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FINAL

REMEDIATION BY NATURAL ATTENUATION TREATABILITY STUDY FOR OPERABLE UNIT 5

at

HILL AIR FORCE BASE, UTAH

December 1997

Prepared for:

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
TECHNOLOGY TRANSFER DIVISION
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022/7296910/HILL/24.DOC

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ACRONYMS AND ABBREVIATIONS

2D	two-dimensional
3D	three-dimensional
°C	degrees centigrade
°F	degrees Fahrenheit
µg/L	micrograms per liter
µg/kg	micrograms per kilogram
µs/cm	microsiemens per centimeter
AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
ASCII	American Standard Code for Information Interchange
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
btoc	below top of casing
CAH	chlorinated aliphatic hydrocarbon
$CaCO_3$	calcium carbonate
CO_2	carbon dioxide
CPT	cone penetrometry testing
DCA	dichloroethane
DCE	dichloroethene
DEQ	Department of Environmental Quality
DO	dissolved oxygen
EOD	Explosive Ordnance Disposal
ET	evapotranspiration
FS	feasibility study
ft/day	feet per day
ft/ft	feet per foot
ft/min	feet per minute
ft msl	feet above mean sea level
ft/yr	feet per year
GAC	granular activated carbon
GC	gas chromatograph
g/cc	grams per cubic centimeter
GFAA	graphite furnace atomic absorption
gpm	gallons per minute
H^+	hydrogen ion
H_2	dissolved hydrogen
HDPE	high density polyethylene
ICP	inductively coupled plasma spectrometry
ID	inside diameter
IRA	interim remedial action
IRP	Installation Restoration Program

IWTP	Industrial Waste Treatment Plant
JMM	James M. Montgomery, Consulting Engineers, Inc.
K_{oc}	soil sorption coefficient
L/kg	liters per kilogram
LTM	long-term monitoring
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MOC	method of characteristics
MS	mass spectrometer
MSL	mean sea level
mV	millivolts
N	nitrogen
nM/L	nanomoles per liter
NPL	National Priorities List
NRMRL	National Risk Management Research Laboratory
ORD	Office of Research and Development
ORP	oxidation-reduction potential
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PAH	polynuclear aromatic hydrocarbon
Parsons ES	Parsons Engineering Science, Inc.
PA/SI	preliminary assessment/site investigation
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
POC	point of compliance
POL	petroleum, oils, and lubricants
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
Radian	Radian Corporation
RI	remedial investigation
RMS	root mean squared
RNA	remediation by natural attenuation
SAIC	Science Applications International Corporation
SAP	sampling and analysis plan
SS	stainless steel
SVOC	semivolatile organic compound
TCA	trichloroethane
TCE	trichloroethene
TMB	trimethylbenzene
TOC	total organic carbon
TPH	total petroleum hydrocarbons

TS	treatability study
USEPA	United States Environmental Protection Agency
UST	underground storage tank
VC	vinyl chloride
VFA	volatile fatty acid
VOC	volatile organic compound
YSI	Yellow Springs Instruments

EXECUTIVE SUMMARY

This report presents the results of a remediation by natural attenuation treatability study (RNA TS) performed by Parsons Engineering Science, Inc. (Parsons ES) at Operable Unit 5 (OU5), Hill Air Force Base, Utah to evaluate the use of natural attenuation with long-term monitoring (LTM) as a remedial option for dissolved chlorinated aliphatic hydrocarbon (CAH) contamination in the surficial water-bearing zone. The presence of groundwater contamination and soil contamination at the site was documented during the remedial investigation performed by Radian International (Radian). This TS focused on the impact of dissolved CAHs, primarily trichloroethene (TCE), on the shallow groundwater system at and downgradient from the site. Site history and the results of soil, groundwater, and surface water investigations conducted previously also are summarized in this report.

Several lines of chemical and geochemical evidence indicate that, although dissolved CAHs are undergoing biologically facilitated reductive dehalogenation, the occurrence of this process is limited and localized. The evidence supporting the limited occurrence of TCE biodegradation includes:

- The limited occurrence and low magnitude of CAH daughter product concentrations and concentrations of other biodegradation byproducts;
- The lack of sufficiently reducing conditions in groundwater;
- The lack of sufficient native or anthropogenic organic carbon to drive dehalogenation reactions;
- The lack of true anaerobic conditions throughout the majority of the TCE plume; and
- The abundance of alternate electron acceptors that may inhibit use of CAHs as electron acceptors.

An important component of this study was an assessment of the potential for contamination in groundwater to migrate from the source area to potential receptors at concentrations above regulatory levels intended to be protective of human health and the environment. To accomplish this objective, the numerical model codes MODFLOW and MT3D were used to estimate the impacts of planned and probable engineered remedial actions on the future migration and persistence of dissolved TCE within the surficial water-bearing zone under the influence of advection, dispersion, sorption, and biodegradation. Input parameters for the numerical model were obtained from existing site characterization data, supplemented with data collected during the RNA TS. Model parameters that were not measured at the site were estimated using reasonable literature values.

SECTION 1

INTRODUCTION

This report was prepared by Parsons Engineering Science, Inc. (Parsons ES) and presents the results of a treatability study (TS) conducted to evaluate the use of remediation by natural attenuation (RNA) for groundwater contaminated with chlorinated aliphatic hydrocarbons (CAHs) at Operable Unit (OU) 5, located at Hill Air Force Base (AFB), Utah. As used in this report, RNA refers to a management strategy that relies on natural attenuation mechanisms to remediate contaminants dissolved in groundwater and to control receptor exposure risks associated with contaminants in the subsurface. The United States Environmental Protection Agency (USEPA) Offices of Research and Development (ORD) and Solid Waste and Emergency Response (OSWER) define natural attenuation as (Wilson, 1996):

> *The biodegradation, dispersion, sorption, volatilization, and/or chemical and biochemical stabilization of contaminants to effectively reduce contaminant toxicity, mobility, or volume to levels that are protective of human health and the ecosystem.*

As suggested by this definition, mechanisms for natural attenuation of CAHs include advection, dispersion, dilution from recharge, sorption, volatilization, abiotic chemical transformation, and biodegradation. Of these processes, biodegradation is the only mechanism working to transform contaminants into innocuous byproducts. During biodegradation, indigenous microorganisms work to bring about a reduction in the total mass of contamination in the subsurface without the engineered addition of nutrients. Patterns and rates of natural attenuation can vary markedly from site to site depending on governing physical and chemical processes.

RNA is advantageous for the following reasons:

- Contaminants can be transformed to innocuous byproducts (e.g., carbon dioxide, ethene, or water), not just transferred to another phase or location within the environment;
- Current pump-and-treat technologies are energy-intensive and generally not as effective in reducing residual contamination;
- The process is nonintrusive and allows continuing use of infrastructure during remediation;
- Engineered remedial technologies may pose a greater risk to potential receptors than RNA (e.g., contaminants may be transferred into another medium during remediation activities); and

- RNA is less costly than conventional, engineered remedial technologies.

A potential disadvantage of RNA is that, in some cases, natural attenuation rates are too slow to make RNA a practical remedial alternative. In addition, biodegradation of highly chlorinated compounds, such as trichloroethene (TCE), can produce vinyl chloride, which is relatively toxic. Under certain geochemical conditions, vinyl chloride may accumulate in the environment rather than be transformed to innocuous byproducts.

The main emphasis of the work described herein was to evaluate the potential for naturally occurring degradation mechanisms to reduce dissolved CAH concentrations in groundwater to levels that are protective of human health and the environment. This study is not intended to be a contamination assessment report or a remedial action plan; rather, it is provided for the use of the Base and its prime environmental contractor(s) as information to be used for future decision making regarding this site.

1.1 SCOPE AND OBJECTIVES

Parsons ES, in conjunction with researchers of the USEPA National Risk Management Research Laboratory (NRMRL), was retained by the United States Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division to conduct site characterization and groundwater modeling to evaluate the scientific defensibility of RNA with long-term monitoring (LTM) as a remedial option for contaminated groundwater at OU5.

The following tasks were performed to fulfill the project objectives:

- Reviewing existing hydrogeologic and soil/groundwater/surface water quality data for the site;
- Conducting supplemental site characterization activities to more thoroughly characterize the nature and extent of groundwater contamination;
- Collecting geochemical data in support of RNA;
- Developing a conceptual hydrogeologic model of the shallow saturated zone, including the current distribution of contaminants;
- Evaluating site-specific data to determine whether naturally occurring processes of contaminant attenuation and destruction are occurring in groundwater at the site;
- Designing and executing a groundwater flow and contaminant fate and transport model for site hydrogeologic conditions;
- Simulating the fate and transport of CAHs (e.g., TCE) in groundwater under the influence of advection, dispersion, adsorption, and biodegradation using the calibrated model;

- Evaluating a range of model input parameters to determine the sensitivity of the model to those parameters and to consider several contaminant fate and transport scenarios;
- Determining if natural processes are minimizing dissolved CAH and hydrocarbon plume expansion so that groundwater and surface water quality standards can be met at a downgradient point of compliance (POC);
- Conducting an exposure pathways analysis for potential current and future receptors;
- Using the results of modeling to asses the effect of current or planned future remedial actions on the TCE plume; and
- Providing a LTM plan that includes LTM and POC wells and a sampling and analysis plan (SAP).

Field work conducted under this program was oriented toward the collection of supplementary hydrogeologic and chemical data necessary to document and model the effectiveness of RNA with LTM for restoration of CAH-contaminated groundwater.

Site characterization activities in support of RNA included the collection of soil samples and installation of groundwater monitoring points with a Geoprobe®; static groundwater level measurement; surface water sample collection and analysis; and groundwater sample collection and analysis from preexisting site monitoring wells and newly installed monitoring points.

Site-specific data were used to develop a solute fate and transport model for the site and to conduct a preliminary receptor exposure pathways analysis. The modeling effort was used to predict the future extent and concentration of the dissolved CAH plume by modeling the combined effects of advection, dispersion, sorption, and biodegradation. Results of the model were used to predict future discharge to surface water, to assess the potential for completion of other exposure pathways involving groundwater, and to identify whether RNA with LTM is an appropriate and defensible remedial option for contaminated groundwater, in conjunction with ongoing and planned engineered remedial actions. The results will be used to provide technical support for the RNA with LTM remedial option during regulatory negotiations, as appropriate.

This TS contains eight sections, including this introduction, and six appendices. Section 2 summarizes site characterization activities. Section 3 summarizes the physical characteristics of the study area. Section 4 describes the nature and extent of soil, groundwater, and surface water contamination, and the evidence of contaminant biodegradation in groundwater at the site. Section 5 describes the fate and transport model and design of the conceptual hydrogeologic model for the site; lists model assumptions and input parameters; and describes sensitivity analysis results. Section 6 describes the predicted effects of current and planned or potential future remedial actions on the TCE plumes. Section 7 presents the LTM plan for the site. Section 8 lists the references used to develop this document. Appendix A contains pertinent figures and tables from previous reports such as the remedial investigation (RI) report for OU5 [Radian Corporation (Radian), 1995]. Appendix B contains Geoprobe®

The results of this study suggest that, even with the implementation of all planned and probable remedial actions, dissolved TCE contamination present in groundwater west of the Tooele Rail Shop has the potential to migrate at least 10,000 feet beyond the August 1996 plume toe unless geochemical conditions are encountered along the plume flowpath that promote increased biodegradation rates and/or significant discharge of contaminated groundwater to surface water occurs. In addition, the model suggests that dissolved TCE concentrations in excess of the state groundwater quality standard of 5 micrograms per liter (µg/L) has the potential to persist downgradient from the Rail Shop for more than 100 years (the duration of the numerical model predictive period). The model predicts that installation of a groundwater extraction trench along 300 West will cause the maximum dissolved TCE concentrations at three downgradient observation points during the 100-year simulation period to be reduced by approximately one-half.

The numerical model results also suggest that dissolved TCE detected at well MW129 north of the Rail Shop has migrated off-Base, has the potential to migrate at least 3,000 feet west of the Base boundary, and persist at concentrations in excess of 5 µg/L for at least 50 years under the influence of RNA alone. If a groundwater extraction system is simulated west of well MW129, the on-Base portion of this dissolved contamination is intercepted, but the off-Base portion continues to migrate toward the west beneath Sunset.

It should be noted that the numerical model constructed for this TS is reasonably conservative; therefore, plume migration and persistence may be less than that predicted by the model. Factors that could cause plume migration and persistence to differ from model predictions include the following:

- The calibrated model is not necessarily unique, and different combinations of input parameters could potentially have been used to achieve an acceptable calibration;
- A wide range of potential TCE biodegradation rates were calculated for the OU5 groundwater system; therefore, the actual biodegradation rate may be different than the rate used in the model;
- The model does not account for the potential occurrence of abiotic degradation and volatilization of TCE;
- Only one round of geochemical data has been collected from a subset of site monitoring wells; therefore, temporal and spatial changes in biodegradation rates have not been fully assessed; and
- Hydrogeologic and/or geochemical conditions that could slow or halt plume migration may exist downgradient from the investigated area.

To calibrate the numerical model for use as a management tool at OU5, regular sampling of 14 existing and 5 new LTM wells and Martin Spring is recommended to monitor the long-term migration and degradation of the dissolved CAH plumes. The plumes should be progressively tracked in the downgradient direction, and additional downgradient LTM wells and surface water sampling stations should be installed/sampled as required. Regular sampling and analysis of groundwater from these wells will allow the effectiveness of RNA and engineered remedial actions to be monitored, and should allow assessment of whether additional engineering controls should be implemented. Likewise, the model can be adjusted to reflect future conditions measured in the aquifer.

Contaminant fate and transport model results indicate that sampling should continue on an annual basis for approximately 15 years (the anticipated maximum duration of engineered remedial actions), followed by less frequent (e.g., every other year) sampling. The LTM plan should be periodically reevaluated and modified as necessary on the basis of newly obtained data and calibration of the numerical model. The LTM plan presented in this TS presents estimated present worth costs for 15 years of annual monitoring, followed by 15 years of biennial monitoring. Along with other analyses used to assess the effectiveness of RNA, the groundwater samples should be analyzed for halogenated volatile organic compounds by US Environmental Protection Agency Method SW8021B.

borehole logs, monitoring point construction diagrams, monitoring well/point development and sampling forms, and survey data. Appendix C presents soil, surface water, and groundwater analytical results that were used in the preparation of this report and collected as a part of this TS. Appendix D contains model input parameters, calculations related to model calibration, and sensitivity analysis results. Appendix E contains model input and output in American Standard Code for Information Interchange (ASCII) format on a diskette. Appendix F contains LTM cost calculations.

1.2 BASE AND OU5 BACKGROUND

Hill AFB is located 25 miles north of Salt Lake City, Utah, just east of Interstate 15 (Figure 1.1). Hill AFB was added to the National Priorities List (NPL) in July 1987. In 1991, Tooele Rail Shop and Bamberger Pond were combined administratively into OU5. The US Army Tooele Rail Shop and Bamberger Pond are located along the western boundary of Hill AFB (Figure 1.1). This RNA TS focuses on the dissolved CAH plume emanating from the Tooele Rail Shop (Figures 1.2 and 1.3). The Tooele Rail Shop was constructed in 1942 to support the Ogden Army Arsenal, and was upgraded in 1944 to service and repair railroad engines for the military. The Tooele Rail Shop is currently operated by the Tooele Army Depot. An open area immediately west of the Rail Shop formerly was used for cleaning large train parts; Building 1712 was constructed over this area in the late 1980s (Figure 1.3) (Radian, 1995).

Historical chemical usage at Hill AFB is illustrated on Figure 1.4. Solvents, petroleum products, and an alkaline sodium cyanide solution have been used at the Rail Shop. TCE was reportedly used at the rail shop during the period from 1949 to 1964. Prior to 1979, runoff from steam-cleaning operations flowed into a drainage grate and thence to drain lines that led to an in-ground oil/water separator. However, foundation excavations for Building 1712 revealed limited areas of stained soil (which were removed), suggesting that some runoff had drained onto the ground west of the steam-cleaning area. Hill AFB drawings indicate that the drain lines extended directly north from the oil/water separator and the Rail Shop, parallel to the rail lines and an irrigation canal (Davis-Weber Canal). As-built Base drawings from 1966 show that the drain line ended about 1,300 feet north of Building 1701 (Figure 1.3). It has since been confirmed through investigation field work (video camera survey) that this line extended north from Building 1712 and joined another line extending west from Building 1723 through an oil/water separator (Radian, 1995). The north/south line continued northward less than 20 feet from this junction and terminated in a gravel leach field. The solids from the oil/water separator were treated at the Hill AFB Industrial Waste Treatment Plant (IWTP). The liquids apparently were allowed to drain into this gravel leach field (resulting in the CAH groundwater plume). In 1979, the cleaning system was redesigned to collect and direct rinseate and runoff into a new oil/water separator, from which the water is discharged into the Base wastewater treatment system.

