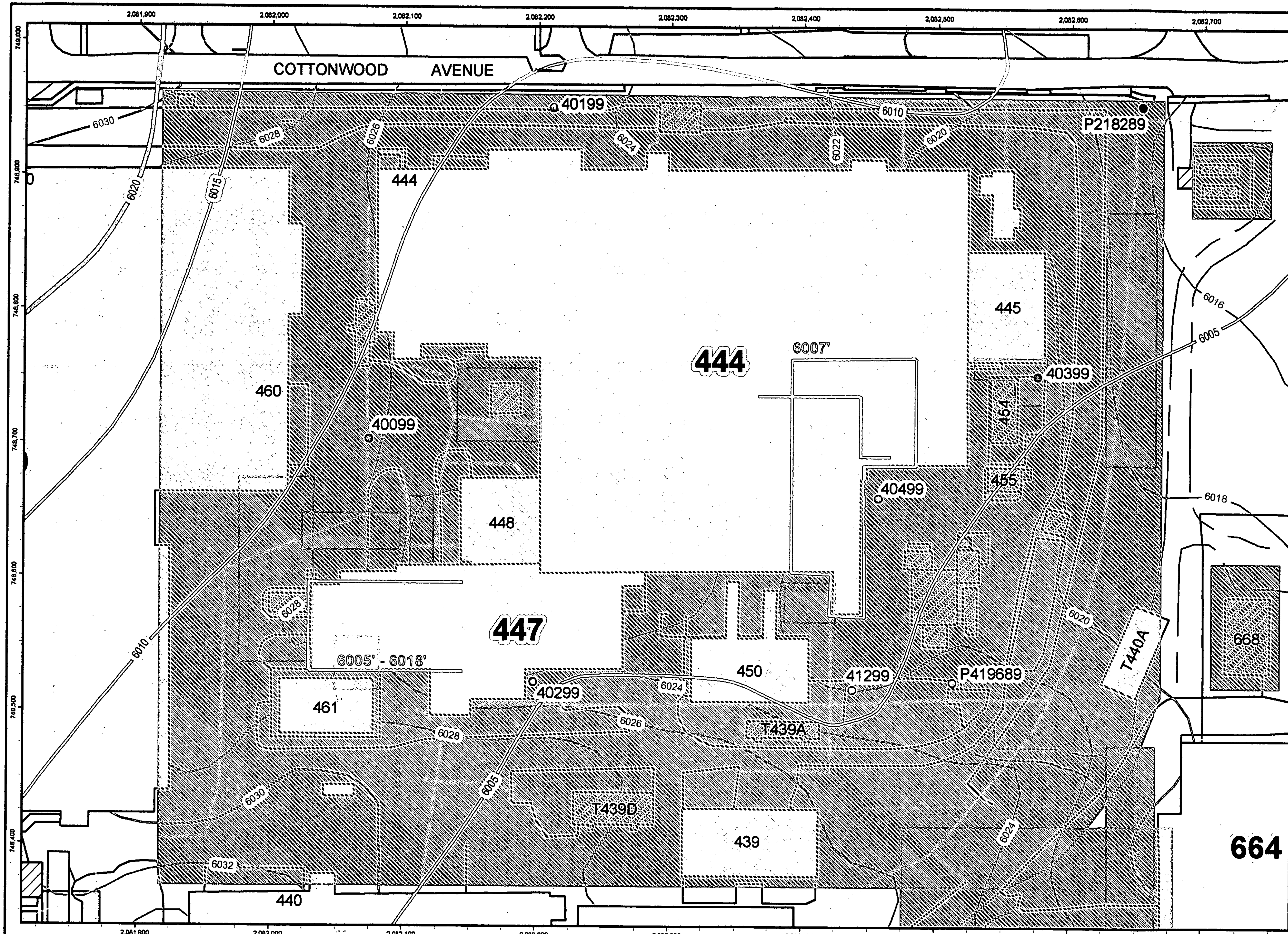
Building 123 Location Map with D&D Monitoring Wells

2002 Annual RFCA Groundwater Monitoring Report

Figure 5-6

Building 444 Location Map with D&D Monitoring Wells

2002 Annual RFCA Groundwater Monitoring Report



EXPLANATION

Well Type -

- D&D Monitoring Well
- Other Well - IMP or non-IMP
- × Well abandoned in 2002

Water Level Contours Second Quarter 2002 -

- 20-Foot Water Level Contour
- 5-Foot Water Level Contour
- Foundation Drain
- Pertinent B444 IHSSs
- D&D Building

Standard Map Features -

- Building or other structure
- Demolished building
- Paved Road
- Stream, ditch, or other drainage feature
- Fence or other barrier
- 10 ft Topographic Contour
- 2 ft Topographic Contour
- Dirt Road

DATA SOURCE BASE FEATURES:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 2-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

N

Scale = 1 : 840
1 inch represents 70 feet

10 0 10 20 30 40 50 60 70

Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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December 1, 2003

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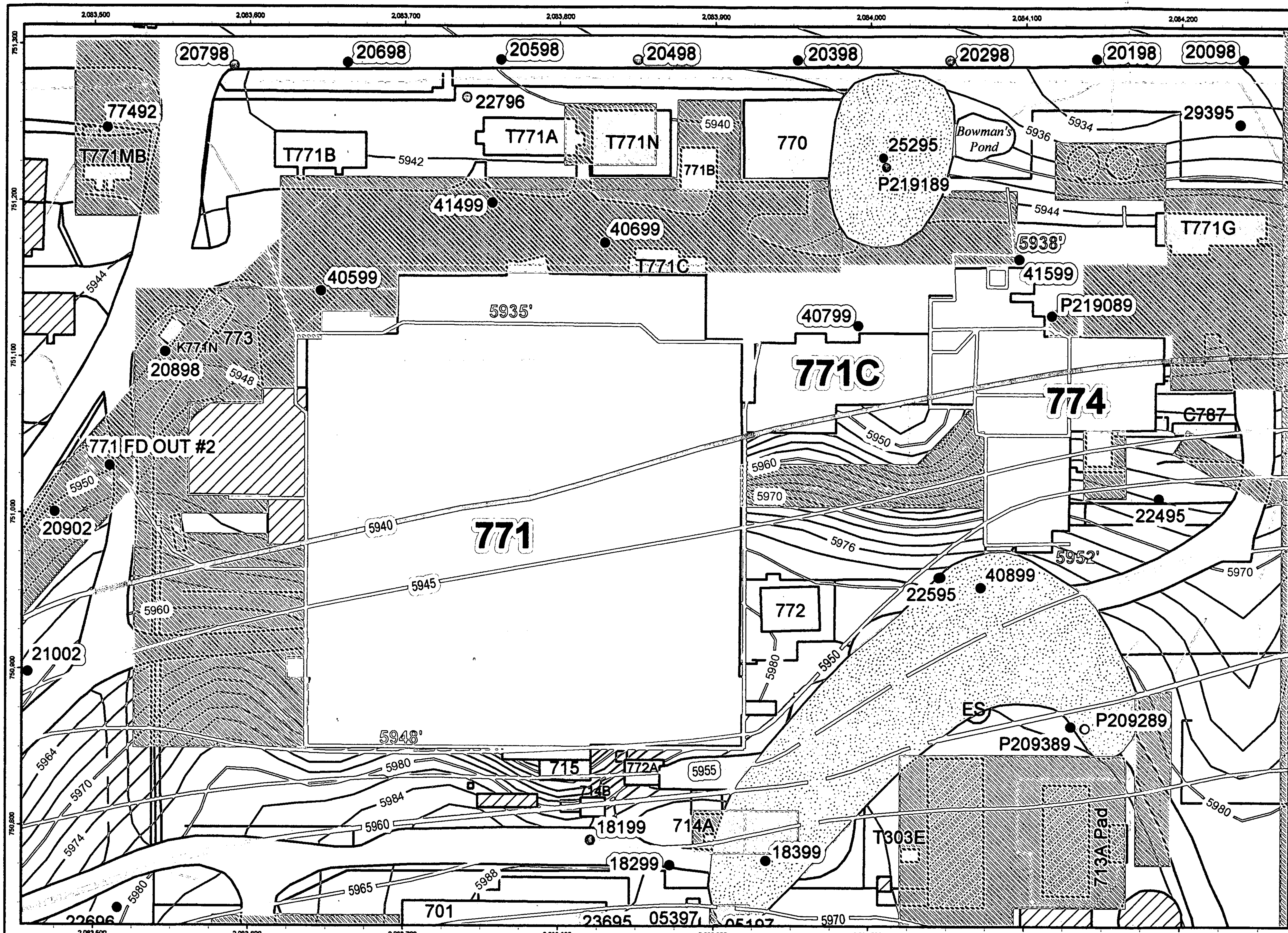
Figure 5-7

Building 771 Location Map with D&D Monitoring Wells

2002 Annual RFCA Groundwater Monitoring Report



EXPLANATION

Well Type -

- D&D Monitoring Well
- Other Well - IMP or non-IMP
- × Well abandoned in 2002

Water Level Contours Second Quarter 2002 -

- 20-Foot Water Level Contour
- 5-Foot Water Level Contour
- Foundation Drain
- Approximate current extent of Unsaturated Alluvium
- Pertinent B771 IHSSs
- D&D Building

Standard Map Features -

- Building or other structure
- Demolished building
- Paved Road
- Stream, ditch, or other drainage feature
- Fence or other barrier
- 10 ft Topographic Contour
- 2 ft Topographic Contour
- Dirt Road

DATA SOURCE BASE FEATURES:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 2-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

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N

Scale = 1 : 720
1 inch represents 60 feet

10 0 10 20 30 40 50

Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

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Prepared for: KAISER-HILL

December 3, 2003

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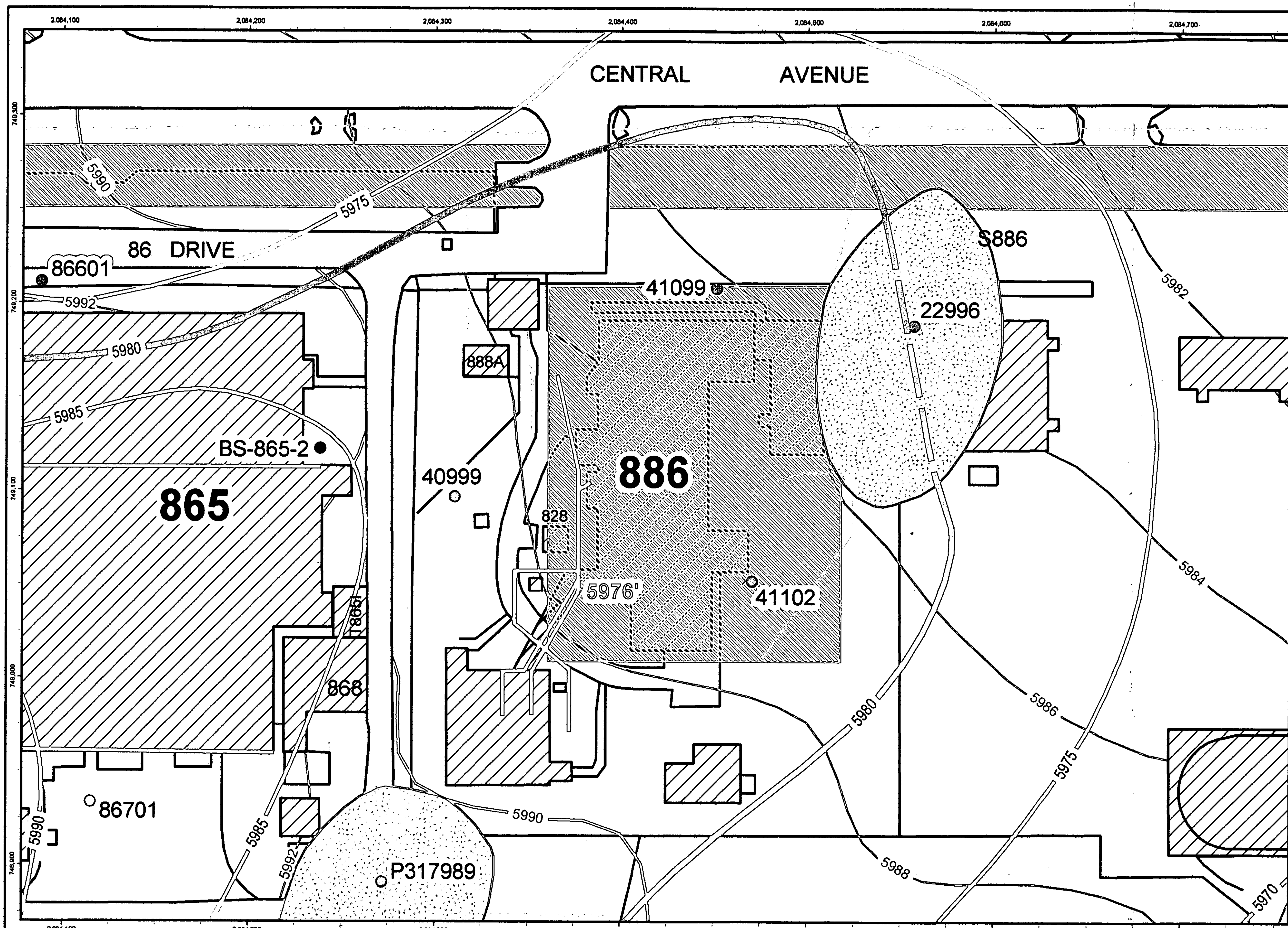

Figure 5-8

Building 886 Location Map with D&D Monitoring Wells

2002 Annual RFCA Groundwater Monitoring Report

EXPLANATION

Well Type -

- D&D Monitoring Well
- Other Well - IMP or non-IMP
- Well abandoned in 2002

Water Level Contours Second Quarter 2002 -

- 20-Foot Water Level Contour
- Dashed where inferred
- 5-Foot Water Level Contour
- Foundation Drain
- Pertinent B886 IHSSs
- D&D Building

Standard Map Features -

- Building or other structure
- Demolished building
- Paved Road
- Stream, ditch, or other drainage feature
- Fence or other barrier
- 10 ft Topographic Contour
- 2 ft Topographic Contour
- Dirt Road

DATA SOURCE BASE FEATURES:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 2-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

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Scale = 1 : 600
1 inch represents 50 feet

10 0 10 20 30 40

Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone Datum: NAD27

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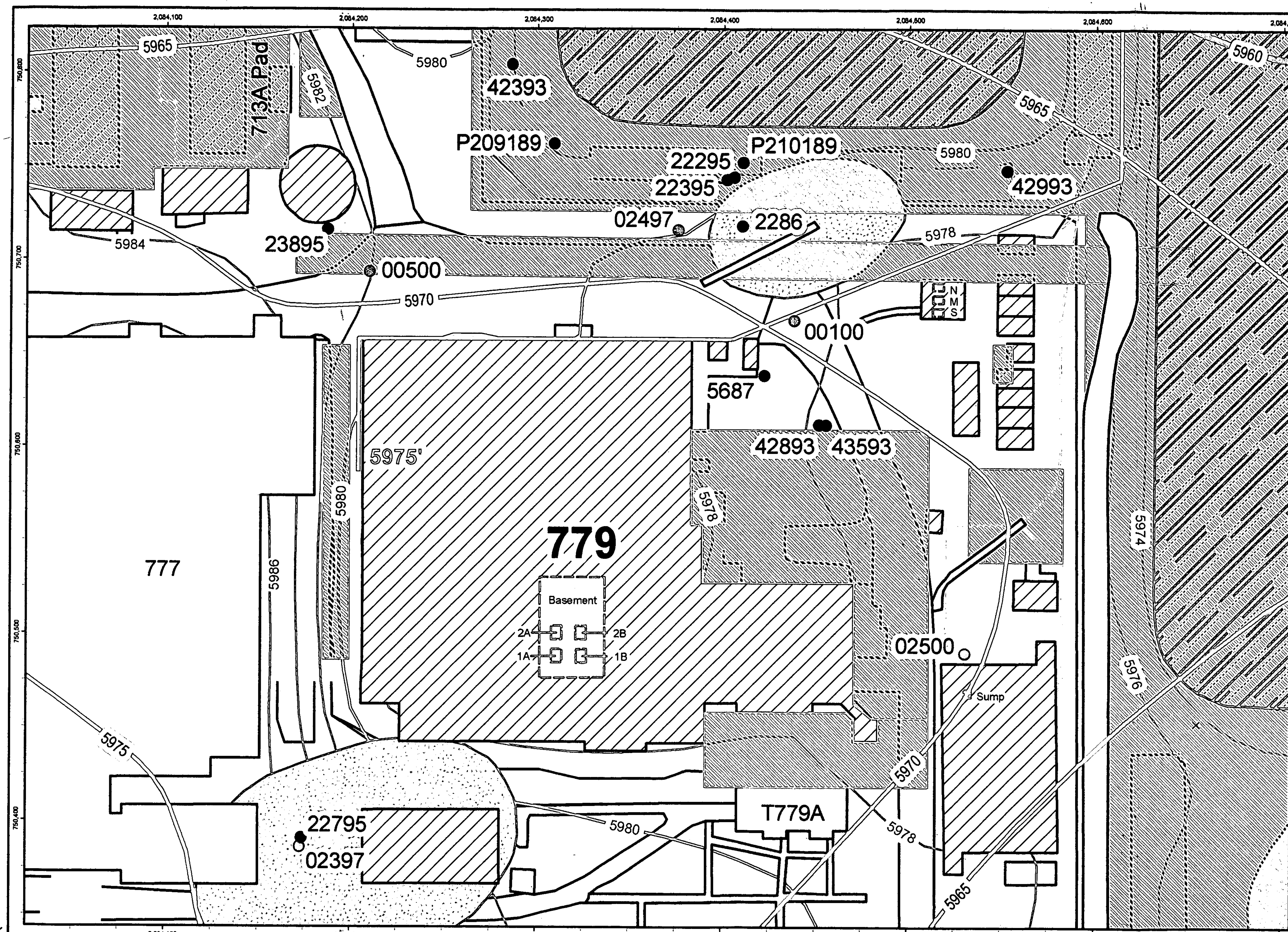

Figure 5-9

Building 779 Location Map with D&D Monitoring Wells

2002 Annual RFCA Groundwater Monitoring Report

EXPLANATION

Well Type -

- D&D Monitoring Well
- Other Well - IMP or non-IMP
- Well abandoned in 2002

Water Level Contours Second Quarter 2002 -

- 20-Foot Water Level Contour
- 5-Foot Water Level Contour
- Foundation Drain
- Approximate current extent of Unsaturated Alluvium
- Pertinent B779 IHSSs

Standard Map Features -

- Basement
- Building or other structure
- Demolished building
- Paved Road
- Stream, ditch, or other drainage feature
- Fence or other barrier
- 10 ft Topographic Contour
- 2 ft Topographic Contour
- Dirt Road

NOTE:
Building 779 sub-basement vaults located directly below basement.