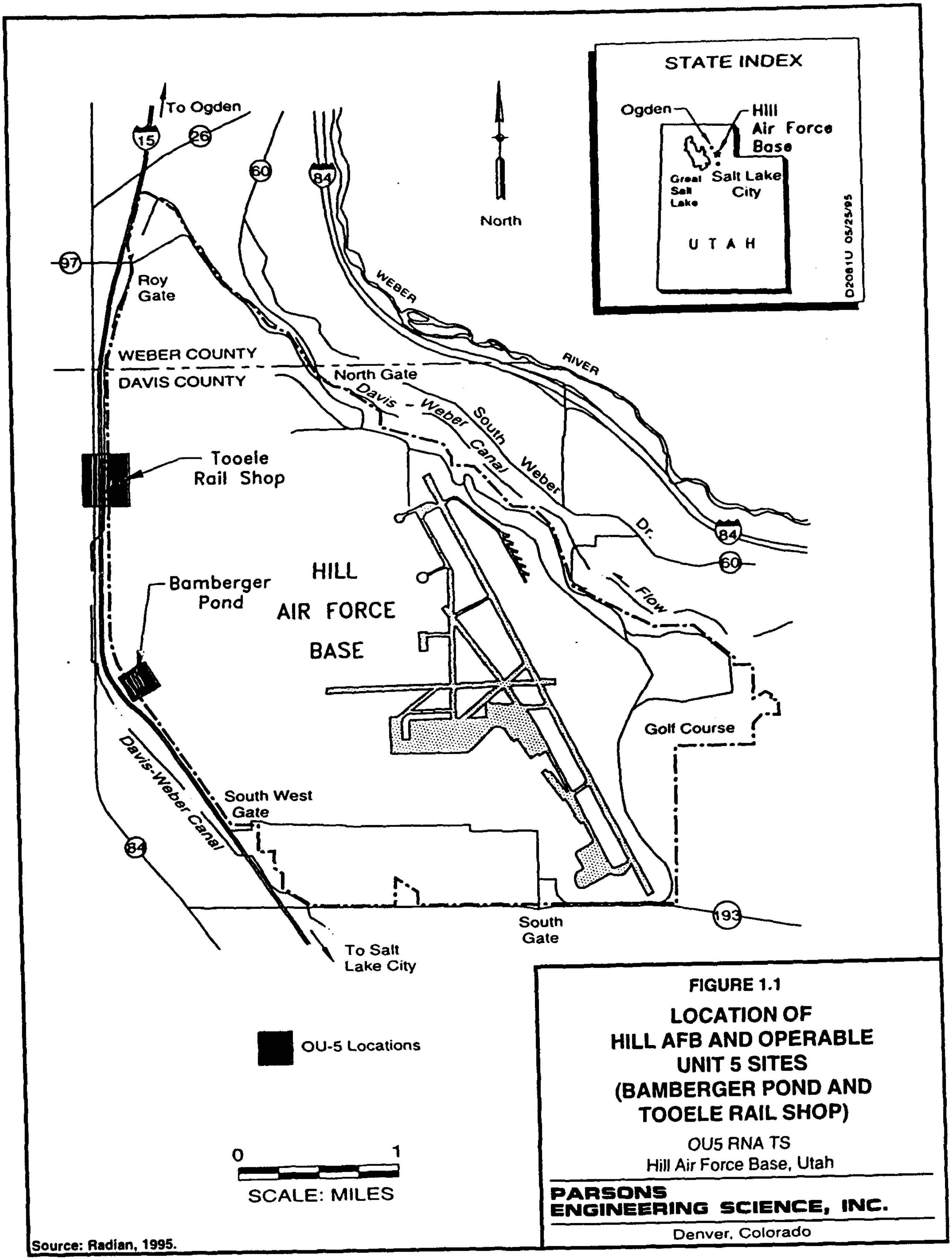


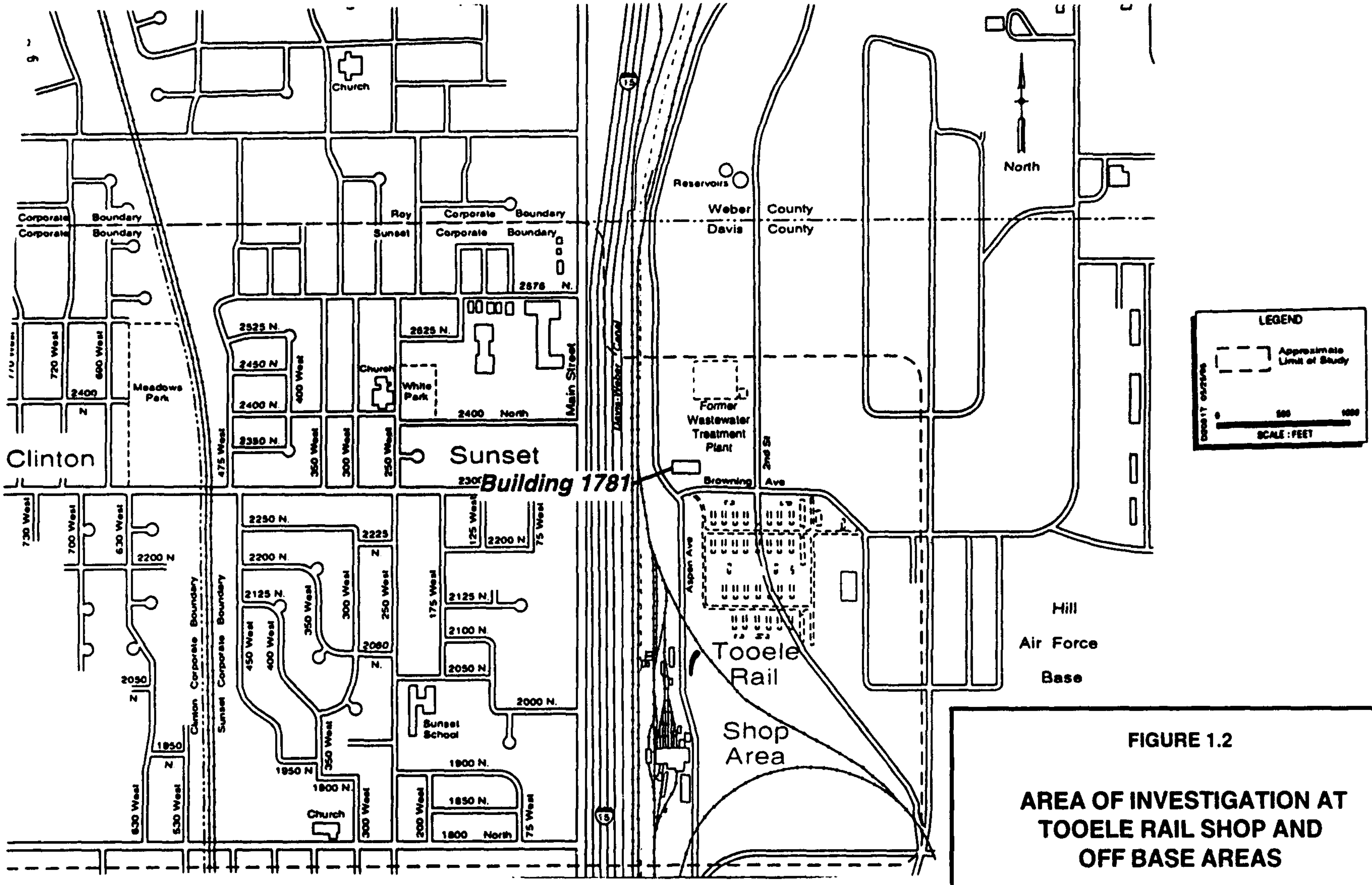
FIGURE 1.1

LOCATION OF HILL AFB AND OPERABLE UNIT 5 SITES (BAMBERGER POND AND TOOELE RAIL SHOP)

OU5 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Source: Radian, 1995.



Source: Radian, 1995.

FIGURE 1.2

AREA OF INVESTIGATION AT TOOELE RAIL SHOP AND OFF BASE AREAS

OU5 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

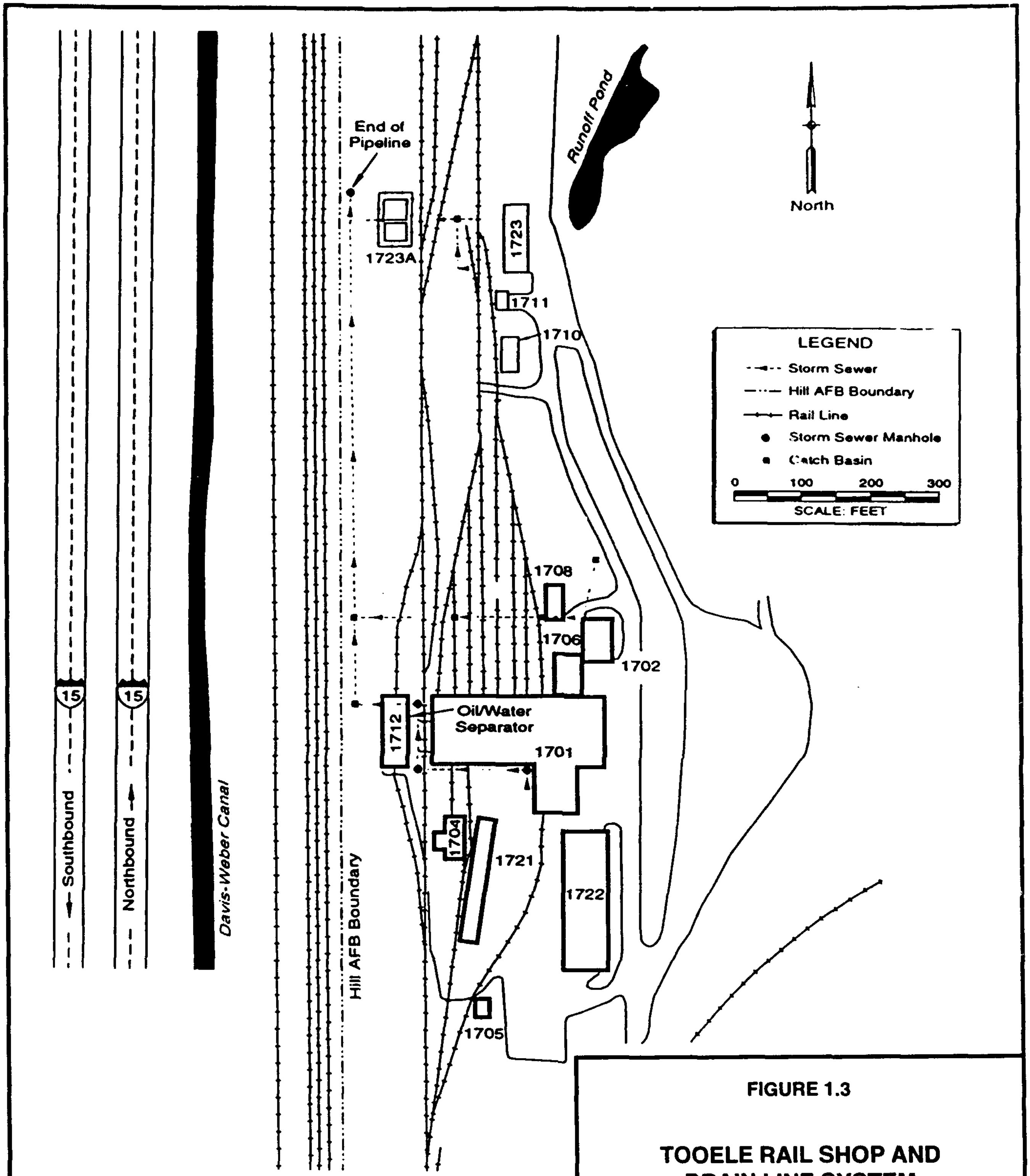


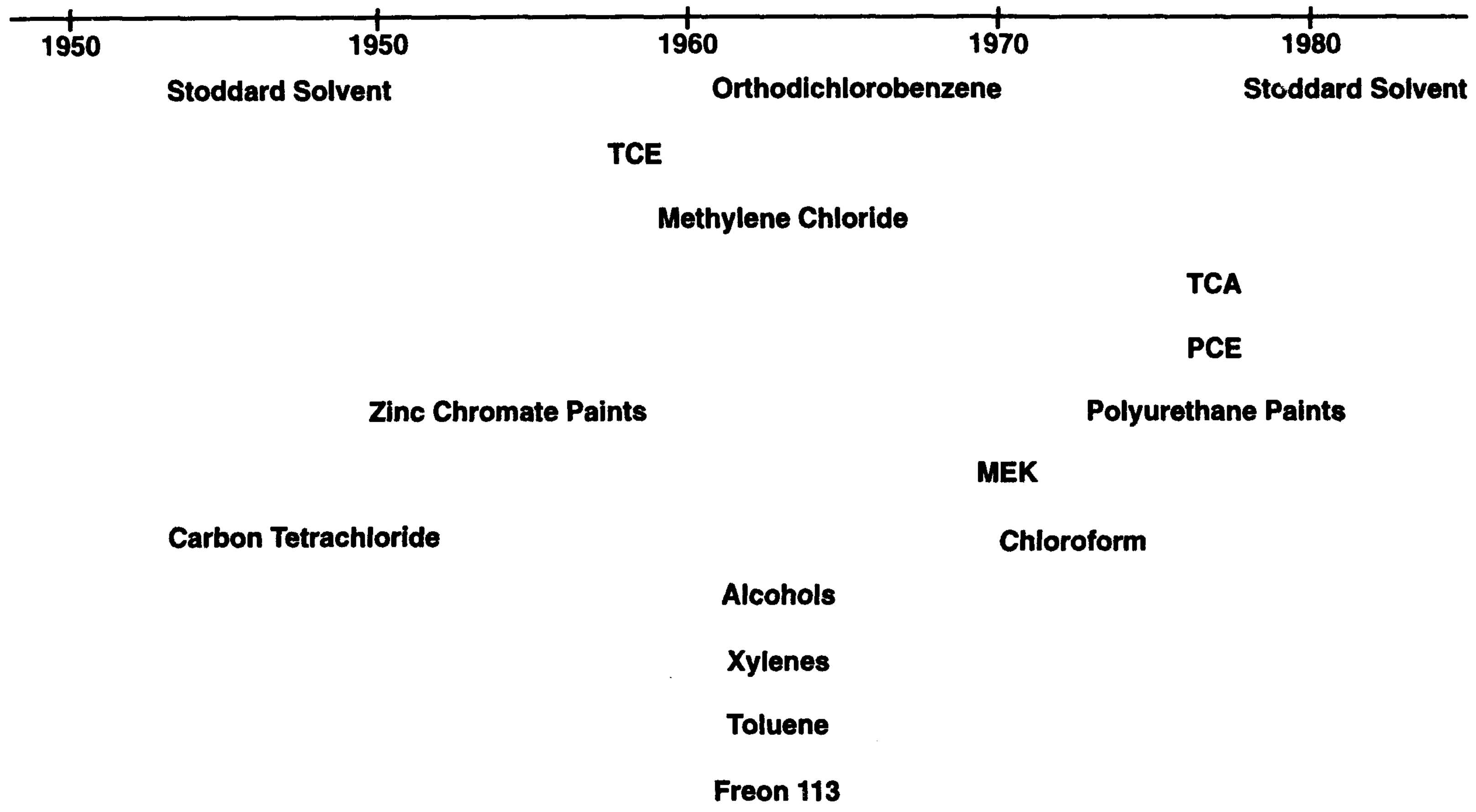
FIGURE 1.3

TOOELE RAIL SHOP AND DRAIN LINE SYSTEM

OU5 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Source: Radian, 1995.



Source: Montgomery Watson, 1995.

FIGURE 1.4

HISTORIC CHEMICAL USAGE

OU5 RNA TS
Hill Air Force Base, Utah

PARSONS
ENGINEERING SCIENCE, INC.
Denver, Colorado

A preliminary assessment/site investigation (PA/SI) identified two sites, the US Army Tooele Rail Shop and Bamberger Pond, as potential sources of contamination. Beginning in 1986, field work at these sites was conducted as part of the Installation Restoration Program (IRP) [Radian and Science Applications International Corporation (SAIC), 1988]. In 1987, trace quantities of TCE and 1,1,1-trichloroethane (TCA) were found in two residential wells and a spring located in the cities of Sunset and Clinton, approximately 1 mile west of the Base (Figure 1.2). Monitoring wells were installed, and soil and groundwater samples were collected at both sites from 1989 through 1991 (SAIC, 1992a and 1992b). In addition, a soil gas survey was performed at the Tooele Rail Shop in 1991. Two underground fuel storage tanks at Building 1705 at the Tooele Rail Shop were removed, and petroleum-hydrocarbon-contaminated soils were removed (Radian, 1993b). The field and laboratory studies at the Tooele Rail Shop and Bamberger Pond conducted prior to 1992 are hereafter referred to as pre- RI studies. The RI effort for OU 5 began in 1992, and was completed in 1995. The contents of the aforementioned references also are summarized in the *Final Remedial Investigation Report-Operable Unit 5-Sites SS17 and SD16* (Radian, 1995).

The RI activities at the Tooele Rail Shop extended well beyond the boundaries of the Rail Shop. Areas of the cities of Sunset and Clinton were investigated, as well as areas north and east of the Tooele Rail Shop that formerly included a Base housing tract and a former wastewater treatment system that serviced the former housing area (Figure 1.2). Little information is available about the former Base housing area and wastewater treatment facility. The site of the former housing area is abandoned, with only remnants of former roads and a concrete foundation remaining. Available aerial photographs show that any buildings in this area were removed before 1960. Likewise, the former wastewater treatment facility has been demolished, although some concrete rubble, metal debris, and the general outline of the percolation beds are still visible. Inspection of aerial photographs and maps suggest that these areas operated during the 1940s and 1950s. In 1993, the Explosive Ordnance Disposal (EOD) building (Building 1781) was completed just southwest of the former percolation beds north of Browning Avenue (Figure 1.2).

The RI work conducted by Radian (1993a and 1995) took place from 1992 through 1995. Based on the results of the soil gas survey conducted at the Tooele Rail Shop, boreholes were drilled and sampled, and monitoring wells were installed in 1992. Results of this work were inconclusive regarding a connection between low concentrations of TCE observed at the Tooele Rail Shop and measured in downgradient wells and springs. In early 1993, an investigation of groundwater conditions along the western perimeter of the Base identified a plume of TCE in shallow groundwater extending from the Tooele Rail Shop area off-Base to the west. Further investigative efforts in late 1993 and in 1994 provided additional data on the nature and extent of contamination. The focus of the following sections is the plume emanating from the Tooele Rail Shop and migrating off-Base in the surficial aquifer to areas beneath the adjacent cities. Bamberger Pond has not contributed to the plume, and therefore is not discussed further.

Work performed as part of the RI during 1992-1994 included:

- Records search and a series of interviews with area residents to determine, if possible, the presence and location of field drains;
- Performance of a passive soil gas survey to evaluate the extent of volatile organic compound (VOC) contamination, identify possible source areas of contaminants, and to aid in the selection of cone penetrometry testing (CPT) and monitoring well locations;
- Performance of CPT at various locations, and collection and analysis of soil-pore fluid and soil gas samples;
- Drilling of boreholes and collection and chemical analysis of soil samples in the vicinity of suspected VOC contamination;
- Installation and development of monitoring wells using previously drilled soil borings as pilot holes;
- Collection and chemical analysis of groundwater samples from all new and existing wells in the area;
- Collection and chemical analysis of surface water (spring/seep) samples;
- Performance of slug tests in groundwater monitoring wells to estimate the hydraulic conductivity of the surficial aquifer;
- Collection and chemical analysis of surface soil samples; and
- Performance of a video camera survey of the terminus of the drain line system.

1.3 OTHER SITE REMEDIATION ACTIVITY

In January 1995, a TS was conducted at OU5 using an air sparging curtain. Based on the TS results, a 400-foot-long sparging curtain was installed across the CAH plume along Main Street, immediately west of Interstate 15 (see Figure 1.2 for street locations). The sparging curtain became operational in April 1997. In addition, an 800-foot-long groundwater extraction trench may be installed along 300 West. There were tentative plans to install groundwater extraction wells near the EOD building (1781) to address an apparent TCE source that is unrelated to the Tooele Rail Shop plume. However, these plans are currently "on hold" while the feasibility of a no-action alternative for this contamination is explored. Groundwater extraction wells and an aboveground activated carbon treatment system will be installed near well pair MW137/MW138 in the city of Sunset.

SECTION 2

SITE CHARACTERIZATION ACTIVITIES

To meet the requirements of the RNA demonstration, additional data were required to evaluate near-surface hydrogeology and geochemistry, and the extent of surface water and groundwater contamination. Site characterization activities involved borehole advancement, soil sampling, and groundwater monitoring point installation using a Geoprobe®; collection of groundwater samples from existing monitoring wells and newly installed monitoring points; and collection of surface water samples from area springs and seeps and a field drain. The scope of these activities was described in the work plan for this RNA TS (Parsons ES, 1996) with the work performed from August 5 through 14, 1996.

The physical and chemical data listed below were collected during the field work phase of the TS:

- Depth from measurement datum to the water table or potentiometric surface in monitoring wells and monitoring points;
- Stratigraphy of subsurface media;
- Groundwater geochemical data [pH; temperature, electrical conductivity; total alkalinity; oxidation-reduction potential (ORP); dissolved oxygen (DO); carbon dioxide, chloride; nitrate+nitrite [as nitrogen (N)]; ammonia; ferrous iron; manganese, sulfate; total organic carbon (TOC); dissolved hydrogen; phenols; aliphatic and aromatic acids; methane, and ethene];
- Groundwater concentrations of chlorinated and aromatic VOCs and metals;
- Concentrations of TOC in soil; and
- Concentrations of CAHs in surface water.

The following sections describe the procedures that were followed when collecting site-specific data. Additional details regarding investigative activities are presented in the final work plan (Parsons ES, 1996).

2.1 GEOPROBE® FIELD ACTIVITIES

The Geoprobe® system is an hydraulically powered percussion/probing machine used to advance sampling tools through unconsolidated soils. This system provides for the rapid collection of soil, soil gas, and groundwater samples at shallow depths while minimizing the generation of investigation-derived waste materials. Figure 2.1 is a diagram of the Geoprobe® system. At OU5, the Geoprobe® was used to collect soil

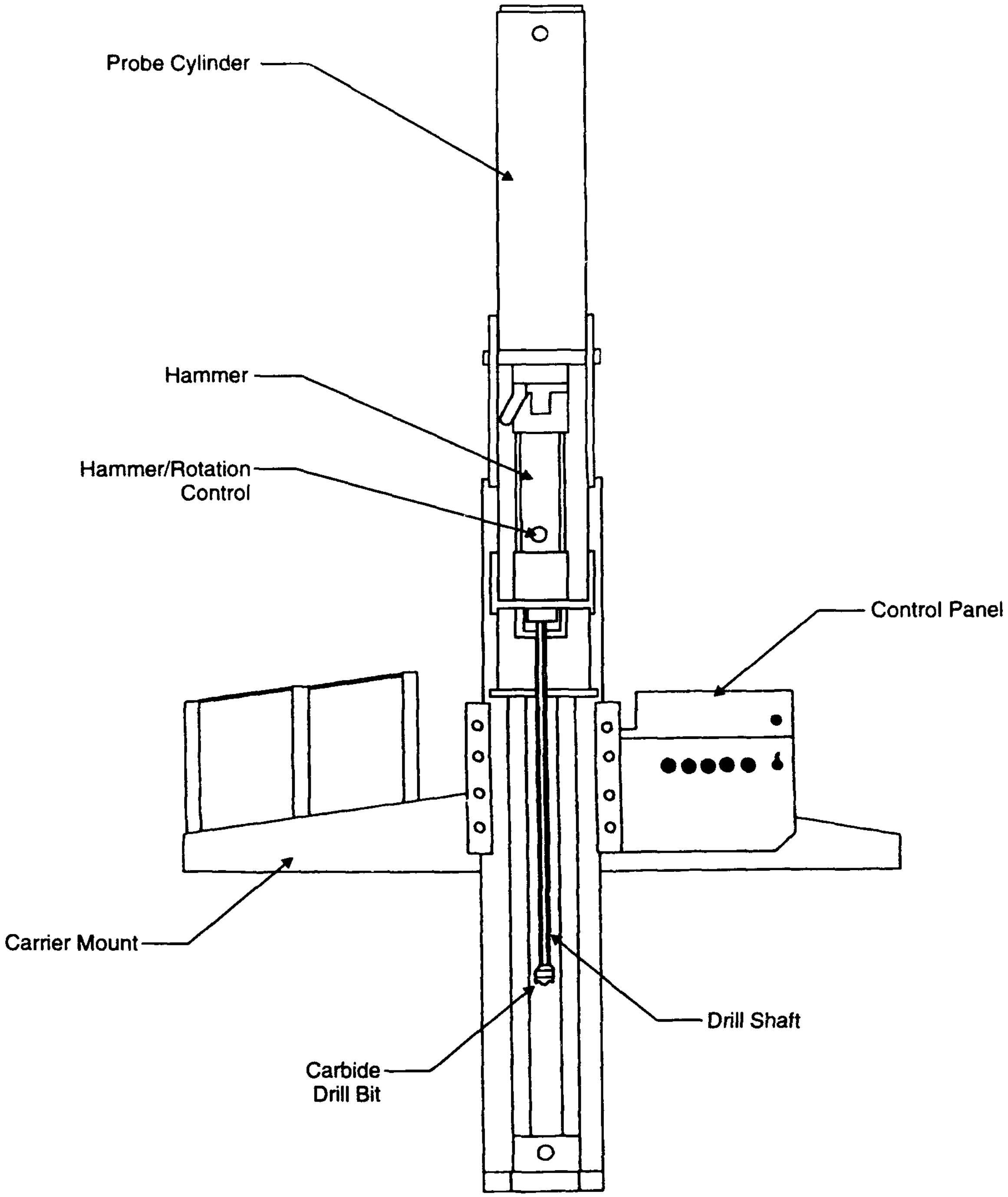


FIGURE 2.1

CROSS-SECTION OF GEOPROBE®

OU5 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

COREL/DRAW/GEOPROBE.CDR NAP 4/4/97 -TIF

samples for visual description and TOC analysis, and to install groundwater monitoring points.

2.1.1 Groundwater Monitoring Point Locations and Completion Intervals

Geoprobe®-related field work included borehole advancement and monitoring point installation at eight on- and off-Base locations (Figure 2.2). The term "monitoring point" is used in this report to distinguish these groundwater monitoring stations from conventionally constructed monitoring wells. One 3- to 4-foot-long soil sample was collected from within or near the screened interval during borehole advancement at each location for stratigraphy identification purposes. Monitoring point pairs, consisting of points screened in the shallow and deep portions of the surficial aquifer, were installed at two on-Base locations (MP-1s/1d and MP-2s/2d), resulting in the installation of a total of 10 monitoring points at the 8 locations. The suffixes "s" and "d" denote the shallow and deep points, respectively. Completion details for new monitoring points and previously installed monitoring wells are provided in Table 2.1.

2.1.2 Groundwater Monitoring Point Installation and Soil Sampling Procedures

2.1.2.1 Pre-Installation Activities

All subsurface utility lines and other man-made subsurface features were located, and proposed monitoring point locations were cleared and approved by the Base or the off-Base utility location group ("Blue Stakes") prior to any drilling activities. Monitoring point locations were moved as necessary to avoid damage to subsurface utilities.

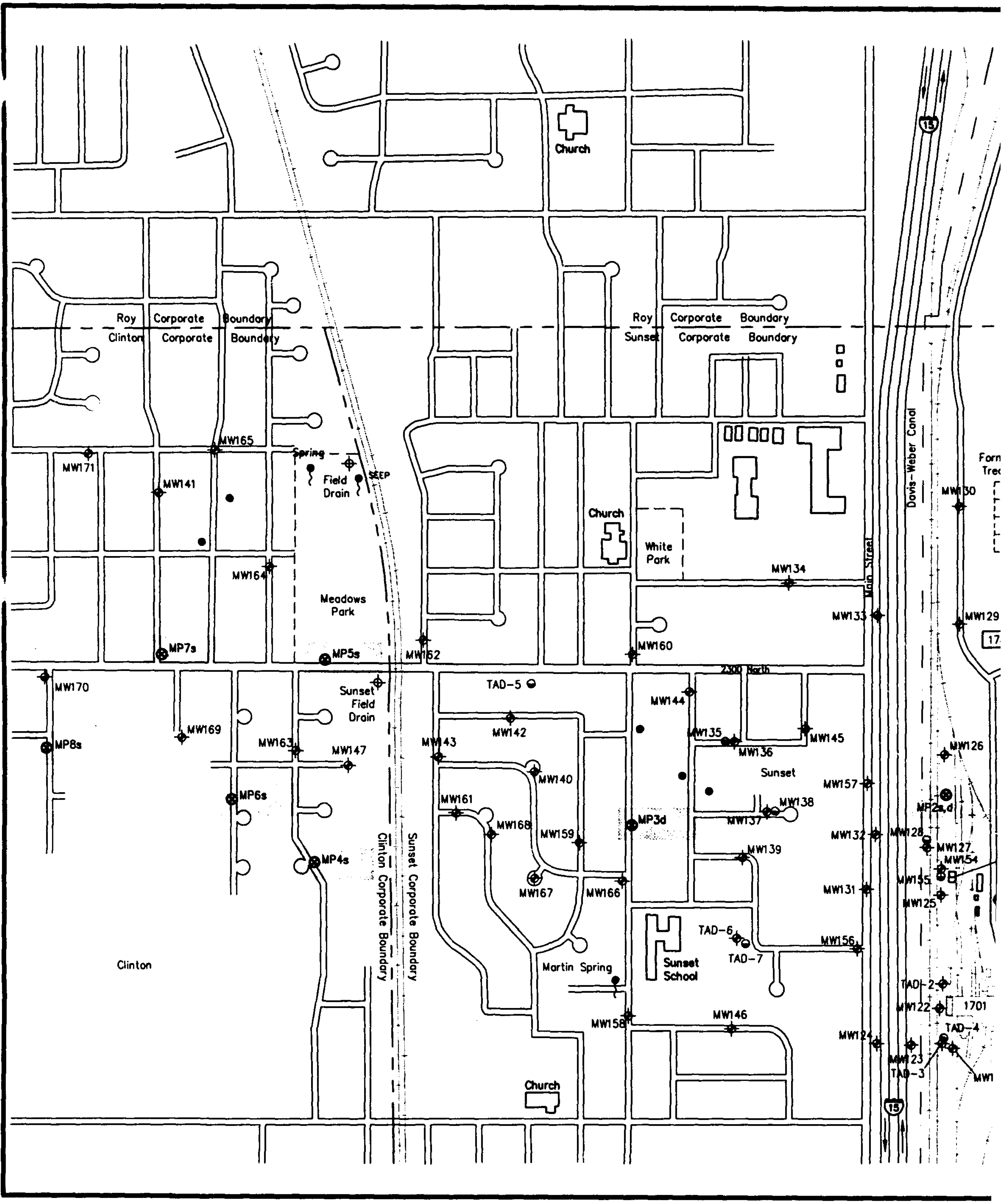
2.1.2.2 Equipment Decontamination Procedures

Prior to arriving at the site and between each monitoring point location, all Geoprobe® rods, tips, sleeves, pushrods, samplers, tools, and other downhole equipment were decontaminated using an Alconox® detergent and potable water solution and scrub brush, followed by a potable water rinse. Decontamination was performed at a designated wash area adjacent to the southwest corner of Building 860.

Fuel, lubricants, and other similar substances were handled in a manner consistent with accepted safety procedures and standard operating practices. All monitoring point completion materials were factory sealed and were not stored near or in areas that could be affected by these substances.

2.1.2.3 Borehole Advancement and Soil Sampling

The Geoprobe®-collected soil samples were obtained using a probe-drive sampler during installation of monitoring points MP-1s/1d through MP-8s (Figure 2.2). The probe-driven sampler serves as both the driving point and the sample collection device and is attached to the leading end of the probe rods. To collect a soil sample, the sampler was pushed or driven to the desired sampling depth, and the stop pin was removed, allowing the piston and drive point to retract as the sample barrel was pushed into undisturbed soil. The soil cores were retained within a clear acetate liner inside the sampling barrel. The probe rods were then retracted, bringing the sampling device to the surface. The samples were visually described, and, in some cases, a sample for



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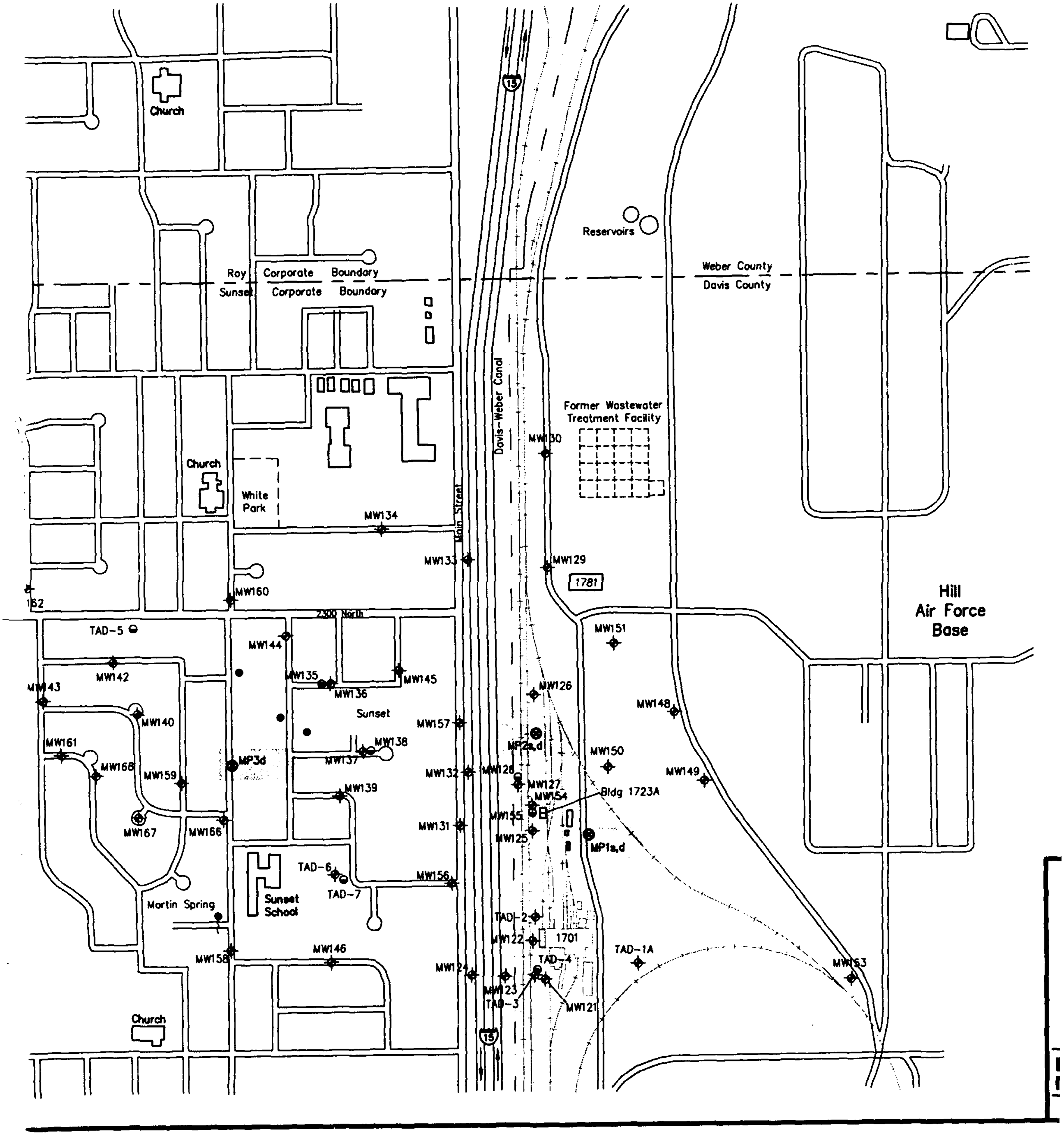

Church
15
Reservoirs
Roy Corporate Boundary
Sunset Corporate Boundary
Weber County
Davis County
Davis-Weber Canal
Former Wastewater Treatment Facility
MW130
Church
White Park
MW134
Main Street
MW133
MW129
1781
162
MW160
2300 North
Hill Air Force Base
TAD-5
MW144
MW151
MW142
MW135
MW136
MW145
MW126
MW143
MW148
MW140
Sunset
MW157
MW161
MP3d
MW138
MP2s,d
MW150
MW168
MW159
MW137
MW132
MW128
MW149
MW139
MW127
MW154
Bldg 1723A
MW155
MW167
MW166
MW131
MW125
MP1s,d
TAD-6
MW156
TAD-7
Sunset School
Martin Spring
TAD-2
MW122
1701
MW158
MW146
TAD-4
TAD-1A
MW124
MW153
MW123
TAD-3
MW121
Church
15

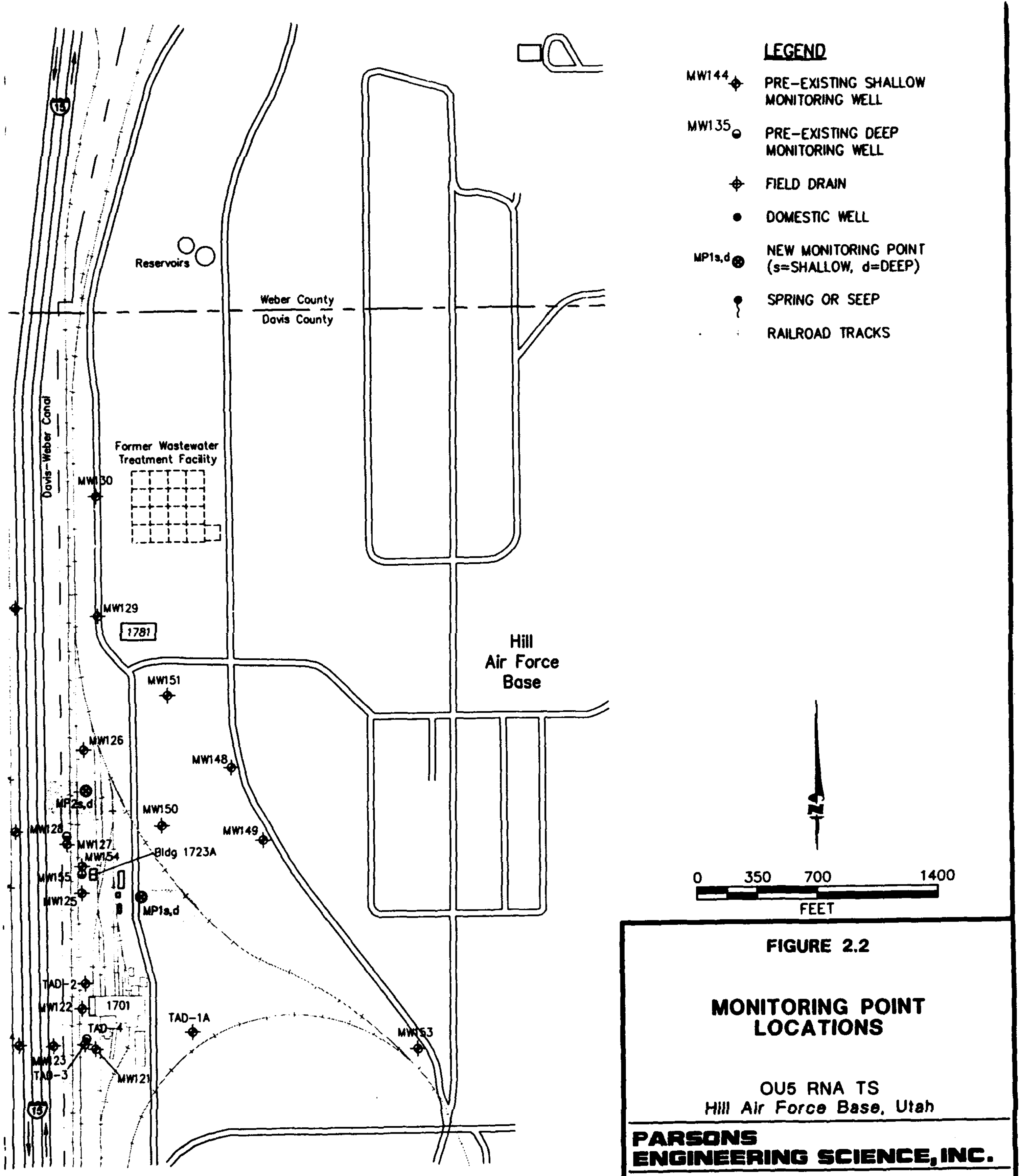


FIGURE 2.2

MONITORING POINT LOCATIONS

OU5 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

TABLE 2.1
MONITORING POINT AND MONITORING WELL COMPLETION DATA
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Well Identification	Installation Date	Well Diameter (Inches)	Screened Interval (Feet bgs)[a]	Survey Northing (State Plane)[b]	Survey Easting (State Plane)	Top of Casing Elevation (Feet msl)[c]	Ground Surface Elevation (Feet msl)
New Monitoring Points							
MP-1s	8/7/96	0.5	19.0 - 24.0	295613.45	1856156.68	4592.06	4592.4
MP-1d	8/7/96	0.25	43.5 - 44.0	295609.53	1856157.19	NA[d]	4592.3
MP-2s	8/8/96	0.25	27.5 - 28.0	296252.40	1855830.86	NA	4582.2
MP-2d	8/8/96	0.25	43.5 - 44.0	296251.54	1855830.69	NA	4582.1
MP-3d	8/10/96	0.5	28.5 - 31.8	296125.09	1854010.14	4496.37	4496.7
MP-4s	8/9/96	0.5	10.0 - 15.0	295852.90	1852157.41	4444.92	4445.1
MP-5s	8/9/96	0.5	9.8 - 14.8	297023.44	1852208.14	4442.14	4442.4
MP-6s	8/9/96	0.5	9.4 - 14.4	296207.53	1851656.17	4436.83	4437.0
MP-7s	8/9/96	0.5	11.5 - 14.8	297048.88	1851213.67	4423.14	4424.0
MP-8s	8/9/96	0.5	12.0 - 15.3	296514.55	1850546.58	4413.68	4413.9
Pre-Existing Monitoring Wells							
MW-121	1992	2.0	25 - 35	294763.00	1855923.00	4594.66	4592.2
MW-122	1993	2.0	17 - 26.9	295032.00	1855825.00	4585.66	4583.2
MW-123	1993	2.0	17 - 26.9	294881.00	1855621.00	4573.27	4573.3
MW-124	1993	2.0	13.0 - 22.96	294882.00	1855378.00	4558.23	4558.4
MW-125	1993	4.0	17.33 - 27.33	295728.00	1855830.00	4582.31	4582.3
MW-126	1993	4.0	30.92 - 40.92	296449.00	1855830.00	4581.61	4581.6
MW-127	1993	4.0	16.25 - 26.40	295941.00	1855729.00	4580.40	4580.4
MW-128	1993	4.0	41.3 - 51.3	295955.00	1855730.00	4580.27	4580.3
MW-129	1993	4.0	55 - 65	297225.00	1855937.00	4587.20	4587.5
MW-130	1993	4.0	54.5 - 64.5	297775.00	1855938.00	4585.39	4585.4
MW-131	1993	4.0	5 - 15	295693.00	1855385.00	4556.11	4556.1
MW-132	1993	4.0	7 - 17	296088.00	1855379.00	4554.45	4554.5
MW-133	1993	4.0	25 - 35	297362.00	1855389.00	4551.49	4551.5
MW-134	1993	2.0	16.55 - 25.5	297380.00	1854904.00	4529.00	4529.4
MW-135	1993	2.0	21.75 - 31.0	296549.00	1854623.00	4516.40	4516.8
MW-136	1993	2.0	8.25 - 17.5	296549.00	1854642.00	4516.95	4517.5
MW-137	1993	2.0	6.75 - 16.0	296117.00	1854805.00	4524.22	4524.7
MW-138	1993	2.0	30 - 39.3	296116.00	1854799.00	4524.00	4524.5
MW-139	1993	2.0	8.25 - 17.5	295843.00	1854630.00	4517.82	4518.2
MW-140	1993	2.0	7.85 - 17.1	296357.00	1853445.00	4478.89	4479.4
MW-141	1993	2.0	9.25 - 18.5	298057.00	1851221.00	4418.91	4419.33
MW-142	1993	2.0	10.3 - 20.0	296677.00	1853254.00	4476.18	4476.8
MW-143	1993	2.0	12.25 - 21.5	296462.00	1852861.00	4465.68	4466.1
MW-144	1993	2.0	10.3 - 19.25	296879.00	1854363.00	4505.61	4506.0
MW-145	1993	2.0	12.82 - 21.77	296643.00	1854971.00	4531.88	4532.4