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 2-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

N

Scale = 1 :600
1 Inch represents 50 feet

10 0 10 20 30 40 50

Scale in Feet
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
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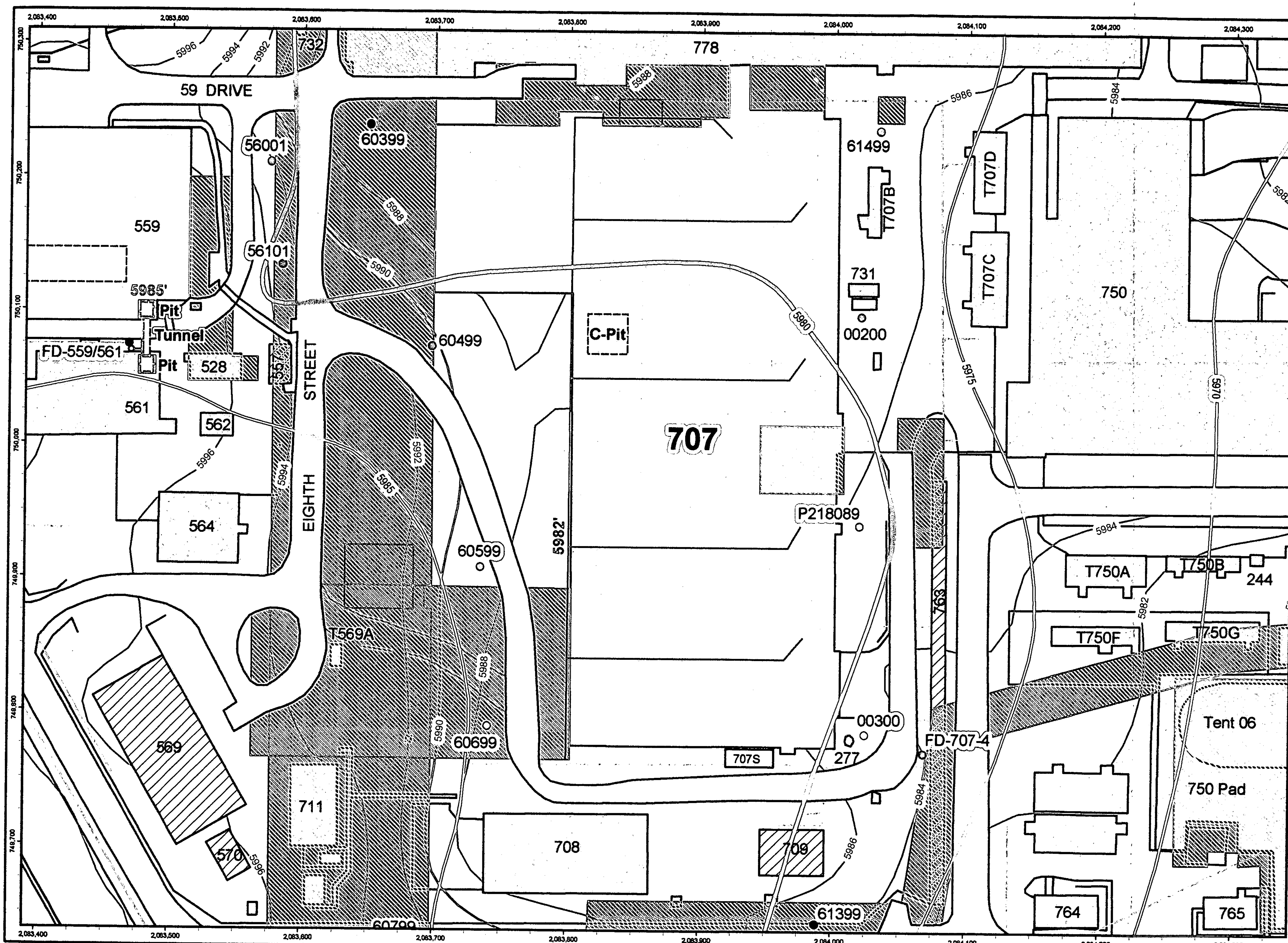

Figure 5-12

Building 707 Location Map with D&D Monitoring Locations

2002 Annual RFCA Groundwater Monitoring Report

EXPLANATION

Well Type -

- D&D Monitoring Location
- Other Well - IMP or non-IMP
- Well abandoned in 2002

Water Level Contours Second Quarter 2002 -

- 20-Foot Water Level Contour
- 5-Foot Water Level Contour
- Foundation Drain
- Pertinent B707 IHSSs
- D&D Building

Standard Map Features -

- Basement
- Building or other structure
- Demolished building
- Paved Road
- Stream, ditch, or other drainage feature
- Fence or other barrier
- 10 ft Topographic Contour
- 2 ft Topographic Contour
- Dirt Road

DATA SOURCE BASE FEATURES:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 2-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

DISCLAIMER:

N

Scale = 1 : 840
1 inch represents 70 feet

10 0 10 20 30 40 50 60 70

Scale in Feet

State Plane Coordinate Projection
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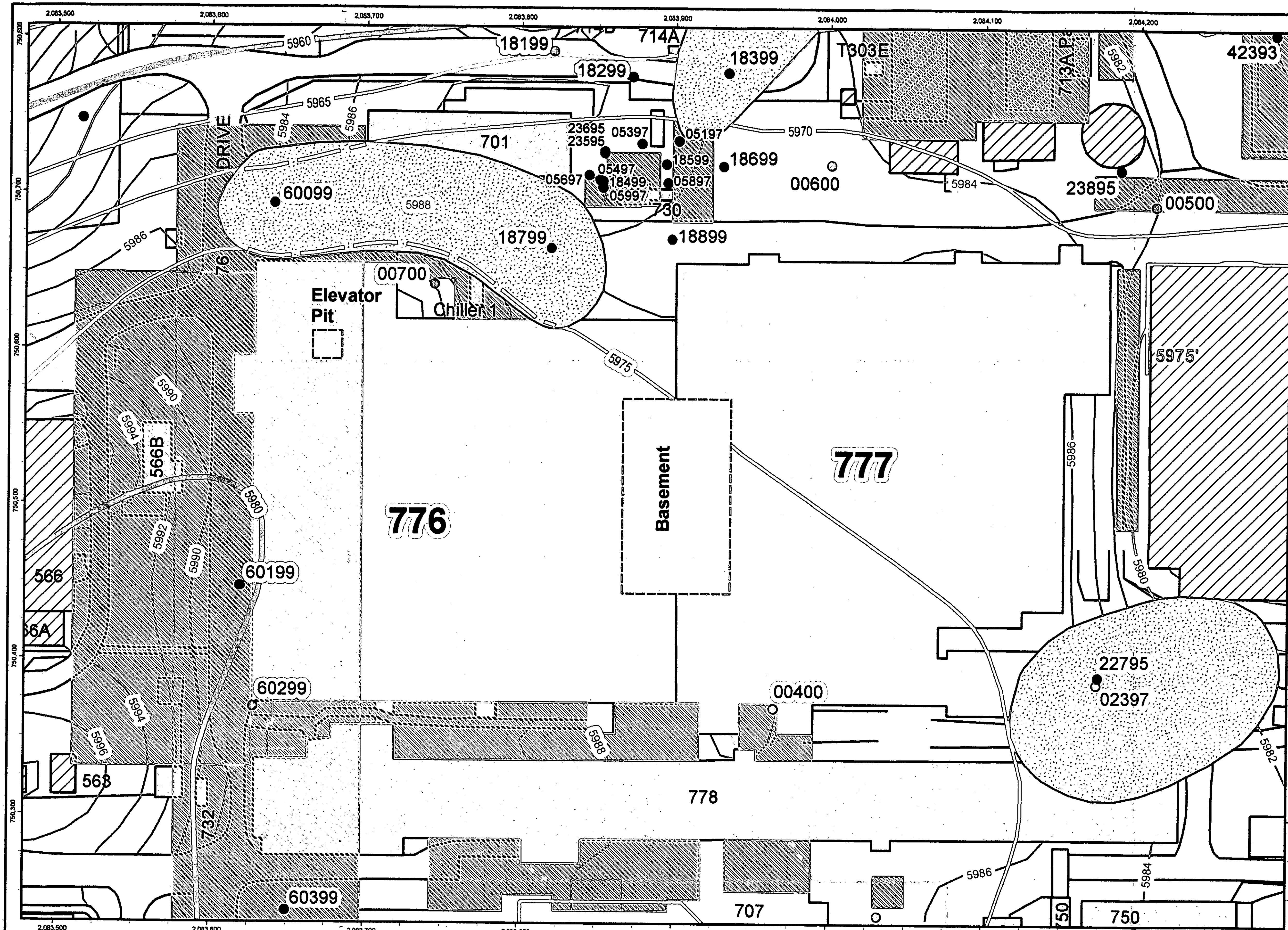

Figure 5-13

Building 776/777 Location Map with D&D Monitoring Wells

2002 Annual RFCA Groundwater Monitoring Report

EXPLANATION

Well Type -

- D&D Monitoring Well
- Other Well - IMP or non-IMP
- Well abandoned in 2002

Water Level Contours Second Quarter 2002 -

- 20-Foot Water Level Contour
- 5-Foot Water Level Contour
- Foundation Drain
- Approximate current extent of Unsaturated Alluvium
- Pertinent B776/777 IHSSs
- D&D Building

Standard Map Features -

- Basement
- Building or other structure
- Demolished building
- Paved Road
- Stream, ditch, or other drainage feature
- Fence or other barrier
- 10 ft Topographic Contour
- 2 ft Topographic Contour
- Dirt Road

DATA SOURCE BASE FEATURES:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 2-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

DISCLAIMER:

N

Scale = 1 : 720
1 inch represents 60 feet

10 0 10 20 30 40 50

Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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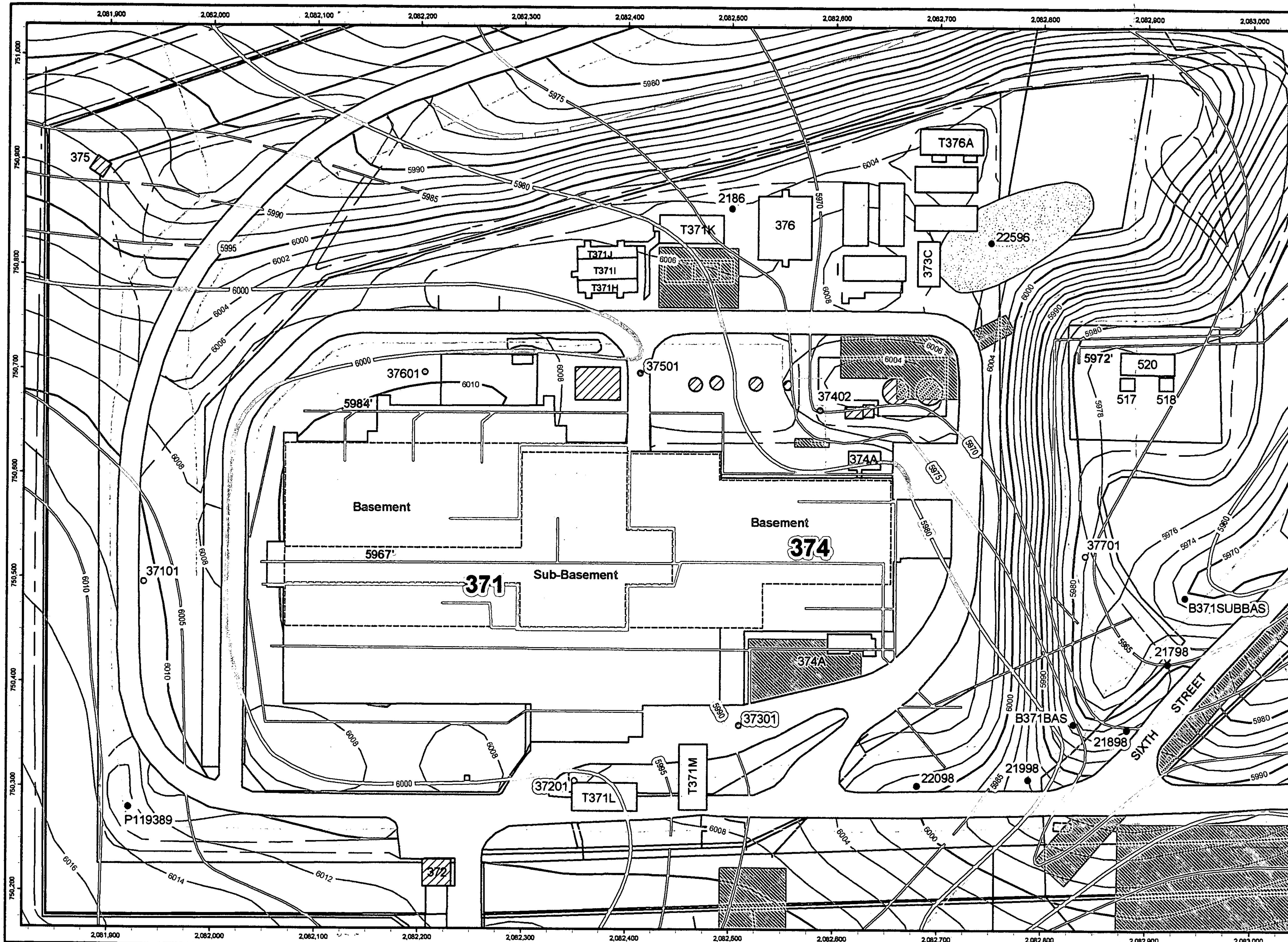

Figure 5-14

Building 371/374 Location Map with D&D Monitoring Wells

2002 Annual RFCA Groundwater Monitoring Report

EXPLANATION

Well Type -

- ○ D&D Monitoring Well
- ● Other Well - IMP or non-IMP
- × Well abandoned in 2002

Water Level Contours Second Quarter 2002 -

- 20-Foot Water Level Contour
- 5-Foot Water Level Contour
- Foundation Drain
- Approximate current extent of Unsaturated Alluvium
- Pertinent B371 & 374 IHSSs
- D&D Building

Standard Map Features -

- Sub-Basement
- Basement
- Building or other structure
- Demolished building
- Paved Road
- Stream, ditch, or other drainage feature
- Fence or other barrier
- 10 ft Topographic Contour
- 2 ft Topographic Contour
- Dirt Road

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95
Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 2-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

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N

Scale = 1 : 1080
1 inch represents 90 feet

Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
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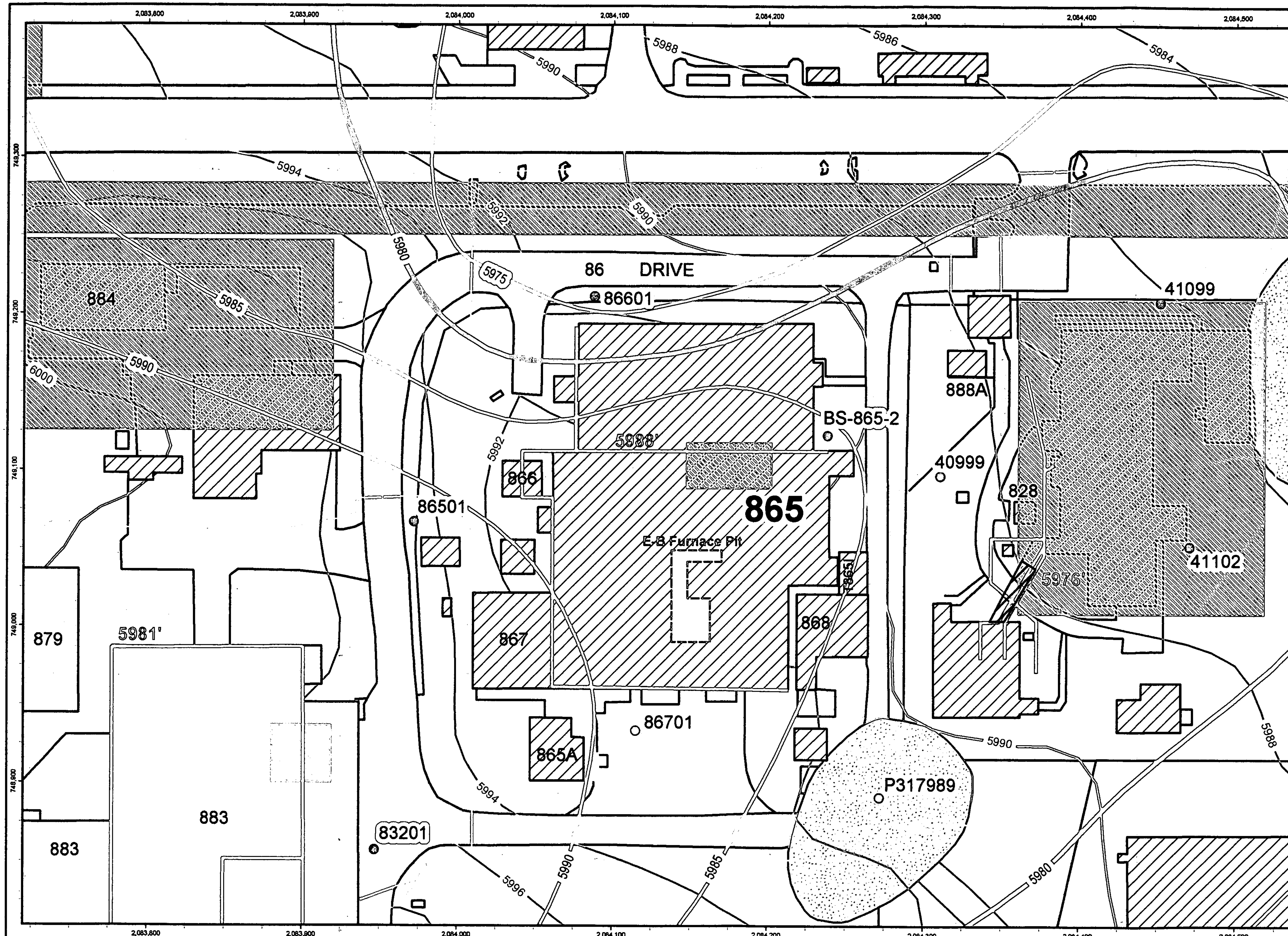
Figure 5-15
Building 865 Location Map with D&D Monitoring Locations
2002 Annual RFCA Groundwater Monitoring Report



EXPLANATION

Well Type -
- D&D Monitoring Location
- Other Well - IMP or non-IMP
- × Well abandoned in 2002

Water Level Contours Second Quarter 2002 -
- 20-Foot Water Level Contour
- 5-Foot Water Level Contour
- Foundation Drain
- Approximate current extent of Unsaturated Alluvium
- Pertinent B865 IHSSs
- D&D Building

Standard Map Features -
- Basement
- Building or other structure
- Demolished building
- Paved Road
- Stream, ditch, or other drainage feature
- Fence or other barrier
- 10 ft Topographic Contour
- 2 ft Topographic Contour
- Dirt Road

DATA SOURCE BASE FEATURES:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 2-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

DISCLAIMER:

N

Scale = 1 : 720
1 inch represents 60 feet

10 0 10 20 30 40 50 60

Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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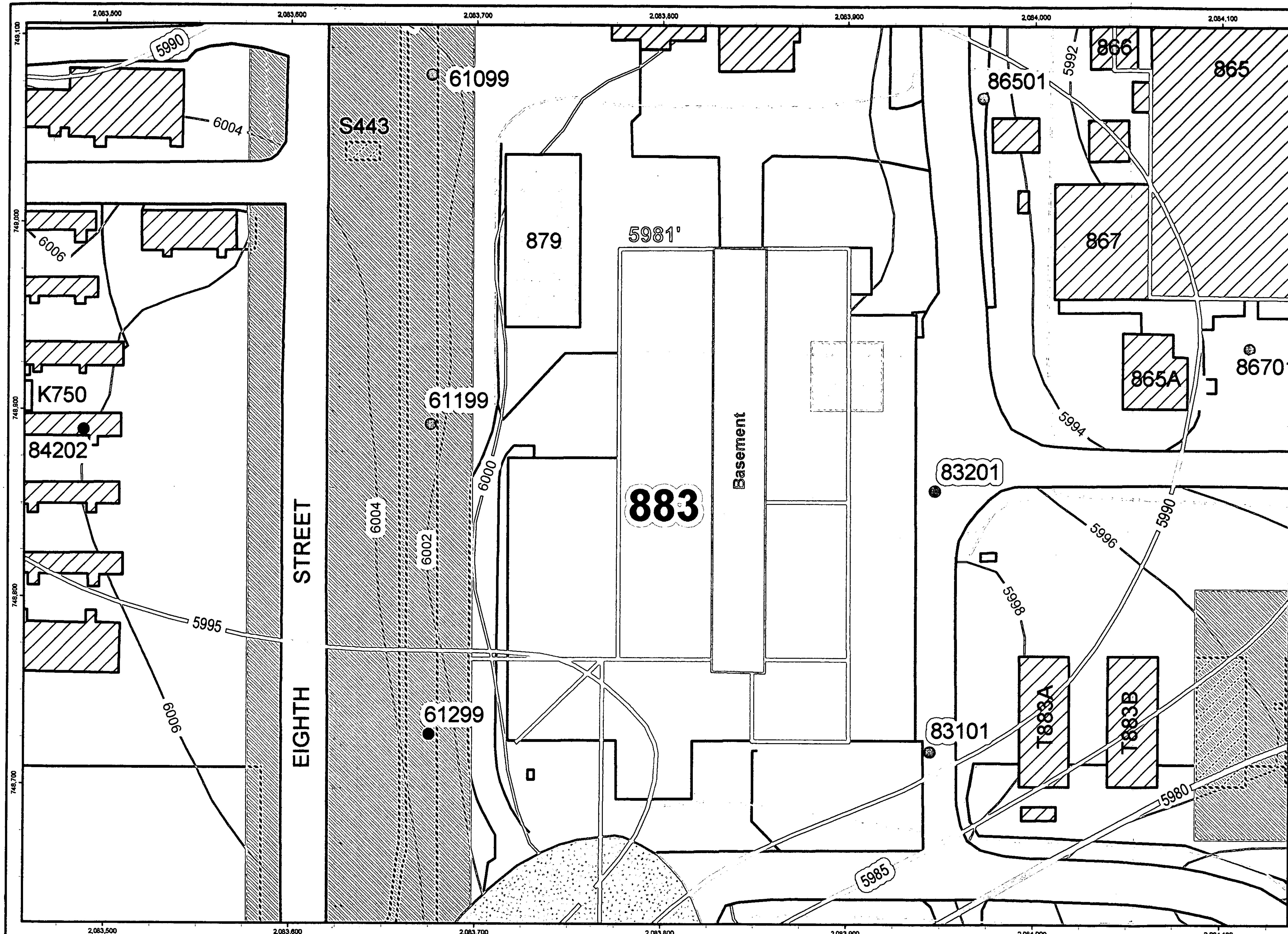

Figure 5-16
Building 883 Location Map with D&D Monitoring Wells
2002 Annual RFCA Groundwater Monitoring Report

EXPLANATION

Well Type -
- D&D Monitoring Well
- Other Well - IMP or non-IMP
- Well abandoned in 2002

Water Level Contours Second Quarter 2002 -
- 20-Foot Water Level Contour
- 5-Foot Water Level Contour
- Foundation Drain
- Approximate current extent of Unsaturated Alluvium
- Pertinent B883 IHSSs
- D&D Building

Standard Map Features -
- Basement
- Building or other structure
- Demolished building
- Paved Road
- Stream, ditch, or other drainage feature
- Fence or other barrier
- 10 ft Topographic Contour
- 2 ft Topographic Contour
- Dirt Road

DATA SOURCE BASE FEATURES:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 2-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

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N

Scale = 1 : 600
1 inch represents 50 feet

10 0 10 20 30 40 50

Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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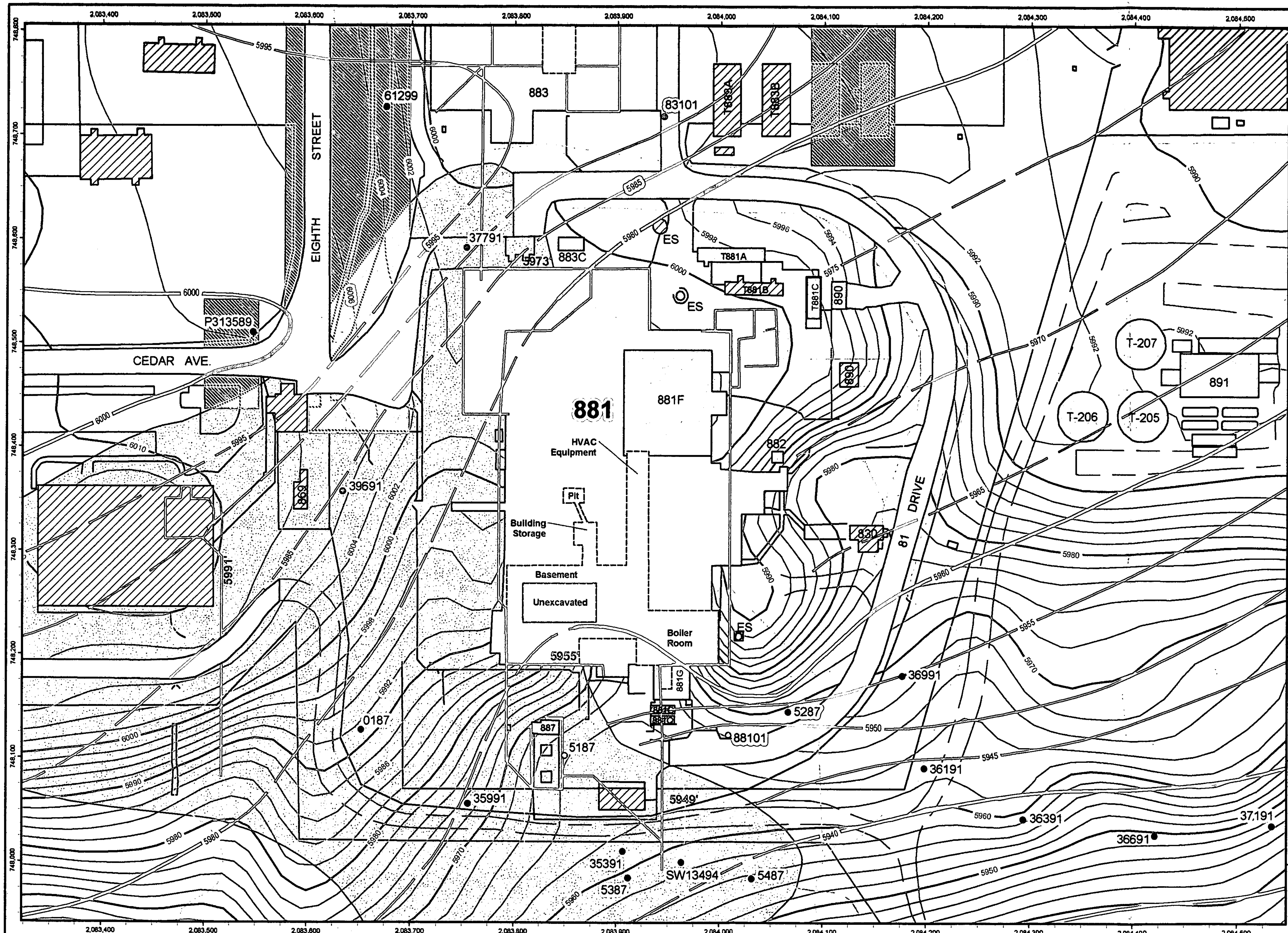
Figure 5-17

Building 881 Location Map with D&D Monitoring Wells 2002 Annual RFCA Groundwater Monitoring Report



EXPLANATION

Well Type -

- D&D Monitoring Well
- Other Well - IMP or non-IMP
- Well abandoned in 2002

Water Level Contours Second Quarter 2002 -

- 20-Foot Water Level Contour
- Dashed where inferred
- 5-Foot Water Level Contour
- Dashed where inferred
- Foundation Drain
- Approximate current extent of Unsaturated Alluvium
- Pertinent B881 IHSSs
- D&D Building

Standard Map Features -

- Basement
- Building or other structure
- Demolished building
- Paved Road
- Stream, ditch, or other drainage feature
- Fence or other barrier
- 10 ft Topographic Contour
- 2 ft Topographic Contour
- Dirt Road

DATA SOURCE BASE FEATURES:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 2-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

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N

Scale = 1 : 1080
1 inch represents 90 feet

10 0 10 20 30 40 50 60 70 80

Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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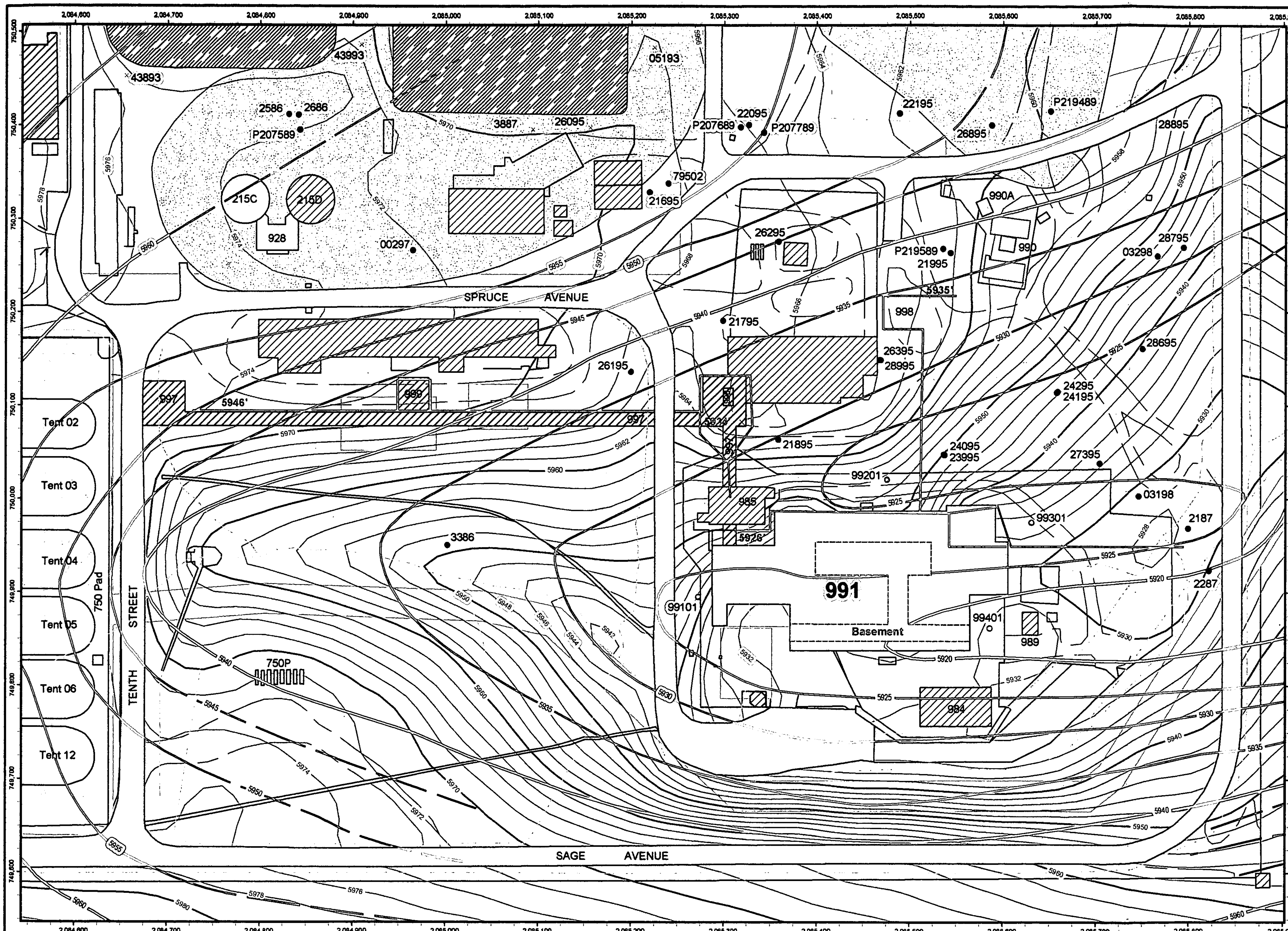