(Continued)

TABLE 2.1 (Concluded)
MONITORING POINT AND MONITORING WELL COMPLETION DATA
SITE OU5
INTRINSIC REMEDIATION
HILL AFB, UTAH

Well Identification	Installation Date	Well Diameter (Inches)	Screened Interval (Feet bgs)[a]	Survey Northing (State Plane)[b]	Survey Easting (State Plane)	Elevation Datum (Feet msl)[c]	Ground Surface (Feet msl)
Pre-Existing Monitoring Wells							
MW-146	1993	2.0	5.75 - 15.0	294853.00	1854521.00	4517.71	4518.1
MW-147	1993	2.0	6.25 - 15.5	296423.00	1852280.00	4443.62	4444.1
MW-148	1993	2.0	49.75 - 59.0	296302.00	1856694.00	4632.41	4630.6
MW-149	1993	2.0	48.25 - 57.5	295928.55	1856870.00	4634.59	4633.8
MW-150	1993	2.0	44.75 - 53.7	296125.00	1856350.00	4617.95	4616.1
MW-151	1993	2.0	53.45 - 62.4	296666.00	1856328.00	4607.74	4607.7
MW-152	1994	2.0	35 - 45.3	288152.00	1857427.20	4608.48	4606.8
MW-153	1994	2.0	28 - 38.3	294645.00	1857816.00	4642.51	4640.5
MW-154	1994	2.0	14 - 24.3	295854.00	1855837.00	4582.44	4582.4
MW-155	1994	2.0	50 - 60.3	295866.00	1855837.00	4582.44	4582.8
MW-156	1994	2.0	10 - 20.3	295297.00	1855241.00	4552.25	4552.3
MW-157	1994	2.0	12 - 22.3	296392.00	1855364.00	4553.66	4553.7
MW-158	1994	2.0	8 - 18.3	294887.00	1854014.00	4502.02	4502.6
MW-159	1994	2.0	9 - 19.2	295879.00	1853711.00	4487.63	4488.1
MW-160	1994	2.0	11 - 21.3	297064.00	1854009.00	4494.63	4495.1
MW-161	1994	2.0	10 - 20.3	296145.00	1852951.00	4469.61	4470.1
MW-162	1994	2.0	11.5 - 21.9	297128.00	1852776.00	4458.64	4459.2
MW-163	1994	2.0	8 - 18.3	296508.00	1852045.00	4441.09	4441.7
MW-164	1994	2.0	9 - 19.3	297574.00	1851858.00	4433.64	4434.2
MW-165	1994	2.0	9 - 19.3	298264.00	1851517.00	4424.20	4424.8
MW-166	1994	2.0	4.2 - 14.6	295698.00	1854009.90	4497.53	4497.5
MW-167	1994	2.0	5.0 - 15.4	295735.00	1853465.30	4481.86	4482.2
MW-168	1994	2.0	5.0 - 15.4	295394.00	1853161.00	4475.98	4476.3
MW-169	1994	2.0	5.0 - 15.4	296632.00	1851334.60	4425.93	4426.3
MW-170	1994	2.0	7.4 - 17.4	296194.00	1850539.40	4413.33	4413.3
MW-171	1994	2.0	4.8 - 15.2	298287.00	1850804.80	4411.00	4411.0
TAD-1	1989	4.0	27.0 - 37.0	300977.33	1856431.61	4613.05	4611.0
TAD-1A	1993	4.0	40.6 - 50.6	NA	NA	4613.01	4613.2
TAD-2	1989	4.0	16.7 - 26.7	300719.69	1856752.92	4588.29	4586.0
TAD-3	1989	4.0	19.0 - 29.0	301039.90	1856806.47	4587.54	4585.1
TAD-4	1989	4.0	45.5 - 55.5	NA	NA	4587.69	4587.7
TAD-5	1991	4.0	37.1 - 47.1	NA	NA	4478.98	4479.0
TAD-6	1991	4.0	5.3 - 15.3	NA	NA	4522.89	4522.9
TAD-7	1991	4.0	90.5 - 100.5	NA	NA	4522.89	4522.9

[a] Feet bgs = feet below ground surface.

[b] State Plane = State of Utah Plane Coordinate System.

[c] Feet msl = Feet below mean sea level.

[d] NA = not applicable or not available. Monitoring points with teflon® tubing do not have a groundwater elevation datum.

Note: All pre-existing monitoring wells were installed by SAIC (1992) or RADIAN (1995).

laboratory TOC analysis was retained in a clean glass jar. A summary of chemical analyses performed for soil and groundwater samples is presented in Table 2.2.

USEPA personnel operated the Geoprobe®, and the Parsons ES field scientist observed Geoprobe® sampling and monitoring point installation activities and maintained a descriptive log of subsurface materials recovered. Soil sample descriptions are provided in Appendix B.

2.1.3 Monitoring Point Installation

Groundwater monitoring points were installed in 10 boreholes under this program. Monitoring point installation procedures are described in the following paragraphs. Monitoring point completion diagrams are included in Appendix B.

2.1.3.1 Monitoring Point Materials Decontamination

Monitoring point completion materials were inspected by the field scientist and determined to be clean and acceptable prior to use. All monitoring point completion materials were factory sealed in plastic wrap. Pre-packaged casing, sand, bentonite, and concrete mix were used in point construction, and the bags were inspected for possible external contamination before use. Materials that could not be cleaned to the satisfaction of the field scientist were not used.

2.1.3.2 Monitoring Point Casing and Screen

Two monitoring point designs were used to construct shallow monitoring points. The majority of the shallow monitoring points were constructed of Schedule 40 polyvinyl chloride (PVC) riser pipe connected to factory-slotted PVC screens having an inner diameter (ID) of 0.5 inch. The PVC points were placed wherever formation soils did not collapse into the borehole after the Geoprobe® rods were extracted. In the event that collapsing soils prevented the placement of the PVC screen after the extraction of the soil probe the monitoring points were constructed with 0.25-inch-ID stainless steel (SS) mesh implants acting as monitoring point screens and 0.25-inch-ID, Teflon®-lined, high-density polyethylene (HDPE) tubing acting as risers connecting the SS mesh to the surface (HDPE tubing was threaded through the center of the Geoprobe® drive rods). All PVC casing and screen sections on the shallow monitoring points were flush threaded, and glued joints were not used. The riser pipe at each PVC monitoring point was fitted with a PVC top cap, and an aluminum drive point was inserted into the bottoms of the PVC screens.

Monitoring point screens constructed of PVC were 3.3 to 5 feet long, depending on location, and factory slotted with 0.010-inch openings. Monitoring point screens constructed of SS were 0.5 foot in length with pore openings of 0.0057 inch. Shallow points were screened near the water table, and deep points were screened approximately 18 to 26 feet below the water table.

All deep monitoring points were constructed using the SS screens and Teflon®-lined HDPE tubing described above. The riser tubing for deep monitoring points extended to the surface, and the bottom of the SS mesh screen was threaded to the dedicated

TABLE 2.2
ANALYTICAL PROTOCOL FOR GROUNDWATER, SURFACE WATER, AND SOIL SAMPLES
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

MATRIX/PARAMETER	METHOD	ANALYTICAL LABORATORY
WATER		
Phenols, Aliphatic/Aromatic Acids	RSKSOP-177	NRMRL[a]
Phenols	CHEMetrics Method 4AAP	Field
Dissolved Hydrogen	Gas Chromatograph	Field
Ferrous Iron (Fe+2)	Colorimetric, HACH Method 8146	Field
Manganese	Colorimetric, HACH Method 8034	Field
Sulfate	N-601 [b]	NRMRL
Nitrate and Nitrite	E353.1	NRMRL
Oxidation-Reduction Potential	Direct reading meter	Field
Dissolved Oxygen	Direct reading meter	Field
pH	Direct reading meter	Field
Conductivity	Direct reading meter	Field
Temperature	Direct reading meter	Field
Alkalinity (Carbonate [CO3-2] and Bicarbonate [HCO3-1])	Titrimetric, HACH Method 8221	Field
Carbon Dioxide	CHEMetrics Method 4500	Field
Chloride	N-601 [b]	NRMRL
Ammonia--Diss. Gas in Water	E350.1	NRMRL
Methane	RSKSOP-175/RSKSOP-147	NRMRL
Ethene	RSKSOP-175/RSKSOP-147	NRMRL
Total Organic Carbon	RSKSOP-102	NRMRL
Aromatic Hydrocarbons (Including Trimethylbenzenes and Tetramethylbenzene)	RSKSOP-133	NRMRL
Metals	ICP, GFAA (lead only) [c]	NRMRL
Volatile Organics	RSKSOP-146	NRMRL
SOIL		
Total Organic Carbon	RSKSOP-102, RSKSOP-120	NRMRL
Surface Water		
Volatile Organics	RSKSOP-146	NRMRL
SURFACE WATER		
Volatile Organics	RSKSOP-146	NRMRL

a/ USEPA National Risk Management Research Laboratory in Ada, Oklahoma.

b/ Waters capillary electrophoresis Method N-601.

c/ ICP = Inductively Coupled Plasma Spectrometry; GFAA = Graphite Furnace Atomic Absorption.

stainless steel drive point/implant anchor that remained in place after the drive rods were removed. Monitoring point construction details are summarized in Table 2.1.

The field scientist verified and recorded the borehole depth and the lengths of all casing sections and tubing. All lengths and depths were measured to the nearest 0.1 foot.

2.1.4 Monitoring Point Development

Before being sampled, newly installed monitoring points were developed. Typically, well development removes sediment from inside the well casing and flushes fines, cuttings, and drilling fluids from the sand pack and the portion of the formation adjacent to the well screen. Use of the Geoprobe® system to place monitoring points eliminates cuttings and drilling fluids. Therefore, development of monitoring points was primarily intended to minimize the amount of fine sediment that might accumulate in the casing.

Development was accomplished using a peristaltic pump with dedicated silicone and HDPE tubing. The pump tubing was regularly lowered to the bottom of the shallow points so that fines were agitated and removed from the point in the development water. Typically, development was continued until a minimum of 10 casing volumes of water were removed, and the pH, temperature, and conductivity of the groundwater had stabilized. Monitoring point MP3d, screened in silty clay, had a very low recharge rate, and only 8 casing volumes were removed during the development process. Development waters were containerized and disposed of at the Base IWTP. Development records are contained in Appendix B.

2.2 GROUNDWATER SAMPLING

This section describes the procedures used for collecting groundwater quality samples. In order to maintain a high degree of quality control (QC) during this sampling event, the procedures described in the site work plan (Parsons ES, 1996) and summarized in the following sections were followed.

2.2.1 Groundwater Sampling Locations

Groundwater samples were collected from 43 previously installed monitoring wells, and 9 of the 10 newly installed monitoring points. Monitoring point MP4s was vandalized shortly after installation, and could not be sampled. After completion of installation and development activities, these monitoring points were purged and sampled using a peristaltic pump with dedicated HDPE and silicone tubing. Monitoring point purging and sampling was performed at least 11 hours after completion of development activities.

2.2.2 Preparation and Equipment Cleaning

All equipment used for sampling was assembled and properly cleaned and calibrated (if required) prior to use in the field. Calibrations were performed in accordance with the manufacturer's specifications. An electric water level meter was used to measure the static water level in the monitoring well/point prior to initiation of purging. Prior to each use, the water level probe was cleaned with a potable water and phosphate-free, laboratory-grade detergent solution, followed by a distilled-water rinse. In addition, a clean pair of new, disposable latex or nitrile gloves was worn each time a different well or monitoring point was sampled. Dedicated HDPE and silicone tubing were used at each sampling location, eliminating the need for decontaminating these items between wells.

2.2.3 Groundwater Sampling Procedures

2.2.3.1 Preparation of Location

Prior to starting the sampling procedure, the area around the well or monitoring point was cleared of foreign materials, such as brush, rocks, and debris. These procedures prevented sampling equipment from inadvertently contacting debris around the monitoring well/point. The integrity of the monitoring well/point also was inspected, and any irregularities in the visible portions of the well/point, protective cover, or concrete pad were noted.

2.2.3.2 Water Level and Total Depth Measurements

Prior to removing any water from the well or shallow monitoring points, an electrical water level probe was used to measure the depth to groundwater below the well datum to the nearest 0.01 foot. Water levels in the newly installed points constructed of Teflon®-lined HDPE tubing were not obtained because the water level probe diameter was larger than the tubing diameter. If the monitoring well/point depth was not known, the water level probe was then lowered to the bottom of the well/point for measurement of total depth (recorded to the nearest 0.1 foot). Based on these measurements, or using total depths recorded in the RI report (Radian, 1995), the volume of water to be purged from the well/point was calculated.

2.2.3.3 Monitoring Well/Point Purging

Where possible, a minimum of three times the calculated saturated casing volume was removed from each monitoring well/point prior to sampling. Purging continued until the pH, DO concentration, ORP, conductivity, and temperature stabilized between successive readings. Physical and chemical parameters were measured at the well head using field meters and a flow-through cell consisting of an Erlenmeyer flask. A peristaltic pump with dedicated silicone and HDPE tubing was used for well evacuation where the depth to groundwater was sufficiently shallow (less than approximately 20 feet). At these wells, the HDPE tubing was lowered to within 2 feet of the bottom of the well. In some cases, the initial purge rate was high enough to evacuate the well or to cause air bubbles to become entrained in the pumped water. When this occurred, the purge rate was reduced until a steady, bubble-free flow was obtained. In all cases, a low pumping rate (i.e., <200 ml/min) was used during sample collection.

A decontaminated PVC bailer or Enviro-Tech® ES Series battery-operated purge pump connected to dedicated PVC discharge tubing was used to purge wells having deeper static water levels. The purge rate of the battery-operated pump is dependent on the depth to water in the well, and cannot be adjusted. All purge water was containerized and disposed of at the Base IWTP. Monitoring point MP4s was vandalized (filled with sand and trash) shortly after installation, and therefore was not purged or sampled. Purging and sampling field forms are contained in Appendix B.

2.2.3.4 Sample Collection

A peristaltic pump with dedicated silicone and HDPE tubing was used to extract groundwater samples from each sampled well and monitoring point where the depth to groundwater was less than approximately 20 feet. A dedicated, disposable polyethylene bailer connected to a new length of nylon or polyethylene rope was used to sample wells having deeper static water levels. In almost all cases, the sampling was performed immediately following well purging. For example, at wells where a peristaltic pump was used, the pump was not turned off in between purging and sampling activities. In a few instances, the monitoring well/point was purged dry, and the samples were collected after sufficient recharge had occurred. All samples were collected within 24 hours of purging.

Sampling from monitoring points constructed of tubing was accomplished by attaching the silicone peristaltic pump tubing directly to the top of the monitoring point tubing. The samples were transferred directly into the appropriate sample containers. The water was carefully poured down the inner walls of each sample bottle to minimize aeration of the sample. Sample bottles for aromatic and chlorinated VOCs and dissolved gases (methane and ethene) were filled so that there was no headspace or air bubbles within the container.

2.2.4 Onsite Chemical Parameter Measurement

DO measurements were taken using an Orion® model 840 or Yellow Springs Instruments (YSI) model 55 DO meter in a flow-through cell at the outlet of the peristaltic pump. DO concentrations were recorded after the readings stabilized, and in all cases represent the lowest DO concentration observed.

Because the electrical conductivity, pH, ORP, and temperature of the groundwater change significantly within a short time following sample acquisition, these parameters were measured in the field, in the same flow-through cell used for DO measurements. Measured values were recorded on the groundwater sampling records (Appendix B).

2.2.5 Sample Handling

The fixed-base analytical laboratory (NRMRL) provided pre-preserved sample containers where appropriate. The sample containers were filled as described in Section 2.2.3.4, and the container lids were tightly closed. The samples were labeled as described in the work plan.

After the samples were sealed and labeled, they were transported to the onsite USEPA mobile laboratory. USEPA personnel packaged the samples to prevent breakage and leakage or vaporization from the containers. Sample shipment to NRMRL and the associated chain-of-custody documentation was the responsibility of the USEPA/NRMRL field personnel.

2.3 SURFACE WATER SAMPLING

Surface water samples were collected from the Martin Spring, a seep in the northeast corner of Meadows Park, and the concrete-lined drainage channel at the north edge of Meadows Park (Figure 2.1). The spring previously identified in the northwest corner of Meadows Park (Figure 2.1) (Radian, 1995) was not evident at the time of this sampling. These samples were collected in order to assess the degree to which CAH-contaminated groundwater was discharging to the surface. The surface water samples were analyzed for CAHs only.

Surface water samples at the Martin Spring were collected directly from the pipe discharging into the concrete-lined pool at the Martin residence. Samples at the Meadows Park seep were obtained by digging a hole in the seepage area with a clean shovel, allowing water to collect in the hole, and submerging the sample bottles in the pooled water. Samples were collected from the downstream (west) end of the concrete-lined field drain channel that parallels the northern boundary of Meadows Park by placing the sample bottle in the channel with the opening facing up and allowing the water to slowly fill the bottle. Sample handling proceeded as described for groundwater samples in Section 2.2.5.

2.4 AQUIFER TESTING

During the RI, Radian (1995) performed slug tests in 43 monitoring wells, and obtained 45 additional hydraulic conductivity values from pore-fluid dissipation tests performed during CPT activities at 18 locations. In addition, direct groundwater velocity measurements were made near Main Street using a borehole flow meter during construction of the air sparging curtain. Therefore, additional aquifer testing was not performed during the TS field program.

2.5 SURVEYING

After completion of field work, the locations and elevations of all new monitoring points were surveyed by Mountain West Land Surveyors, Inc. a licensed land surveyor from Salt Lake City, Utah. The survey tied into preexisting monitoring wells installed during the RI (Radian, 1995) and cultural features such as building corners and a road intersection. For monitoring points constructed of PVC, the horizontal locations and elevations of the measurement datum (top of PVC well casing) and the ground surface adjacent to the well casing were measured relative to the Utah state plane coordinate system. Only the ground surface elevations were measured for monitoring points constructed of Teflon®-lined tubing. PVC casing elevations are presented in Table 2.2; the remaining survey data are presented in Appendix B.

SECTION 3

PHYSICAL CHARACTERISTICS OF THE STUDY AREA

This section describes the physical characteristics of OU5. Existing site-specific data were reviewed and supplemented with data collected by Parsons ES in August 1996 to develop a synopsis of OU5 physical characteristics. The following sections include data from the following sources:

- Radian and SAIC, 1988;
- SAIC, 1992a and 1992b;
- Radian, 1993b; and
- Radian, 1995.

3.1 CLIMATE

The climate of Hill AFB is semi-arid. Mean annual precipitation is just over 18 inches, and annual evaporation is approximately 45 inches (Feth *et al.*, 1966). Most of the precipitation occurs from October through May. Based on data collected from 1980 through 1994, the months with the highest average precipitation were March (2.2 inches), May (2.7 inches), and October (2.0 inches). June through August was the driest period (Montgomery Watson, 1995). At Ogden, just north of Hill AFB, the average temperature is 50.5 degrees Fahrenheit (°F); mean monthly temperatures range from 25°F in January to 75°F in July. Winds average about 5 knots and are generally out of the south and east-southeast, although winds from the north and northwest are common.

3.2 SURFACE FEATURES

3.2.1 Geography and Physiography

Hill AFB is located in northern Utah, approximately 25 miles north of Salt Lake City and 5 miles south of Ogden (Figure 1.1). The Base covers 6,666 acres in Davis and Weber Counties. The western boundary of the Base is near Interstate 15, and the southern boundary is near State Route 193. The western, northern, and northeastern perimeters of the Base are bounded by the Davis-Weber Canal, a privately-owned irrigation canal. The Wasatch Mountain Range is about 4 miles to the east, and the Great Salt Lake is about 6 miles to the west. The Base is located within the Bonneville Basin subsection of the Great Basin section of the Basin and Range physiographic province.