Figure 5-18

Building 991 Location Map with D&D Monitoring Wells
2002 Annual RFCA Groundwater Monitoring Report

EXPLANATION

Well Type -

- D&D Monitoring Well
- Other Well - IMP or non-IMP
- Well abandoned in 2002

Water Level Contours Second Quarter 2002 -

- 20-Foot Water Level Contour
- Dashed where inferred
- 5-Foot Water Level Contour
- Dashed where inferred
- Foundation Drain
- Approximate current extent of Unsaturated Alluvium
- Pertinent B991 IHSSs
- D&D Building

Standard Map Features -

- Basement
- Building or other structure
- Demolished building
- Paved Road
- Stream; ditch, or other drainage feature
- Fence or other barrier
- 10 ft Topographic Contour
- 2 ft Topographic Contour
- Dirt Road

DATA SOURCE BASE FEATURES:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 2-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

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N

Scale = 1 :1200
1 inch represents 100 feet

50 0 50 100

Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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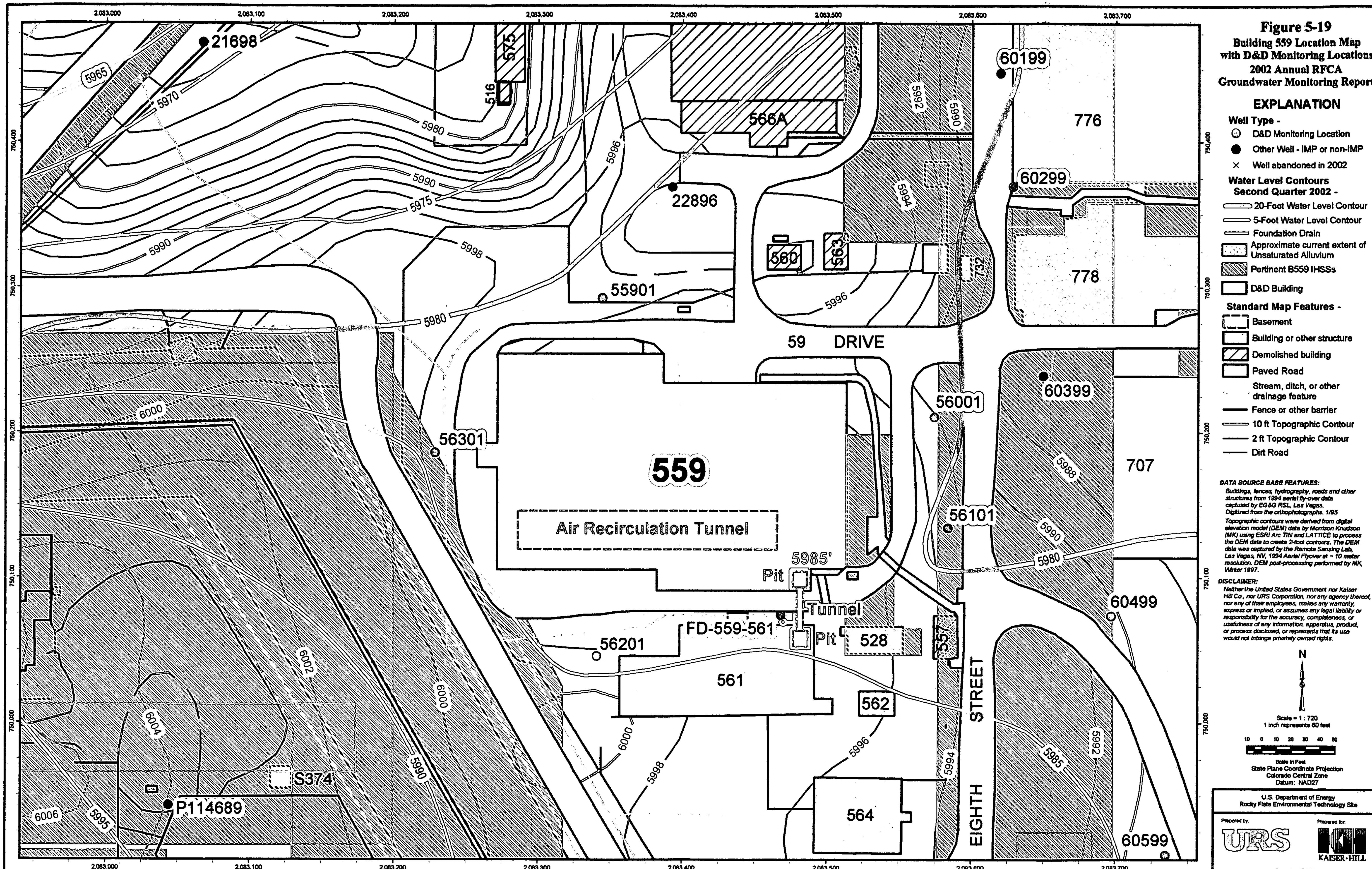

Figure 5-19
Building 559 Location Map with D&D Monitoring Locations
2002 Annual RFCA Groundwater Monitoring Report

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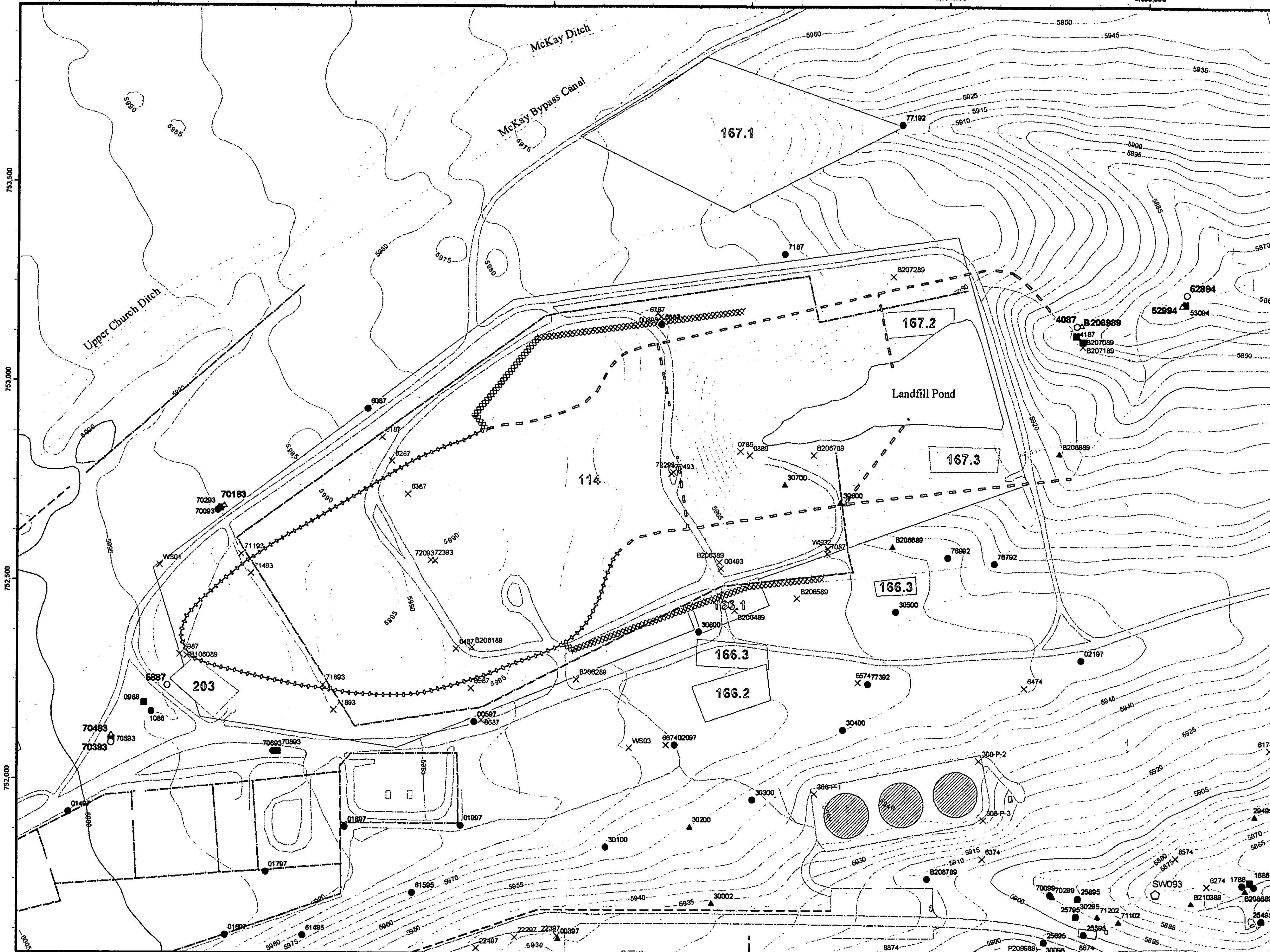
Figure 6-1
Well Locations
Present Sanitary Landfill
2002 Annual RFCA Groundwater Monitoring Report



Legend

- ○ Groundwater Monitor Well UHSU Surficial Material
- △ Groundwater Monitor Well UHSU Bedrock
- □ Groundwater Monitor Well LHSU Bedrock
- ○ RCRA Groundwater Monitoring Well
- ● Other Existing Well
- × Abandoned Well
- ⬠ Surface Water Monitoring Location
- Individual Hazardous Substance Site
- Slurry Wall
- GW Intercept System - Perforated
- GW Intercept System - Non-Perforated
- Lake or pond
- Stream, ditch, or other drainage feature
- Demolished building or other structure
- Existing building or other structure
- Fence or other barrier
- Topographic Contour (5-Foot)
- Paved road
- Dirt road

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95
Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

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N

Scale = 1 : 3000
1 inch represents 250 feet
50 0 50 100 150 200
Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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November 17, 2003

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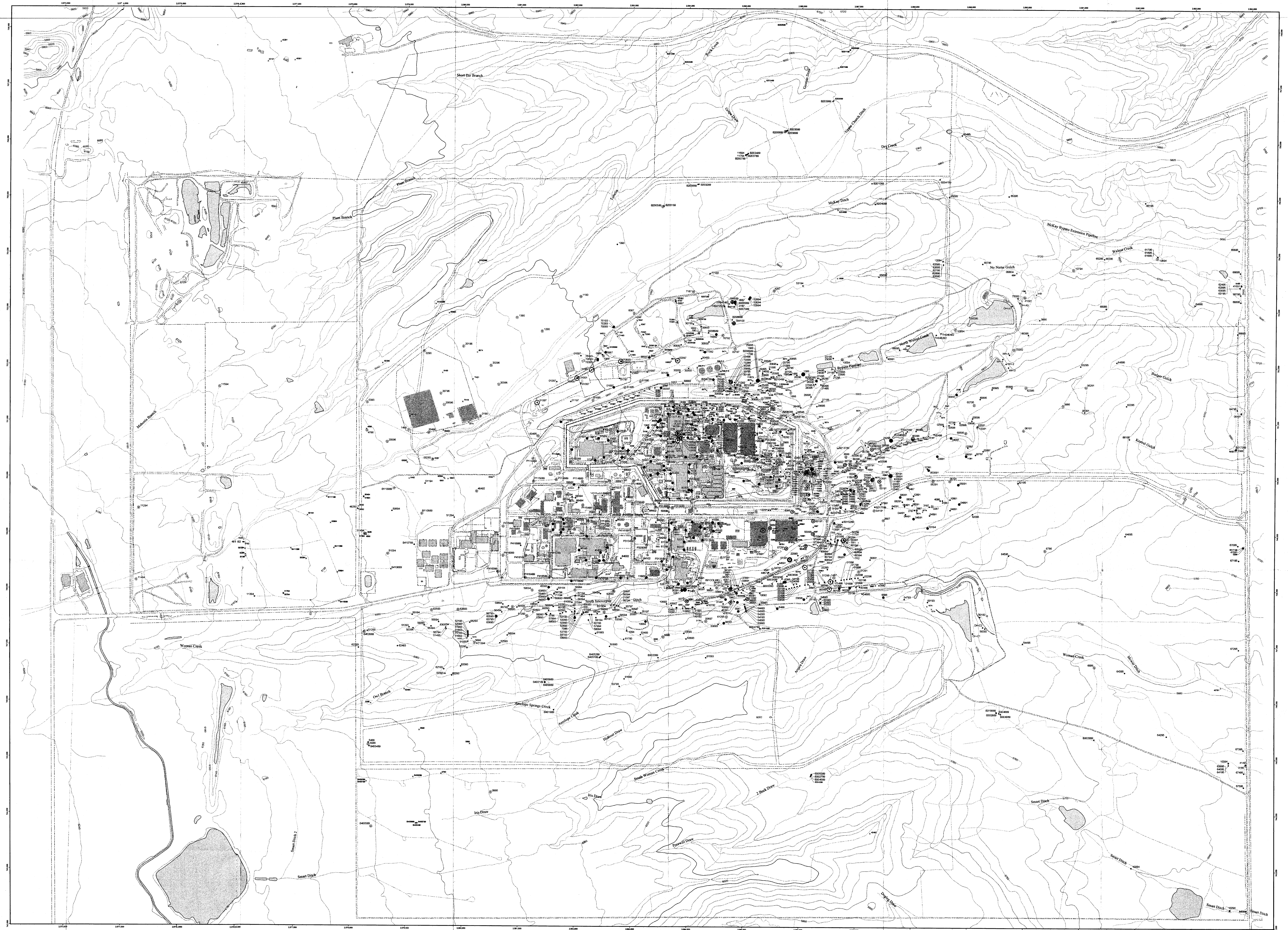

Plate 1

Well Location, Installation, and Abandonment Map

2002 Annual RFCA Groundwater Monitoring Report

Legend

- 90502 • Monitoring well installed in 2002
- 4386 • Well installed before 2002
- 21897 × Well abandoned in 2002
- 0571 × Well abandoned before 2002
- BS-865-2 + 2002 IMP Footing Drain or Outfall location

Note:
Well number is printed in smaller font size in some areas due to crowding.

2002 IMP Well Classes -

- 41691 Boundary
- 6486 Drainage
- 5187 Building D and D
- 18499 Plume Degradation
- 22896 Plume Definition
- 08091 Plume Extent
- 11891 Performance Monitoring
- 70193 RCRA
- 71102 Water level only

Note:
Associated well number is printed in green, except for those installed in 2002, which are printed in red.

Standard Map Features

- Existing Building
- Demolished Building
- Solar Evaporation Ponds (SEPs)
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt road
- Trail
- Fence
- 500-foot Topographic Contour
- 100-foot Topographic Contour
- 20-foot Topographic Contour

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January 28, 2004

NT_Svr W:\Projects\FY2003103-0007\Plate 1 Well map.mxd

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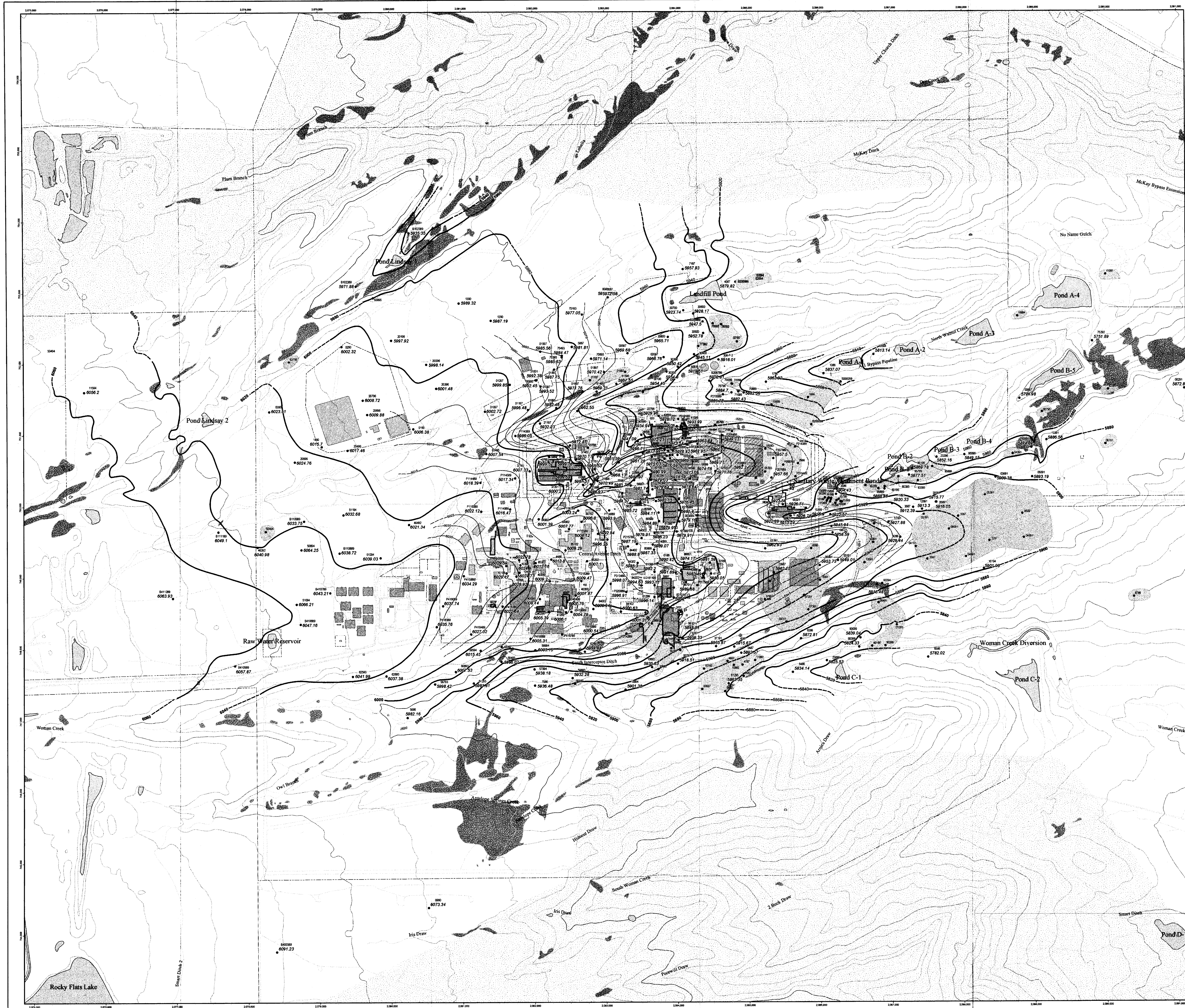
1 of 4
Box 239