3.2.2 Ground Surface Topography

Hill AFB is located on a plateau that rises approximately 300 feet above the Weber River Valley on the east and approximately 50 to 100 feet above Sunset and Clinton on the west. Except for areas dissected by erosion, most of Hill AFB is relatively level, ranging in altitude between approximately 4,550 and 4,800 feet above mean sea level (ft msl). Although the Tooele Rail Shop site is on nearly level ground, the ground surface on the western side of the Base slopes to the west (Figure 3.1). The elevation of the Tooele Rail Shop is approximately 4,595 feet above msl.

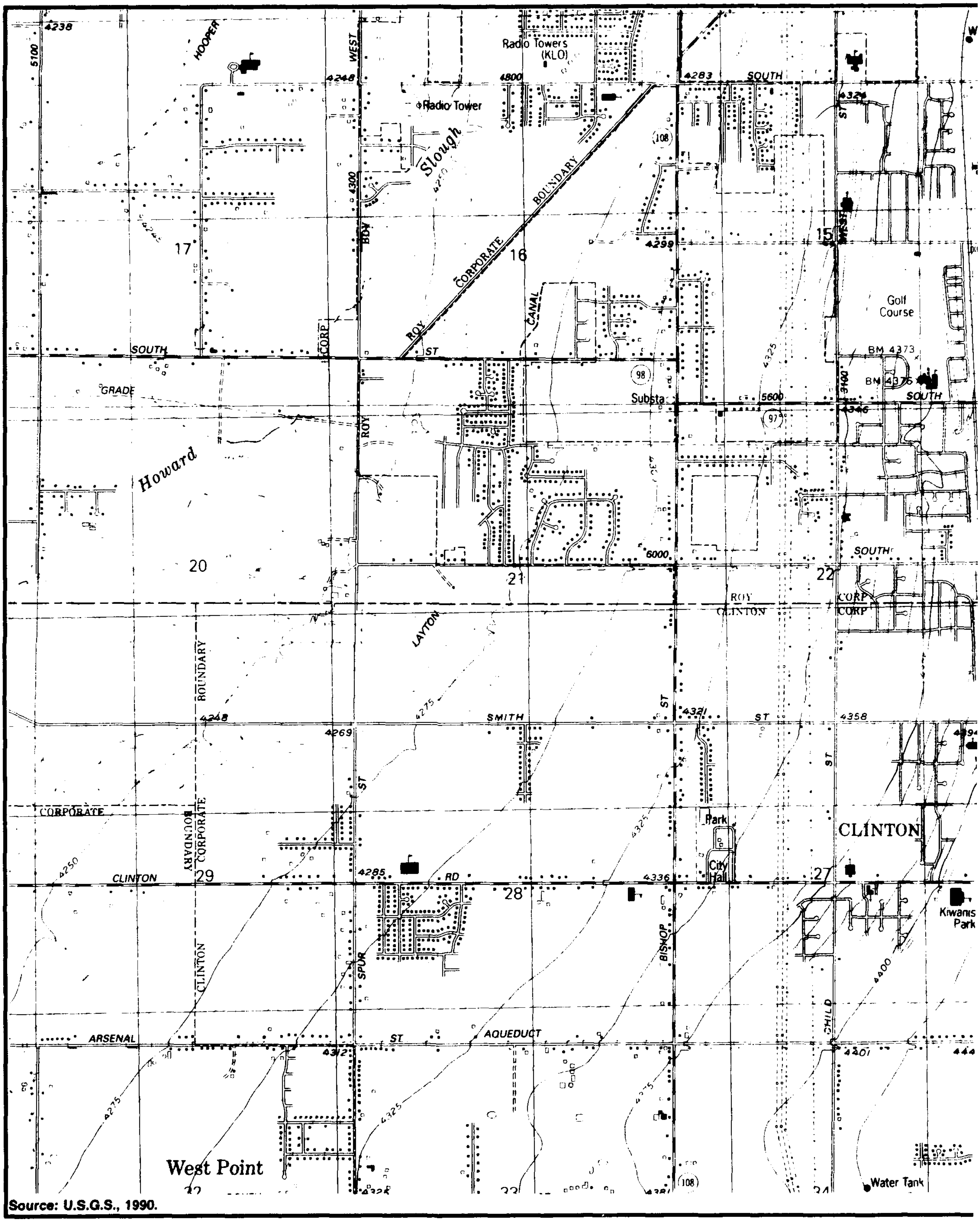
3.2.3 Surface Hydrology

Precipitation at Hill AFB generally infiltrates through coarse-grained, near-surface sediments to shallow perched water tables. Surface waters may locally flow in small erosional gullies during storm events. The Weber River flows toward the northwest near the northeastern portion of the Base. To the west of the Tooele Rail Shop, groundwater locally discharges to seeps and springs in the cities of Sunset and Clinton. In the Tooele Rail Shop Area, surface stormwater flows to drain lines that service the train steam cleaning and maintenance areas, and that run northward, parallel to the rail lines and the Davis-Weber Canal (Section 1.2, Figure 1.3). In the cities of Sunset and Clinton, stormwater flows to field drains and city stormwater collection systems (Figure 2.2). The Davis-Weber Canal, a privately-owned canal used to supply irrigation water, runs adjacent (west) to the Tooele Shop Area.

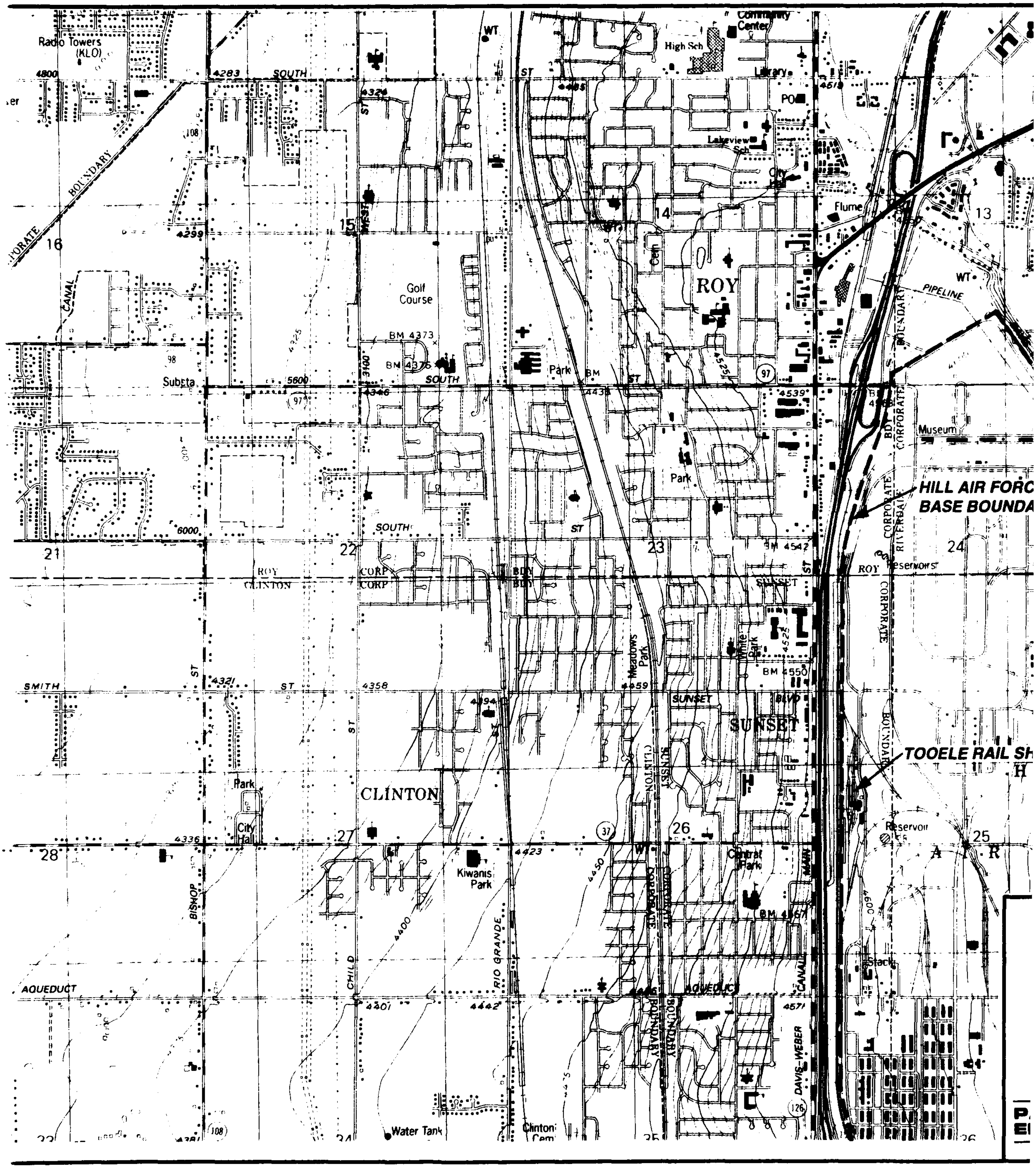
3.3 REGIONAL GEOLOGY AND HYDROGEOLOGY

3.3.1 Regional Geology

The geologic formations exposed at the surface in the vicinity of Hill AFB vary from Precambrian-age crystalline bedrock at the western margin of the Wasatch Mountain Range to Pleistocene unconsolidated deposits forming benches, plateaus, and lowlands west of the Wasatch Front (Figures 3.2 and 3.3). The plateau upon which Hill AFB is located is an erosional remnant of a fan-delta complex that formed as sediments were transported from the Wasatch front into Pleistocene Lake Bonneville. Cross-section X - X' (Figure 3.4, located on Figure 3.3) illustrates the aquifers and confining units comprising the plateau and underlying formations. Coarse-grained fan-delta deposits of the Provo stage of Lake Bonneville are present within the boundaries of the Base. The fan-delta has been dissected along the northeastern perimeter of the Base by the Weber River, creating a steep terrace. Silts, sands, and clays of the Alpine stage of Lake Bonneville underlie the Provo deposits across much of the Base and are exposed on the steep hillsides northeast of the Base and on the hilltops in the eastern portion of the Base. Although older, some of the Alpine-stage sediments were deposited at higher altitudes than Provo-stage sediments because the lake level was higher during Alpine times.



Source: U.S.G.S., 1990.


HILL AIR FORC
BASE BOUNDA
TOOELE RAIL SH
Radio Towers (KLO)
Community Center
High Sch
Library
PO
Lakeview Sch
City Hall
Flume
ROY
Golf Course
Park
Museum
Reservoirs
SUNSET
Meadows Park
White Park
CLINTON
City Hall
Kiwanis Park
Central Park
Reservoir
Stack
Water Tank
Clinton Cem
CORPORATE BOUNDARY
CANAL
PIPELINE
5600 SOUTH ST
6000 SOUTH ST
4000 SOUTH ST
SMITH ST
SUNSET BLVD
AQUEDUCT
BISHOP ST
CHILD ST
RIO GRANDE
DAVIS-WEBER CANAL
MAIN ST
3100 WEST ST
ROY CORP BDY
CLINTON CORP BDY
RIVERDALE CORPORATE BOUNDARY
BM 4373
BM 4376
BM 4542
BM 4550
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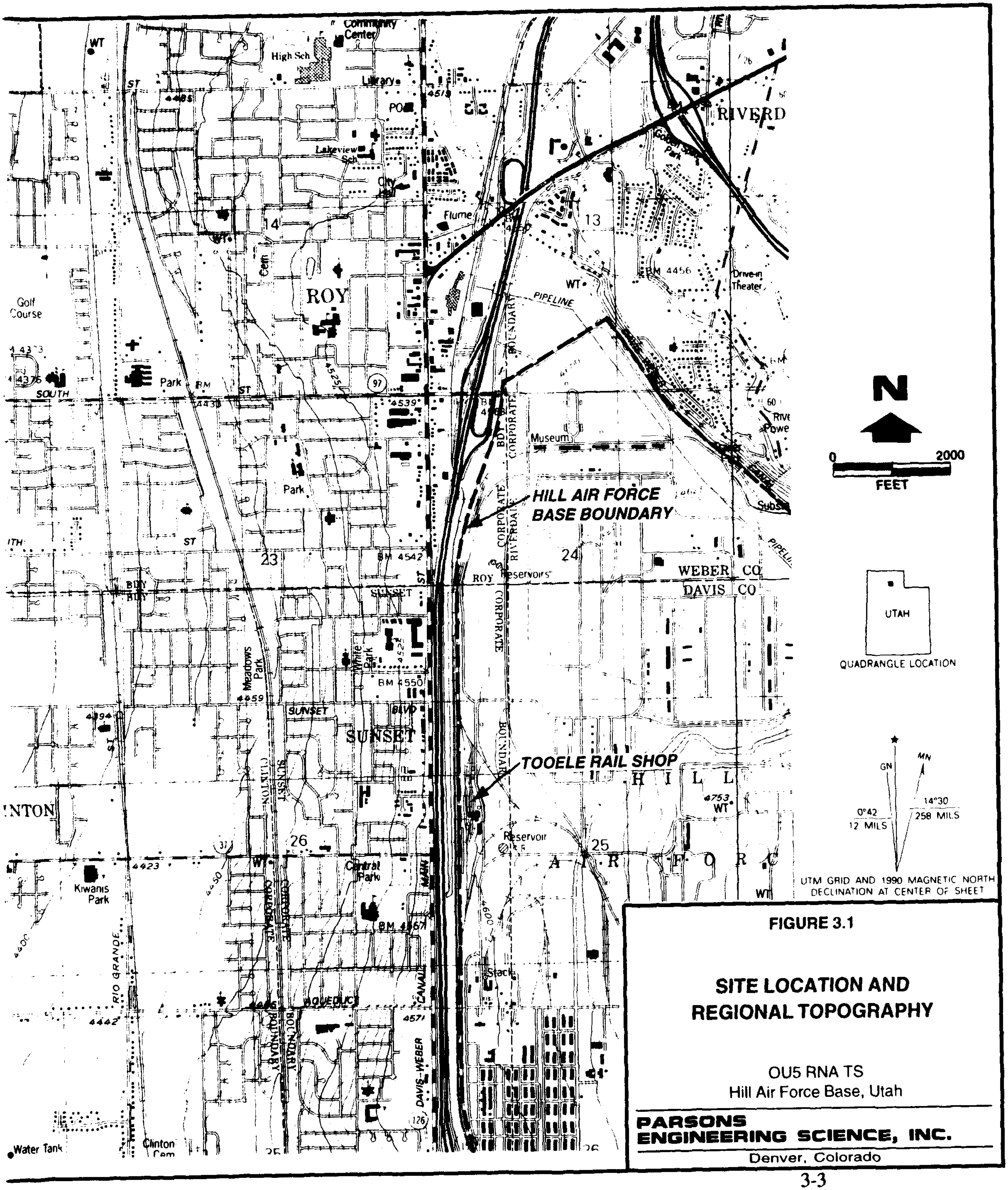


FIGURE 3.1

SITE LOCATION AND REGIONAL TOPOGRAPHY

OU5 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Symbol	System	Series	Formation and Lithology	Thickness in Feet
Qa	Quaternary	Recent	Alluvium: Permeable river sand and gravel; includes mudflow deposits near mountains which are impermeable locally.	200
Qg			Gravel: Permeable floodplain sand and gravel.	
Qs			Sand: Permeable fine sands underlying lowlands.	10-20
Qc			Clay: Impermeable plastic to non-plastic clay overlaying artesian aquifer.	35+
UNCONFORMITY				
	Quaternary	Pleistocene	(Lake Bonneville Group): Provo Formation:	
Qpg			gravel, permeable;	5-20
Qpgs			gravel and sand, permeable;	10-50
Qps			sand, permeable	10-20
Qba			Bonneville and Alpine Formation: sand and gravel over bedrock, very permeable	5-50
			Alpine Formation:	
Qag			gravel, permeable;	<25
Qas			sand, permeable;	100
Qac			clay silt, fine sand, usually impermeable;	200
Q			Unconsolidated basin-fill deposits	>1000
UNCONFORMITY				
Cl	Cambrian	Middle to Late (?)	Limestone: Silty with interbedded shale and dolomite. Permeable.	1375(±)
Ct		Lower to Middle (?)	Tintic Quartzite: massive, cross-bedded, pebbly. Permeable where fractured.	500-700
ANGULAR UNCONFORMITY				
Pcf		Precambrian	Farmington Canyon Complex: metasedimentary and metavolcanic rocks. Permeable where jointed or fractured.	10,000

SOURCE: Modified from Feth et al. (1966)

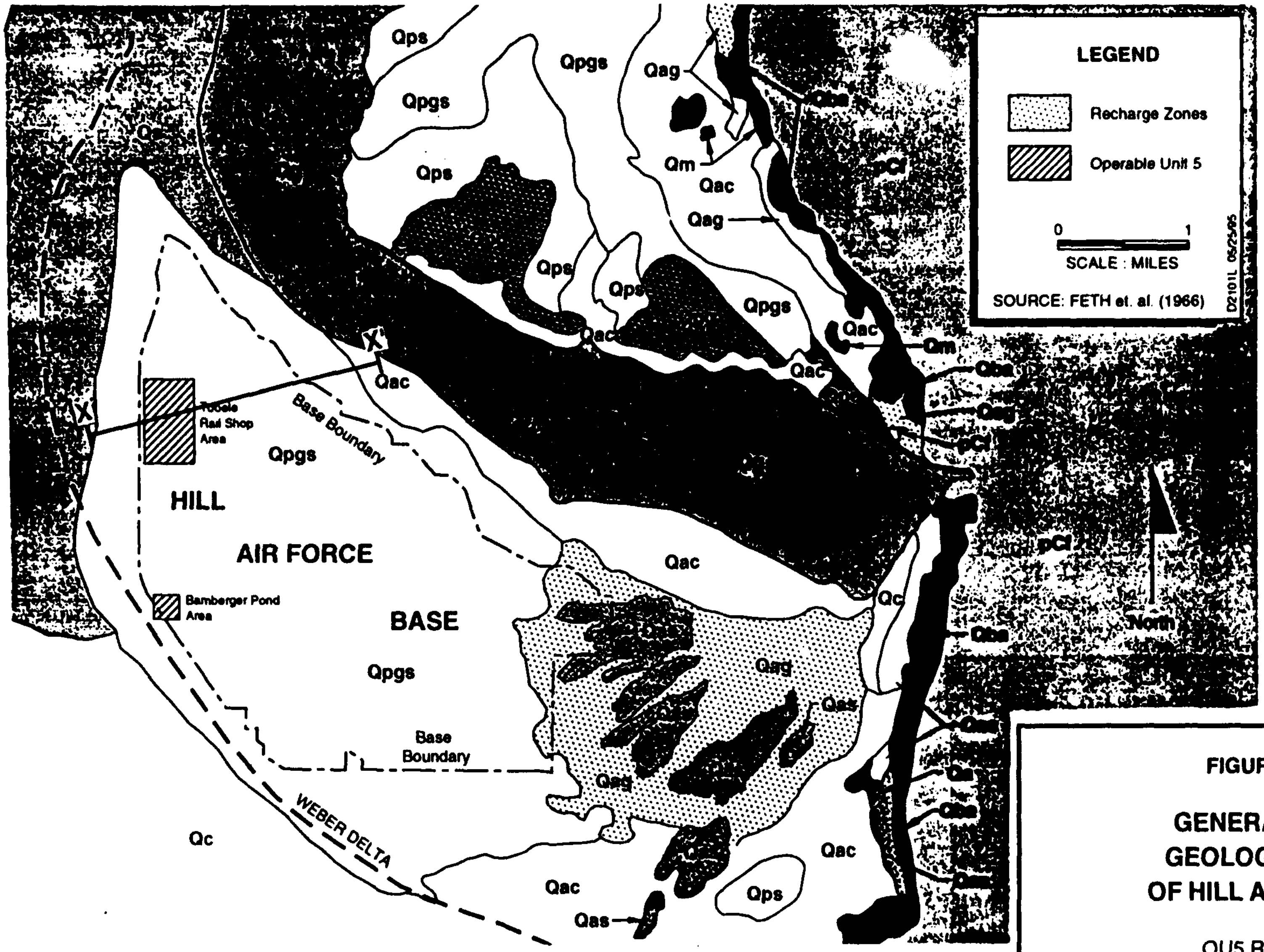
Source: Radian, 1995.

FIGURE 3.2

GENERALIZED STRATIGRAPHY OF THE HILL AFB AREA

OU5 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado



Note: X ⊢—⊣ X' = Location of Cross-Section

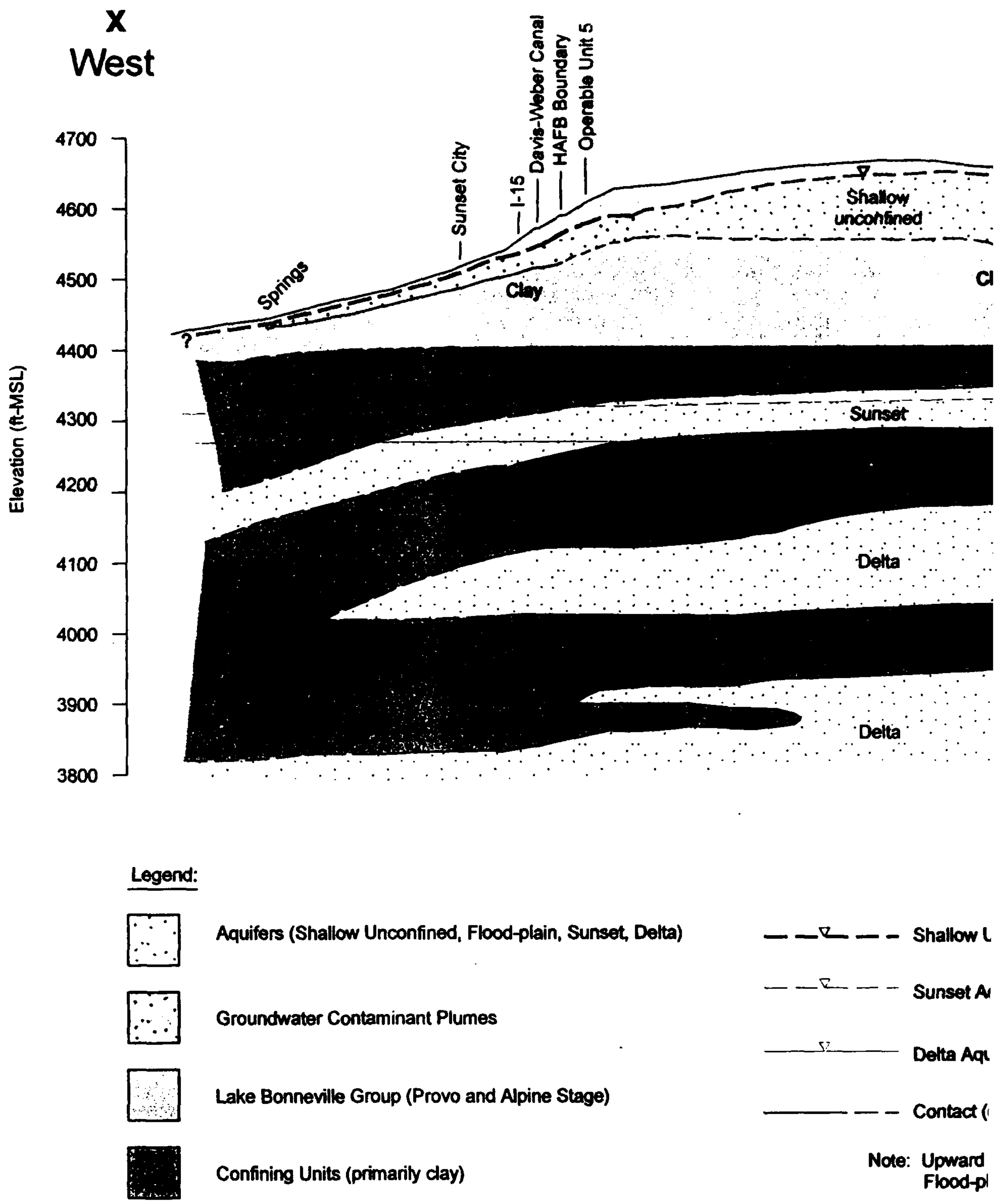
Sou lian, 1995.

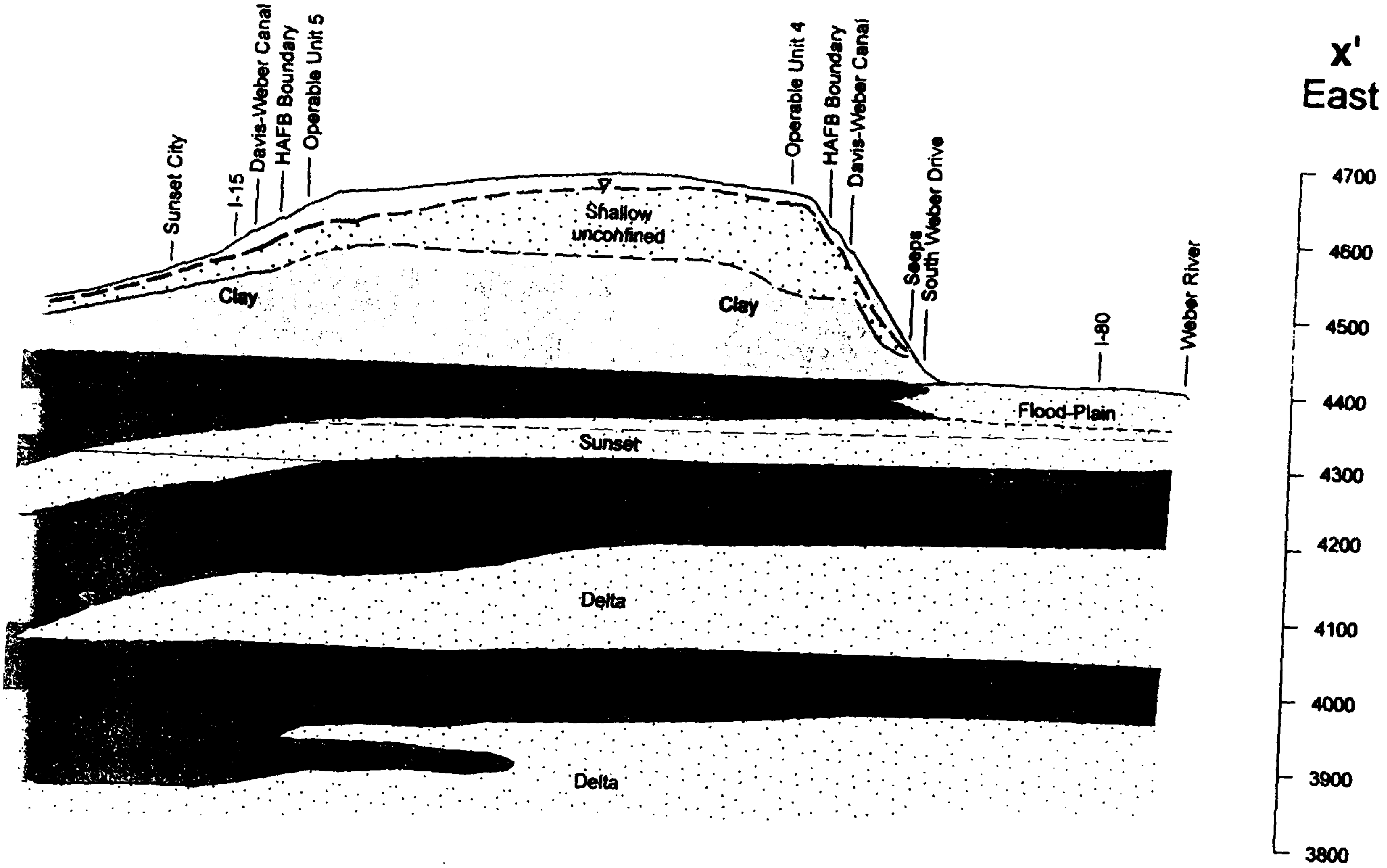
FIGURE 3.3

GENERALIZED GEOLOGIC MAP OF HILL AFB AREA

OU5 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado


X
West
Sunset City
I-15
Davis-Weber Canal
HAFB Boundary
Operable Unit 5
Springs
?
Clay
Shallow unconfined
Cl
Sunset
Delta
Delta
Elevation (ft-MSL)
4700
4600
4500
4400
4300
4200
4100
4000
3900
3800
Legend:
Aquifers (Shallow Unconfined, Flood-plain, Sunset, Delta)
Groundwater Contaminant Plumes
Lake Bonneville Group (Provo and Alpine Stage)
Confining Units (primarily clay)
Shallow U
Sunset A
Delta Aqu
Contact (
Note: Upward
Flood-pl



ow Unconfined, Flood-plain, Sunset, Delta)

ontaminant Plumes

e Group (Provo and Alpine Stage)

s (primarily clay)

— —▽— — — Shallow Unconfined Aquifer static water level

— —▽— — — Sunset Aquifer potentiometric surface (JMM, 1989)

———▽——— Delta Aquifer potentiometric surface - 1985 (Clark and others, 1990)

——— — — Contact (dashed where inferred)

Note: Upward hydralic gradients are present in the Flood-plain Aquifer at OU4 (USGS, 1992)

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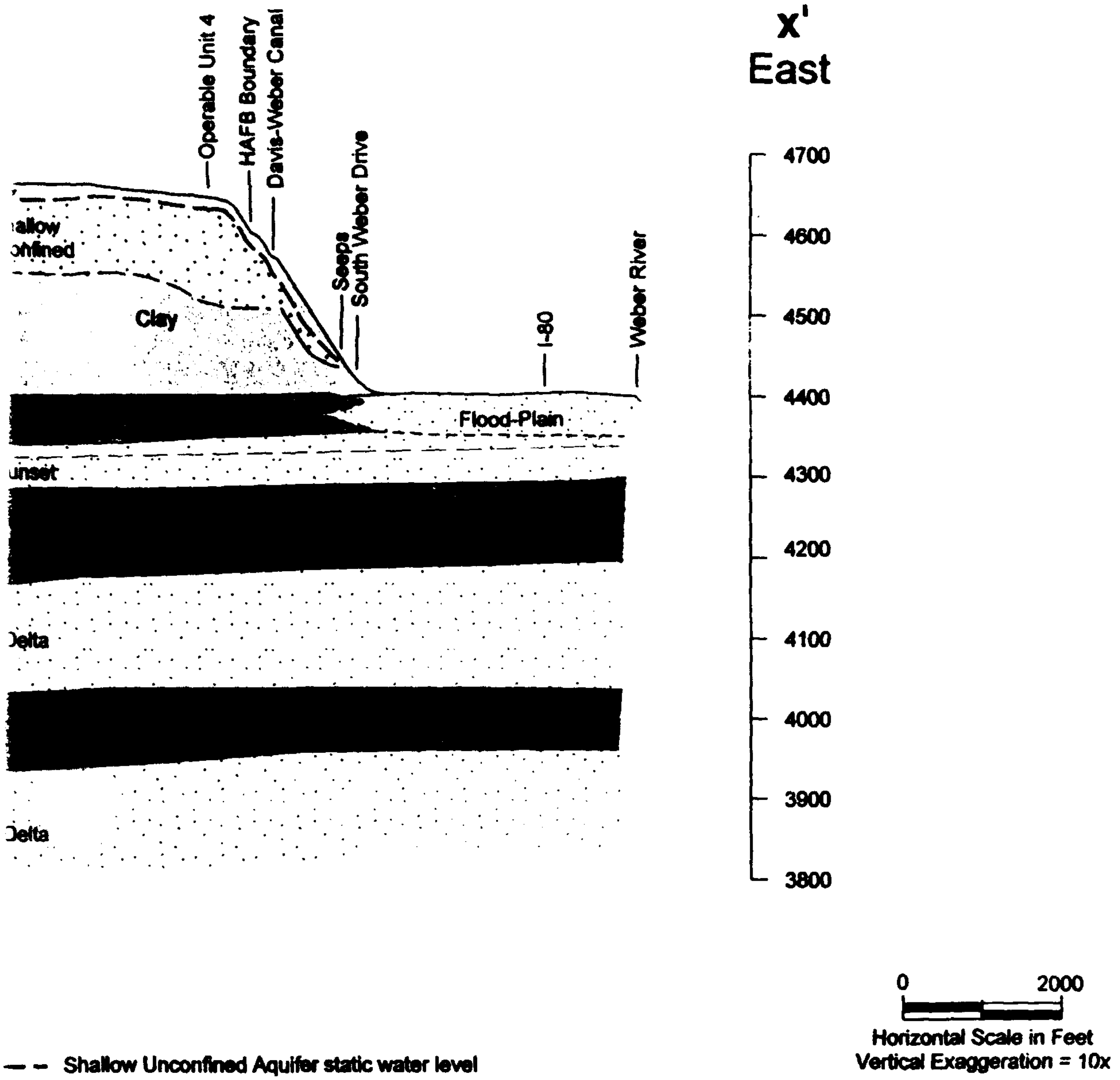


— - Shallow Unconfined Aquifer static water level

- - Sunset Aquifer potentiometric surface (JMM, 1989)

— Delta Aquifer potentiometric surface - 1985 (Clark and others, 1990)

— — Contact (dashed where inferred)

Note: Upward hydralic gradients are present in the
Flood-plain Aquifer at OU4 (USGS, 1992)

FIGURE 3.4

HYDROSTRATIGRAPHIC
CROSS-SECTION X-X'

OU5 RNA TS
Hill Air Force Base, Utah

**PARSONS
ENGINEERING SCIENCE, INC.**
Denver, Colorado

In addition to the formations exposed at the surface, 2,000 to 3,000 feet of pre-Lake Bonneville sediments are present in a north/south-trending graben underlying the area of Hill AFB (Feth *et al.*, 1966). This basin fill consists of thick sequences of interbedded coarse alluvium and lacustrine clays. The coarse alluvial units are successively older (and deeper) lobes and layers of the fan-delta complex, and they function as artesian aquifers.

3.3.2 Regional Hydrogeology

Shallow (surficial) aquifers are present in unconsolidated deposits. In addition, localized perched aquifers occur in shallower deposits at various locations on and around Hill AFB. In the upper part of the delta, the interaction of Lake Bonneville and the delta resulted in a complex system of interfingering lenticular strata where the more coarse grained units likely act as preferential pathways for groundwater flow. Shallow groundwater zones are constrained vertically with depth by the fine-grained units within the Lake Bonneville Group deposits; with the base of the shallow groundwater system (shallow unconfined aquifer) defined by an irregular contact with low-permeability clay (Figure 3.4).

In the OU5 area, flow in the surficial aquifer is generally to the west and northwest. Elsewhere on the Base, local groundwater flow in the surficial aquifers may be locally controlled by topography or other features. Two aquifers in deeper unconsolidated deposits supply water to area communities. The Sunset aquifer is found primarily beneath the City of Sunset and the western portion of the Base (Figure 3.4). This aquifer is approximately 250 to 400 feet below ground surface (bgs). The aquifer most commonly used for water supply is the Delta Aquifer, which is approximately 500 to 700 feet bgs. The regional hydraulic gradient in the deeper aquifers is also to the west-northwest. The potentiometric surfaces in the deep aquifers beneath the Base are relatively flat. However, because of high pumpage, local perturbations of the potentiometric surfaces are evident, and the potentiometric surfaces have been lowered substantially.

Regionally, vertical components of groundwater flow are generally downward in recharge areas near the mountain front and upward in discharge areas to the west of the Base and near the Great Salt Lake, except in areas affected by groundwater pumping. Beneath the Base, gradients are generally downward between the surficial aquifer and the deeper aquifers. However, the downward migration of groundwater through the confining units between the aquifers depends on the degree of hydraulic connection between the aquifers, which in turn depends on the thickness and hydraulic properties of the clay layers separating the aquifers. Drillers' logs indicate that the confining units in the area of the Base are primarily tight blue-gray clay. The clays appear to limit the amount of recharge and vertical leakage that directly reaches the deep aquifers beneath the Base. The deep aquifer system becomes less confined and undifferentiated near the mountain front and the mouth of Weber Canyon. The unconfined extension of the deep aquifer system is the main source of recharge to those units. Recharge to the deeper aquifers primarily occurs near the mountain front by direct infiltration into the more permeable Lake Bonneville deposits and by seepage losses from the Weber River near the mountain front.

High-yield production wells at Hill AFB are screened in one or both coarse-grained water-bearing units of the Delta Aquifer starting at about the 4,200-foot-msl elevation. City well logs to the west and south of Hill AFB indicate that the upper water-bearing unit or lobe of the Delta Aquifer fan complex thins and eventually terminates in these directions. Therefore, this upper lobe is unique to the Hill AFB area. The lower water-bearing unit of the Delta Aquifer is tapped elsewhere outside of the Base. The shallower, lower yield Sunset Aquifer is more differentiated from the Delta Aquifer in the areas west and southwest of the Base, and is used for water supply in these areas, though less frequently than the Delta Aquifer.

3.4 OU5 GEOLOGY AND HYDROGEOLOGY

The geologic and hydrogeologic features of the Tooele Rail Shop and nearby, hydraulically downgradient areas have been defined during previous investigations by a combination of auger drilling and continuous logging at a total of 82 locations on-Base and 34 locations in Sunset and Clinton, and CPT at 106 locations on-Base and 54 locations off-Base. Additional Geoprobe® installation of 10 monitoring points was conducted during this RNA investigation. Many of these locations, especially those relevant to this RNA TS, are shown on Figure 3.5. Depth to groundwater and groundwater flow directions and rates have been defined from the collection of water-level measurements in monitoring wells and points, slug testing in selected monitoring wells, and the performance of pore-fluid dissipation tests at CPT locations.

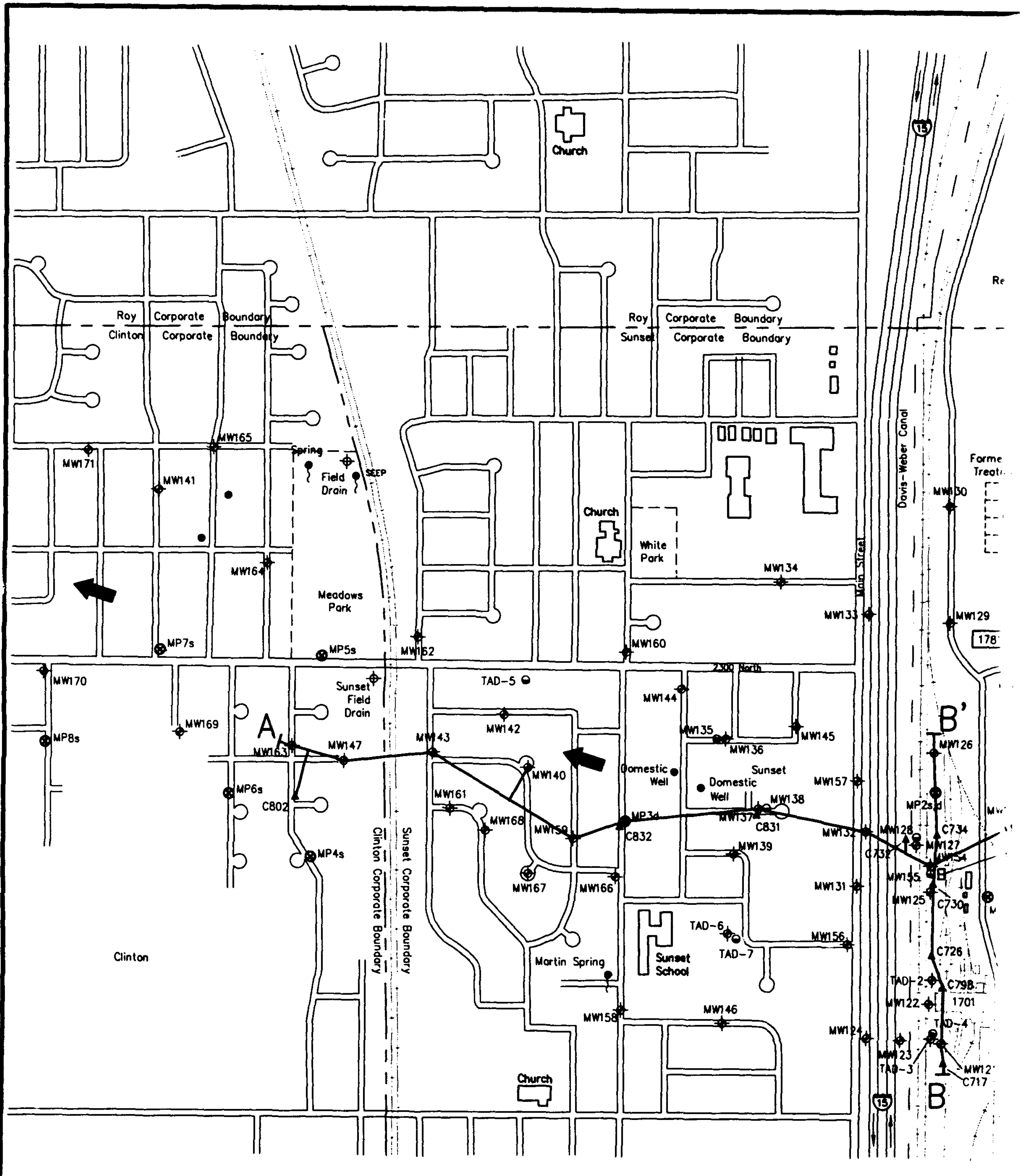
3.4.1 Site Geology

The locations of two site hydrostratigraphic cross sections are shown in Figure 3.5, and cross-sections A-A' and B-B' are presented in Figures 3.6 and 3.7, respectively. These cross-sections depict the surface topography, hydrostratigraphic units, and the estimated groundwater surface along the section lines. The hydrostratigraphic cross-sections were compiled primarily from results of previous investigations, supplemented with data collected during the RNA field program.