Plate 2

Sitewide Potentiometric Surface Second Quarter 2002

2002 Annual RFCA Groundwater Monitoring Report



Legend

- Well with Water Level
- Dry Well
- Potentiometric Contour (20 foot interval)
- Inferred Potentiometric Contour
- Potentiometric Contour (5 foot interval)
- Inferred Potentiometric Contour
- Approximate Current Extent of Unsaturated Alluvium
- Seep
- Area without Groundwater Elevation Data
- Footing Drain
- Building or other structure
- Demolished building or other structure
- Solar Evaporation Pond
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt Road
- Trail
- Fence
- 500-foot Topographic Contour
- 100-foot Topographic Contour
- 20-foot Topographic Contour

N

Scale = 1 : 6000
1 inch represents 500 feet

500 0 500 1,000 1,500

Scale in Feet

State Plane Coordinate Projection
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29x43

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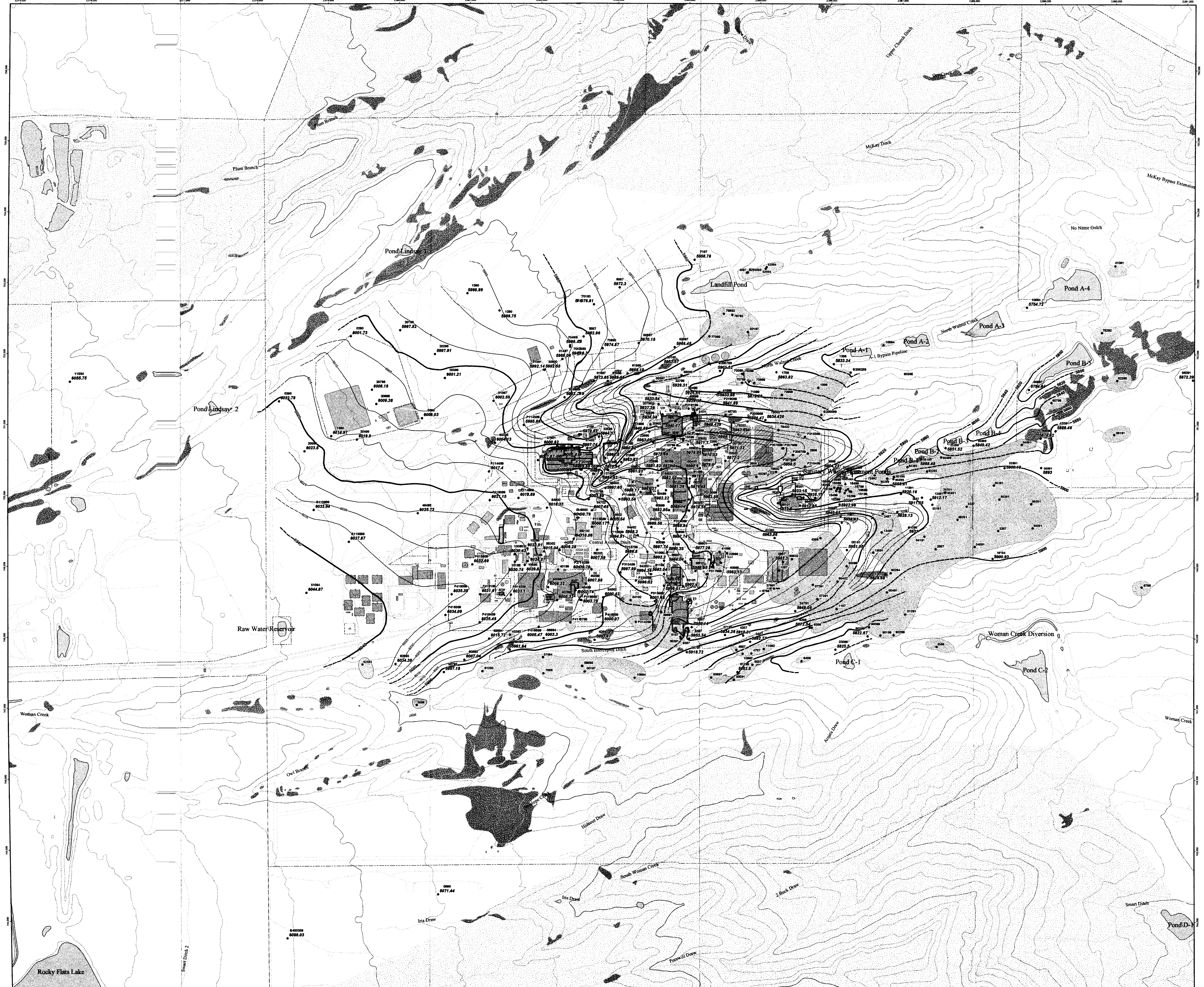

Plate 3

Sitewide Potentiometric Surface Fourth Quarter 2002

2002 Annual RFCA Groundwater Monitoring Report

Legend

- Well with Water Level
- Dry Well
- Potentiometric Contour (20 foot interval)
- Inferred Potentiometric Contour
- Potentiometric Contour (5 foot interval)
- Inferred Potentiometric Contour
- Approximate Current Extent of Unsaturated Alluvium
- Seep
- Area without Groundwater Elevation Data
- Footing Drain
- Building or other structure
- Demolished building or other structure
- Solar Evaporation Pond
- Lake or pond
- Stream, ditch, or other drainage feature
- Paved road
- Dirt Road
- Trail
- Fence
- 500-foot Topographic Contour
- 100-foot Topographic Contour
- 20-foot Topographic Contour

N

Scale = 1 : 6000
1 inch represents 500 feet

500 0 500 1,000 1,500

Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
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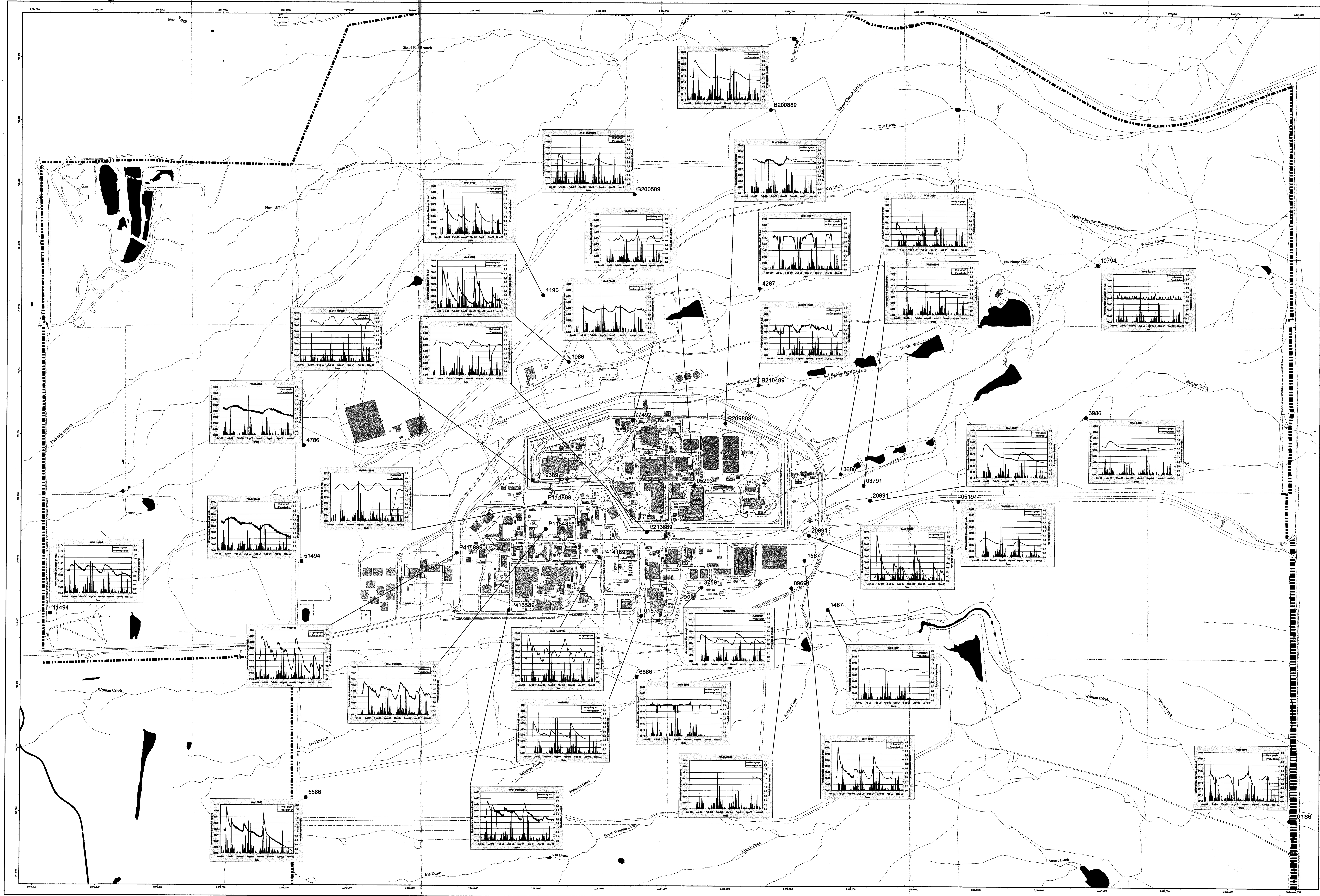

Plate 4

Real Time Groundwater Monitoring Location Hydrographs with Precipitation Data

2002 Annual RFCA Groundwater Monitoring Report

EXPLANATION

Real time groundwater monitoring hydrograph with precipitation data

- Groundwater well with real time water level monitoring
- Real time monitoring location abandoned during 2002
- Real time monitoring location added during 2002

Standard Map Features

- Building or other structure
- Demolished building
- Solar Evaporation Pond (SEPs)
- Lake or pond
- Stream, ditch, or other drainage feature
- Fence or other barrier
- Paved road
- Dirt Road

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads, and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

U.S. Department of Energy
Rocky Flats Environmental Technology Site

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