The subsurface features in the vicinity of the Rail Shop and downgradient areas are consistent with the regional setting of the Provo Formation fluvial-deltaic deposits of interbedded clay, silt, sand, and gravel. In general, deposits in the rail shop area show a fining-downward trend. These deposits have been grouped into three main geologic units present in the following descending order (Radian, 1995):

- Surficial gravelly sand grading to silty fine sand;
- Interbedded fine sand, silt, and clayey silt and sand; and
- Silty clay to clay.

The silty sand is the principal sediment making up the shallow aquifer underlying the site, and consists of yellow-brown, fine- to medium-grained sand, occasionally



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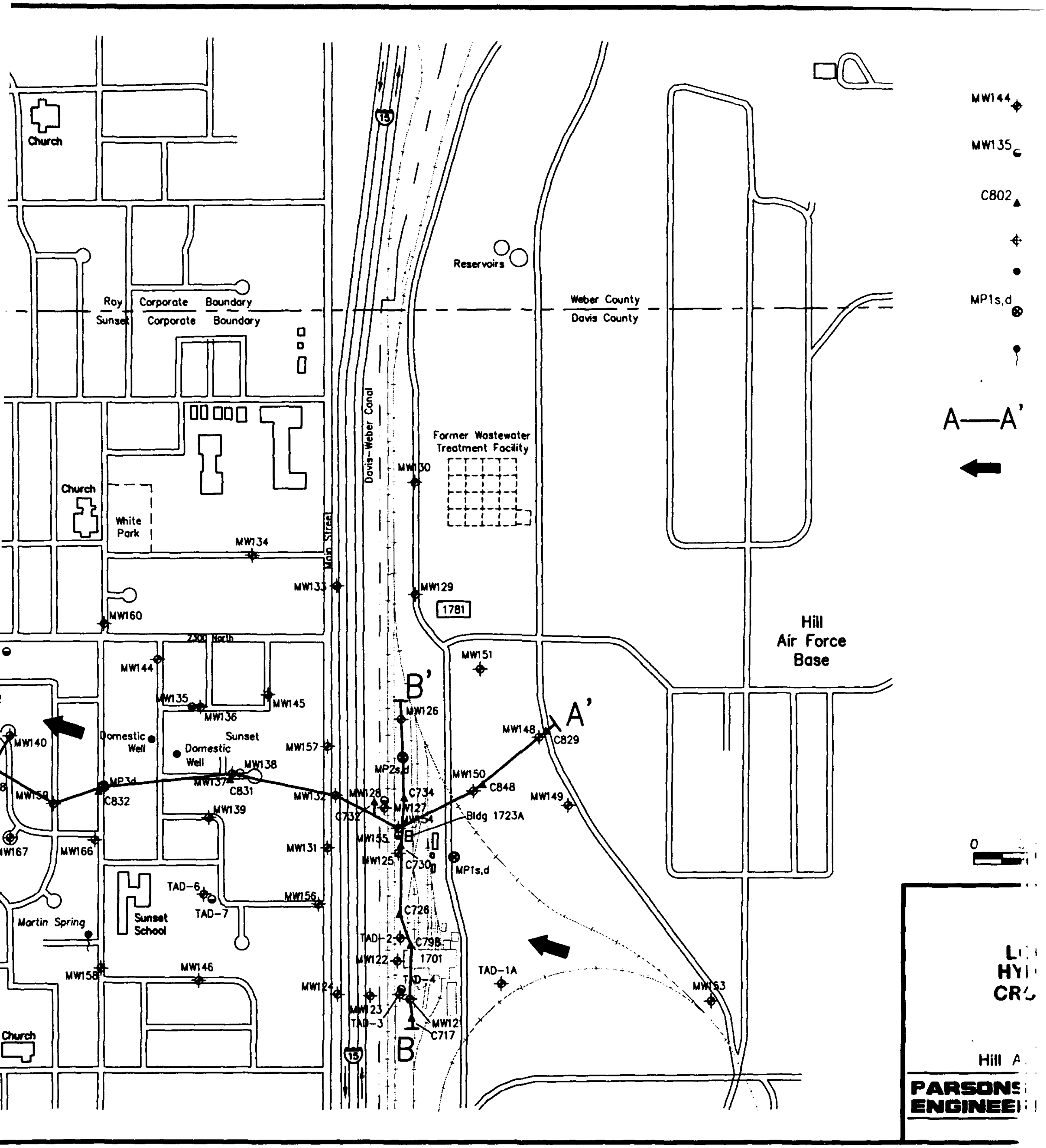

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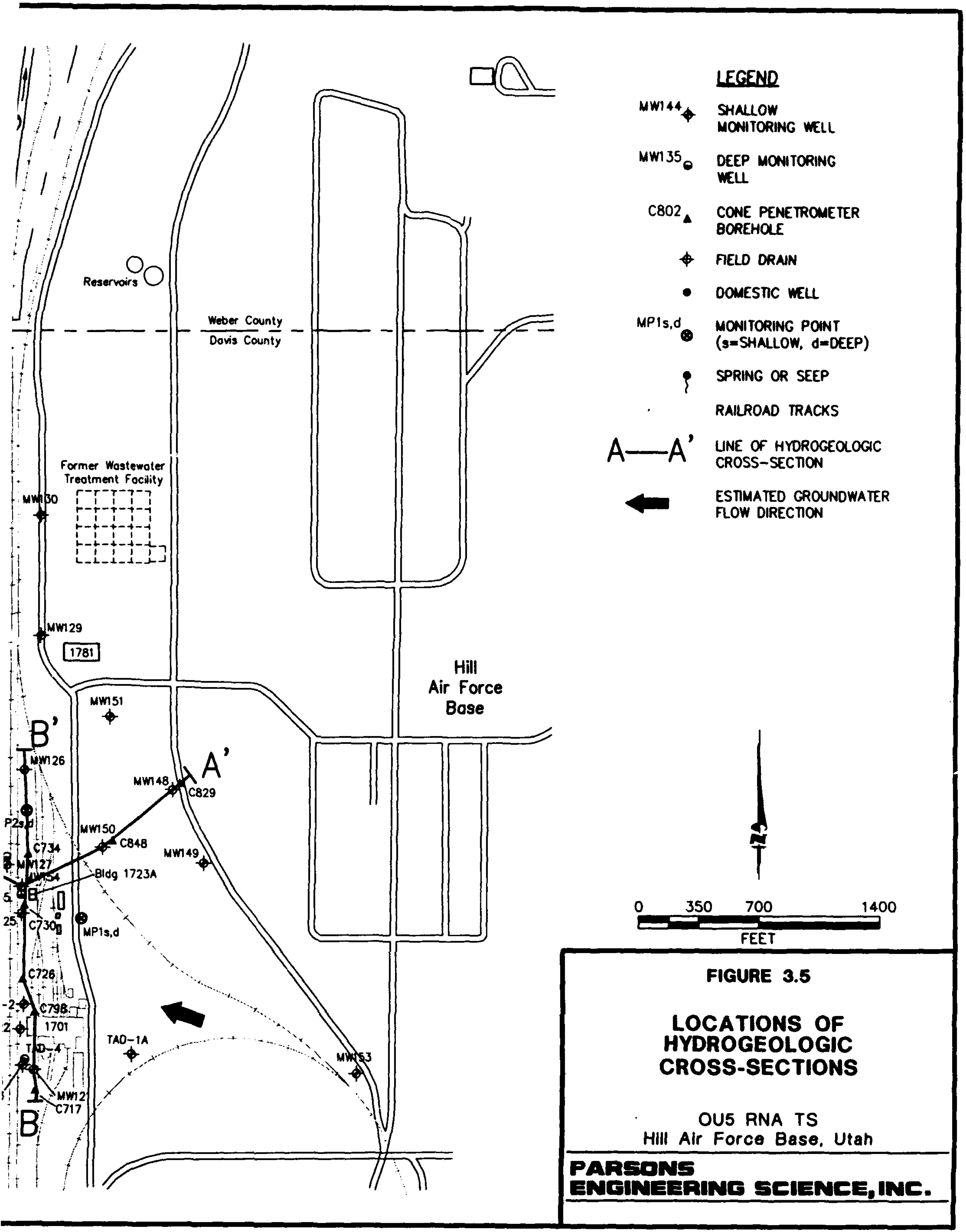
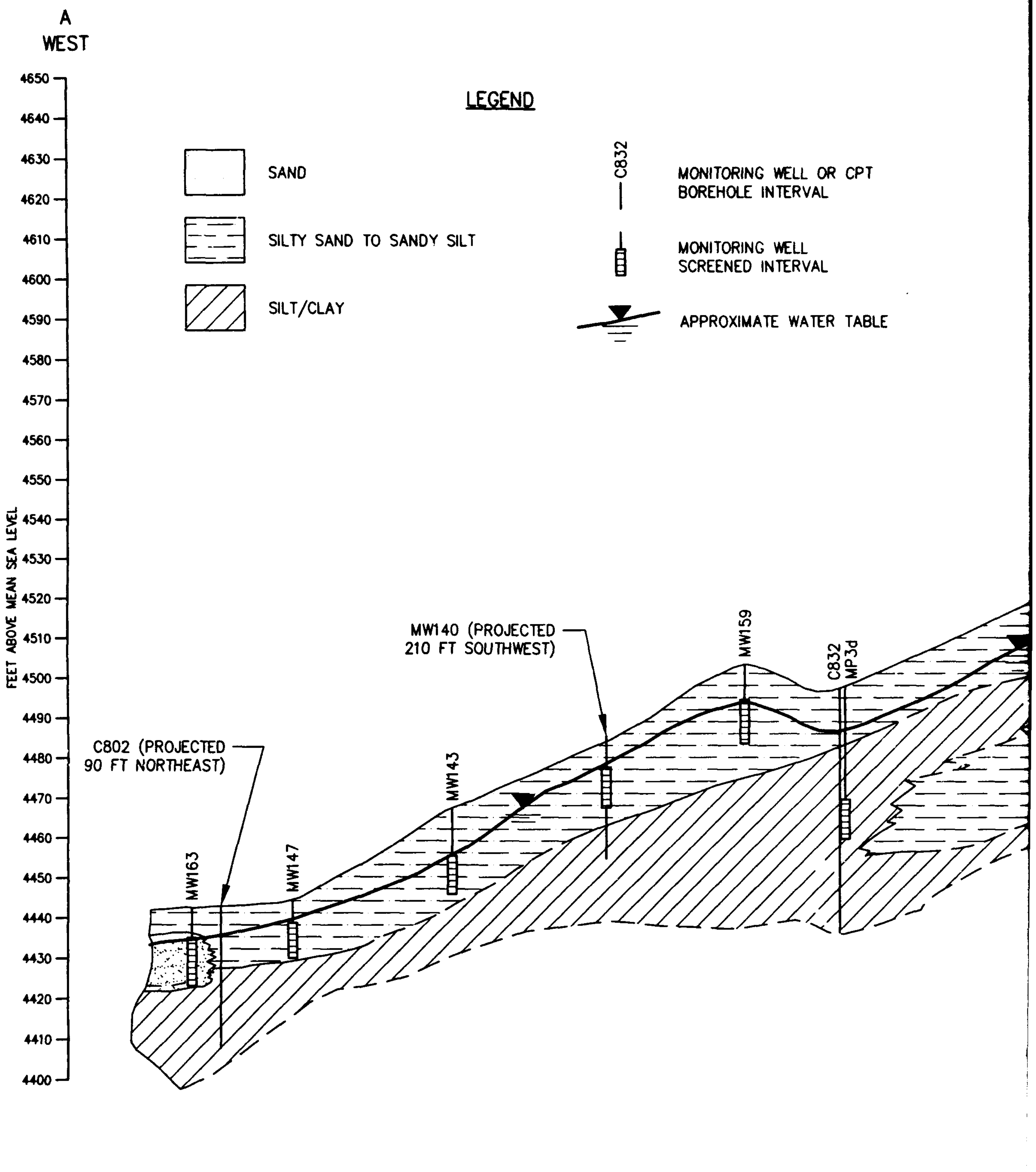


FIGURE 3.5

LOCATIONS OF HYDROGEOLOGIC CROSS-SECTIONS

OU5 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.



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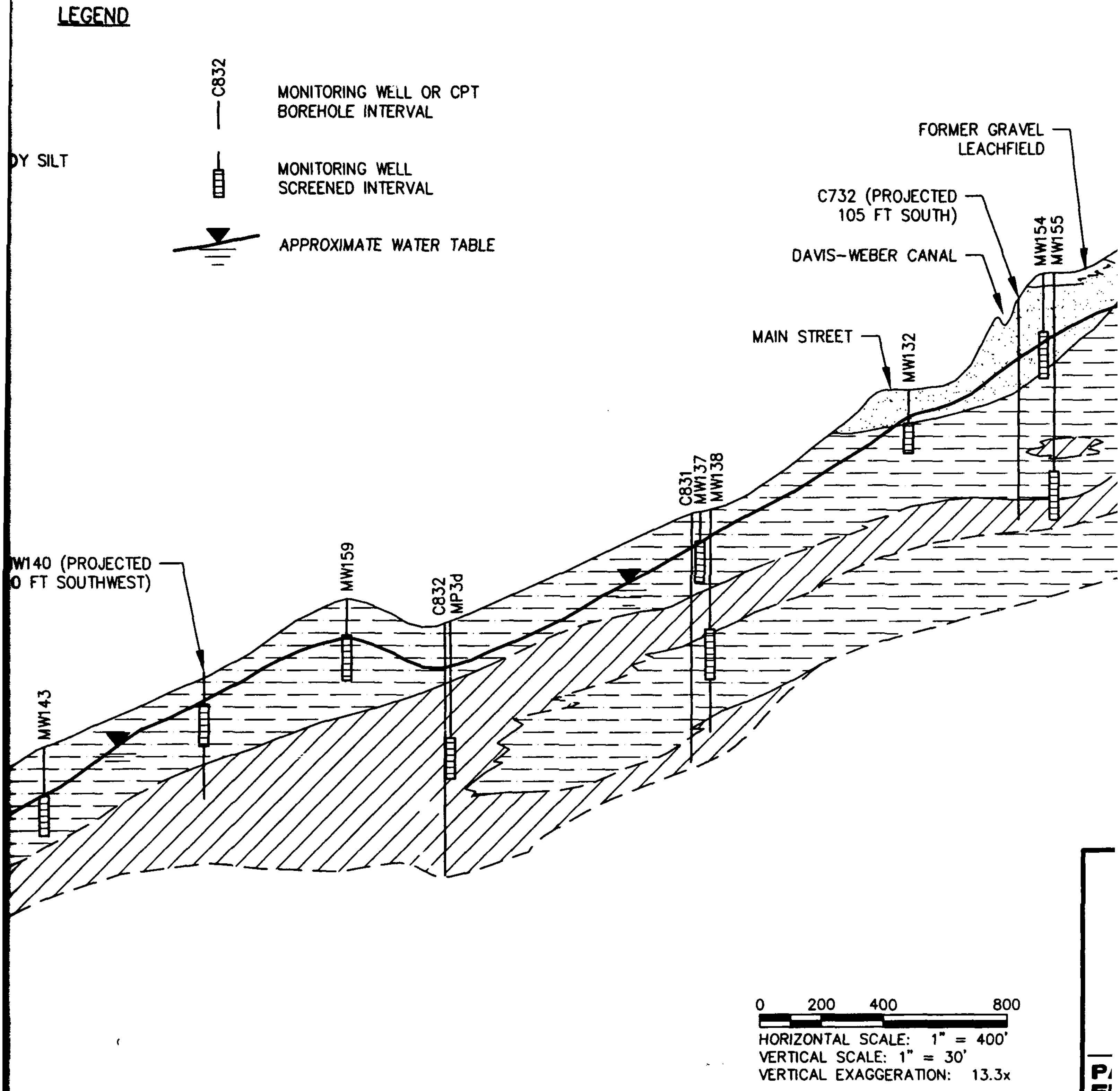
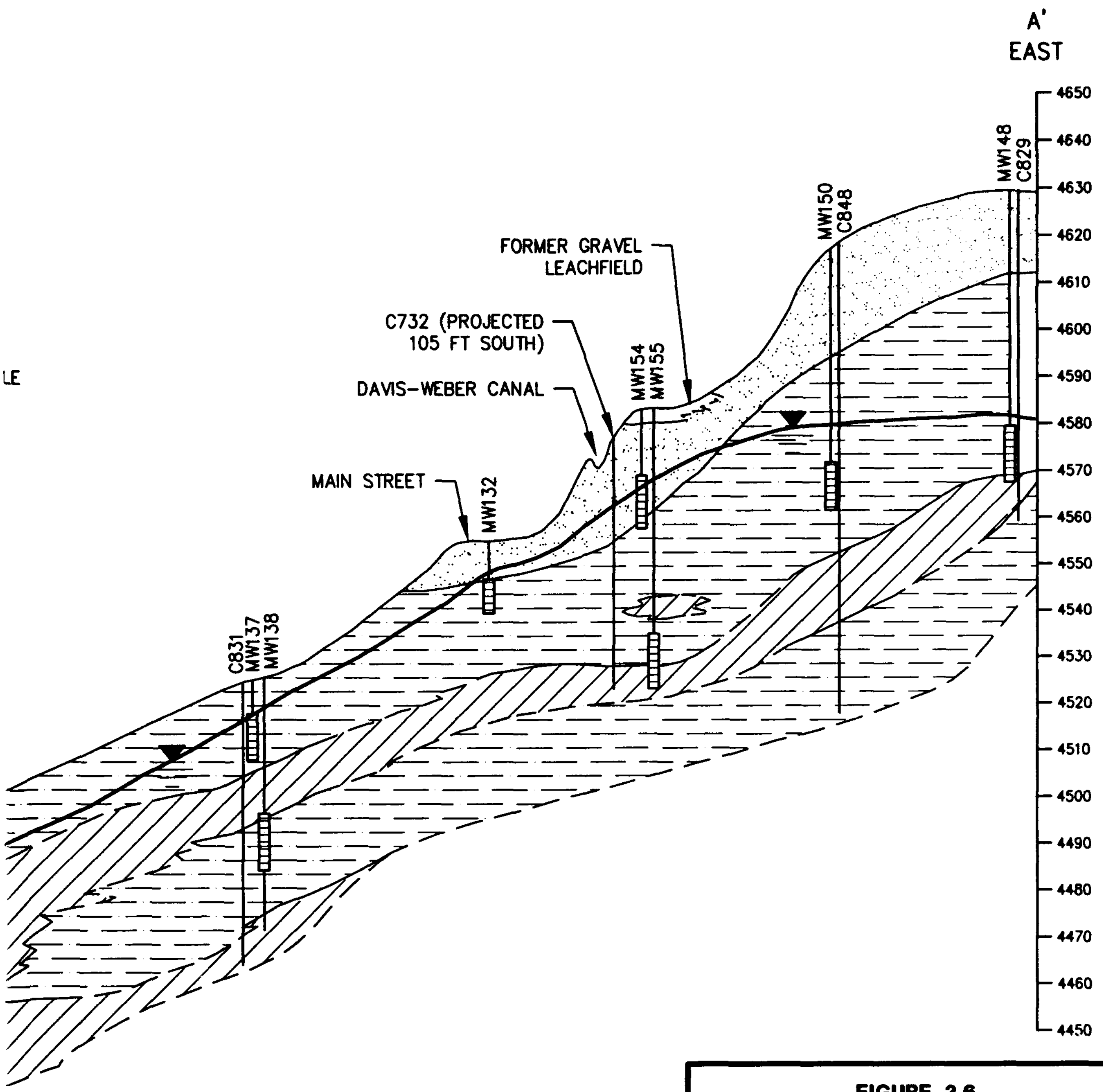

LEGEND
C832
MONITORING WELL OR CPT BOREHOLE INTERVAL
MONITORING WELL SCREENED INTERVAL
APPROXIMATE WATER TABLE
DY SILT
FORMER GRAVEL LEACHFIELD
C732 (PROJECTED 105 FT SOUTH)
MW154
MW155
DAVIS-WEBER CANAL
MAIN STREET
MW132
C831
MW137
MW138
W140 (PROJECTED
0 FT SOUTHWEST)
MW159
C832
MP3d
MW143
0
200
400
800
HORIZONTAL SCALE: 1" = 400'
VERTICAL SCALE: 1" = 30'
VERTICAL EXAGGERATION: 13.3x



HORIZONTAL SCALE: 1" = 400'
VERTICAL SCALE: 1" = 30'
VERTICAL EXAGGERATION: 13.3x

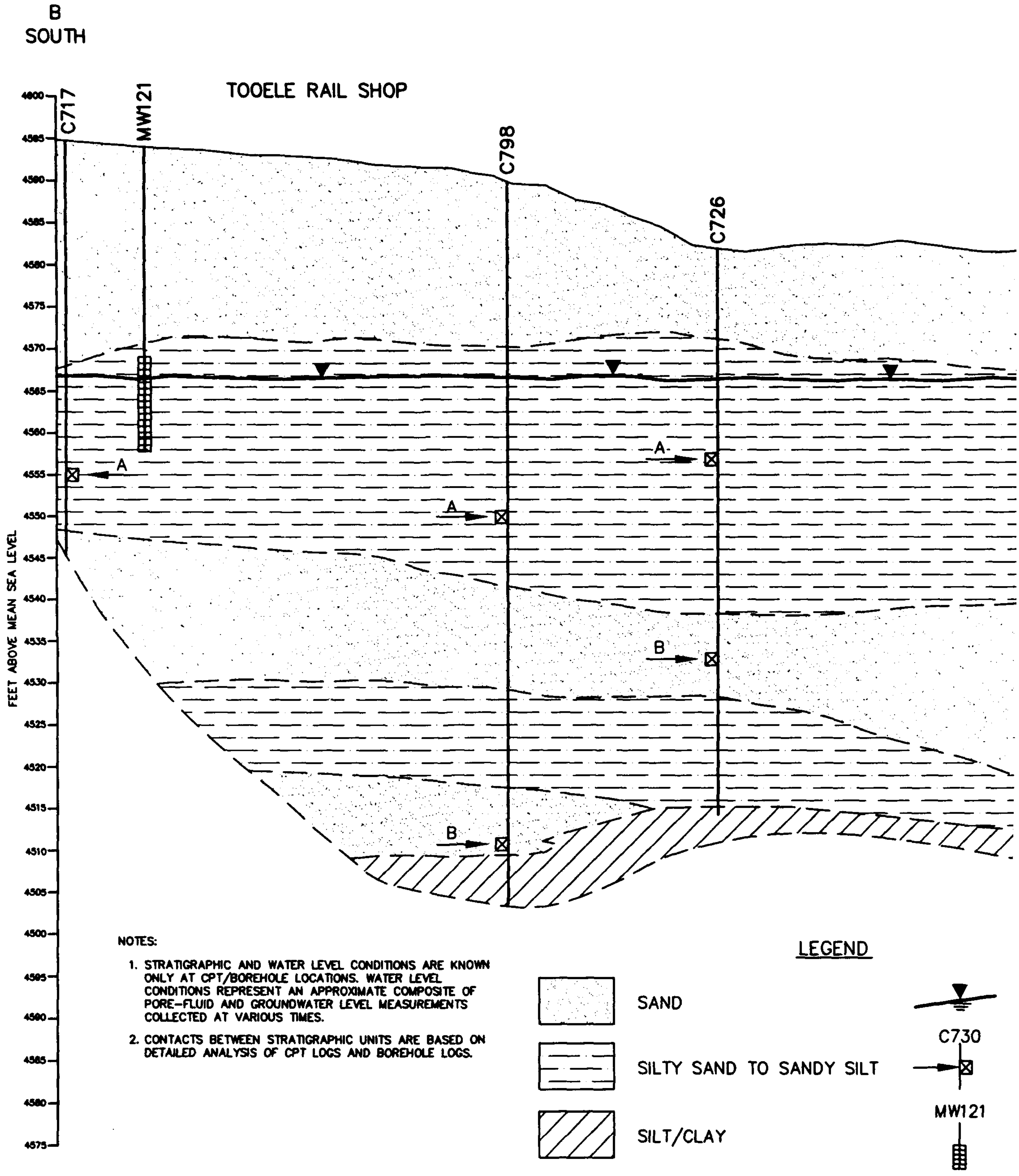
FIGURE 3.6

HYDROGEOLOGIC CROSS-SECTION A-A' AUGUST 1996

OU5 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado



NOTES:

1. STRATIGRAPHIC AND WATER LEVEL CONDITIONS ARE KNOWN ONLY AT CPT/BOREHOLE LOCATIONS. WATER LEVEL CONDITIONS REPRESENT AN APPROXIMATE COMPOSITE OF PORE-FLUID AND GROUNDWATER LEVEL MEASUREMENTS COLLECTED AT VARIOUS TIMES.
2. CONTACTS BETWEEN STRATIGRAPHIC UNITS ARE BASED ON DETAILED ANALYSIS OF CPT LOGS AND BOREHOLE LOGS.

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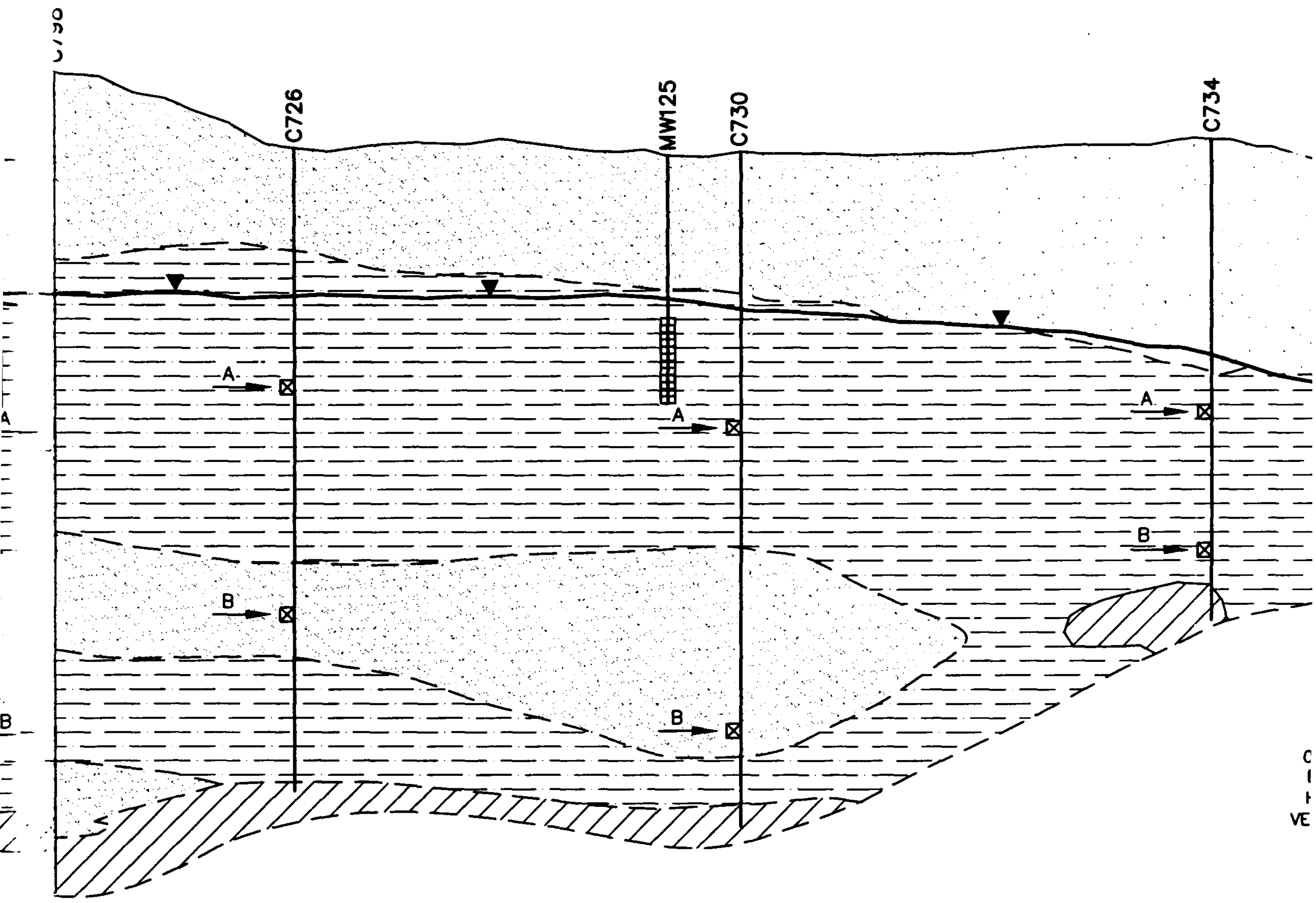


LEGEND

PR
E

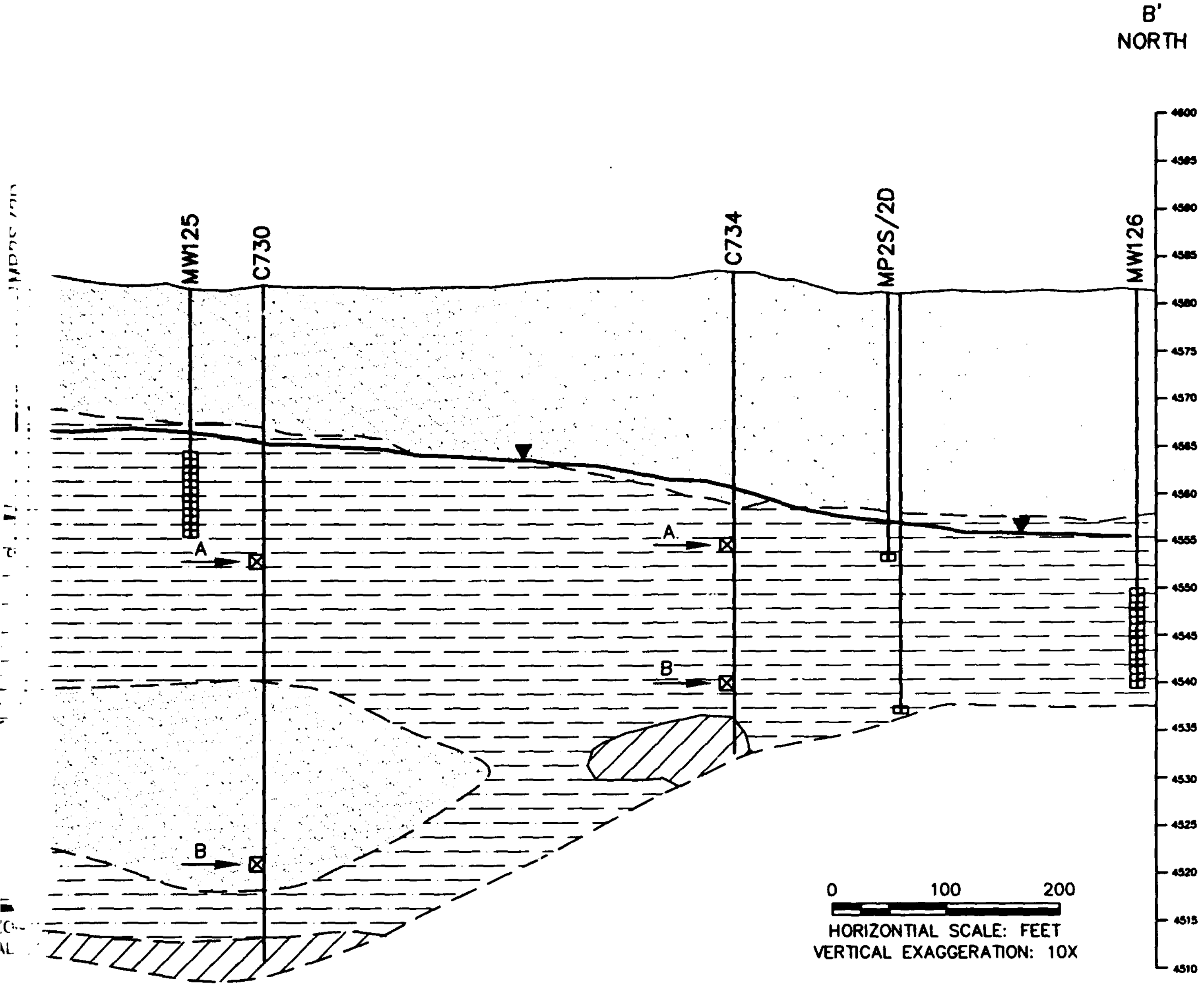
TU
MF

NI
RE

⬚	SAND
☰	SILTY SAND TO SANDY SILT
▨	SILT/CLAY
▼	APPROXIMATE WATER TABLE (SEE NOTE 1)
C730 ⊠	CPTU-EC/PORE-FLUID SAMPLE LOCATION
MW121 ▦	MONITORING WELL SCREENED INTERVAL

T

PAR
ENG



APPROXIMATE WATER TABLE (SEE NOTE 1)

C730

CPTU-EC/FORE-FLUID SAMPLE LOCATION

MW121

MONITORING WELL SCREENED INTERVAL

FIGURE 3.7

HYDROGEOLOGIC CROSS-SECTION B-B' TOOELE RAIL SHOP AREA

Hill Air Force Base, Utah

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Denver, Colorado

interbedded with alternating layers of coarser sand and fine gravel and thin seams of silt and clay. Underlying the sand and interbedded sand and silt deposits is a distinctive gray to dark-gray silty clay. Most of the boreholes and CPT soundings terminated at the top of this clay unit. Cross-section A-A' is oriented parallel to the general direction of groundwater flow, and shows the east/west section through and downgradient from the release point of the CAH plume. Cross-section B-B' provides a north/south view of the stratigraphy and water levels at the rail shop, perpendicular to the direction of groundwater flow at the site. Additional cross-sections are presented in the RI report (Radian, 1995).

The Rail Shop is underlain by fine sand extending to approximately 25 to 30 feet bgs, transitioning into interbedded silty sand and sandy silt, with some clay layers, near the water table (Figure 3.6). These interbedded strata continue to at least 60 to 80 feet bgs, and overlie a thin (5- to 20-foot thick) unit consisting of silty to sandy clay. This thin, semi-confining layer overlies a lower silty sand to sandy silt interval. As shown on cross-section A-A', the surface topography, subsurface strata, and water table dip to the west from the on-Base Rail Shop. The shallow sand and silt water-bearing zones thin, or pinch-out toward the west and are subtended by a thickening silt/clay layer. The stratigraphic data west of the Base show the near-surface fine sand unit grading into the silty sand/sandy silt unit, with relatively little indication of the fine sand unit that is observed beneath the Tooele Rail Shop area.

Cross-section B-B' (Figure 3.7) shows similar lithologic intervals in a south to north orientation across the Rail Shop area. Intermediate, semi-confining silty to sandy clay layers may not be continuous beneath the site, and may influence contaminant migration pathways.

3.4.2 Site Hydrogeology

Groundwater flow directions and rates are controlled by topography, surface water hydrology (recharge and discharge), and subsurface geology. Water table elevations for October 1993, March 1995, and August 1996 are shown in Table 3.1, and the water table in the shallow water-bearing zone in August 1996 is illustrated on Figure 3.8. Groundwater is 15 to 40 feet bgs in the Tooele Rail Shop area, and emerges at the surface in the form of seeps and springs in the cities of Sunset and Clinton west of the Base. Groundwater seeps and springs (Figure 3.8) occur downgradient at approximate elevations of 4,435 to 4,450 feet msl (Meadows Park) and also at an approximate elevation of 4490-4500 feet msl (Martin Spring). The presence of springs or seeps at downgradient locations may result from several factors such as structural contacts with clay units, topographic low spots, and upward hydraulic gradients in the lowland areas.

Groundwater flow is west to northwest on-Base and off-Base. The generally westward flow direction is the same as that in deeper, drinking water aquifers. Water levels measured in October 1993 and May/June 1994 indicated a flow direction consistent with that of Figure 3.8 (See Appendix A [Radian, 1995]). In August 1996, the depth to groundwater in the study area ranged from 58.66 feet bgs at MW130 to the ground surface at the Martin and Meadow Park Springs. The depth to groundwater in most of the off-Base plume area west of the Tooele Rail Shop is less than 12 feet.

TABLE 3.1
WATER LEVEL DATA
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Well Location	Datum Elevation (ft msl)[a/]	Depth to Water Oct-93 (ft btoc)[b/]	Elevation of Water Table Oct-93 (ft msl)	Depth to Water Mar-96 (ft btoc)	Elevation of Water Table Mar-96 (ft msl)	Depth to Water Aug-96 (ft btoc)	Elevation of Water Table Aug-96 (ft msl)
MP-1s	4592.06	NA[c/]	NA	NA	NA	16.60	4575.46
MP-1d	NA	NA	NA	NA	NA	NA	NA
MP-2s	NA	NA	NA	NA	NA	NA	NA
MP-2d	NA	NA	NA	NA	NA	NA	NA
MP-3d	4496.37	NA	NA	NA	NA	10.41	4485.96
MP-4s	4444.92	NA	NA	NA	NA	6.96	4437.96
MP-5s	4442.14	NA	NA	NA	NA	5.05	4437.09
MP-6s	4436.83	NA	NA	NA	NA	9.62	4427.21
MP-7s	4423.14	NA	NA	NA	NA	9.00	4414.14
MP-8s	4413.68	NA	NA	NA	NA	7.18	4406.50
MW-121	4594.66	29.13	4565.53	NM[d/]	NM	27.74	4566.92
MW-122	4585.66	24.47	4561.19	NM	NM	23.09	4562.57
MW-123	4573.27	18.34	4554.93	NM	NM	NM	NM
MW-124	4558.23	14.91	4543.32	NM	NM	14.22	4544.01
MW-125	4582.31	15.83	4566.48	NM	NM	14.58	4567.73
MW-126	4581.61	24.43	4557.18	NM	NM	24.62	4556.99
MW-127	4580.40	17.03	4563.37	16.23	4564.17	16.06	4564.34
MW-128	4580.27	18.02	4562.25	17.13	4563.14	16.83	4563.44
MW-129	4587.20	52.24	4534.96	52.41	4534.79	52.10	4535.10
MW-130	4585.39	58.77	4526.62	NM	NM	58.66	4526.73
MW-131	4556.11	4.02	4552.09	3.14	4552.97	NM	NM
MW-132	4554.45	5.19	4549.26	4.70	4549.75	NM	NM
MW-133	4551.49	28.64	4522.85	NM	NM	29.09	4522.40
MW-134	4529.00	16.13	4512.87	NM	NM	16.90	4512.10
MW-135	4516.40	8.07	4508.33	8.00	4508.40	8.02	4508.38
MW-136	4516.95	7.91	4509.04	7.70	4509.25	7.90	4509.05
MW-137	4524.22	6.15	4518.07	5.50	4518.72	6.34	4517.88
MW-138	4524.00	6.73	4517.27	6.58	4517.42	NM	NM
MW-139	4517.82	7.12	4510.70	NM	NM	7.01	4510.81
MW-140	4478.89	6.44	4472.45	5.87	4473.02	6.57	4472.32
MW-141	4418.91	7.73	4411.18	NM	NM	8.14	4410.77
MW-142	4476.18	11.73	4464.45	12.00	4464.18	12.07	4464.11
MW-143	4465.68	10.78	4454.90	10.42	4455.26	11.31	4454.37
MW-144	4505.61	9.67	4495.94	10.63	4494.98	10.81	4494.80
MW-145	4531.88	12.63	4519.25	NM	NM	11.65	4520.23

(Continued)

TABLE 3.1 (Concluded)
WATER LEVEL DATA
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

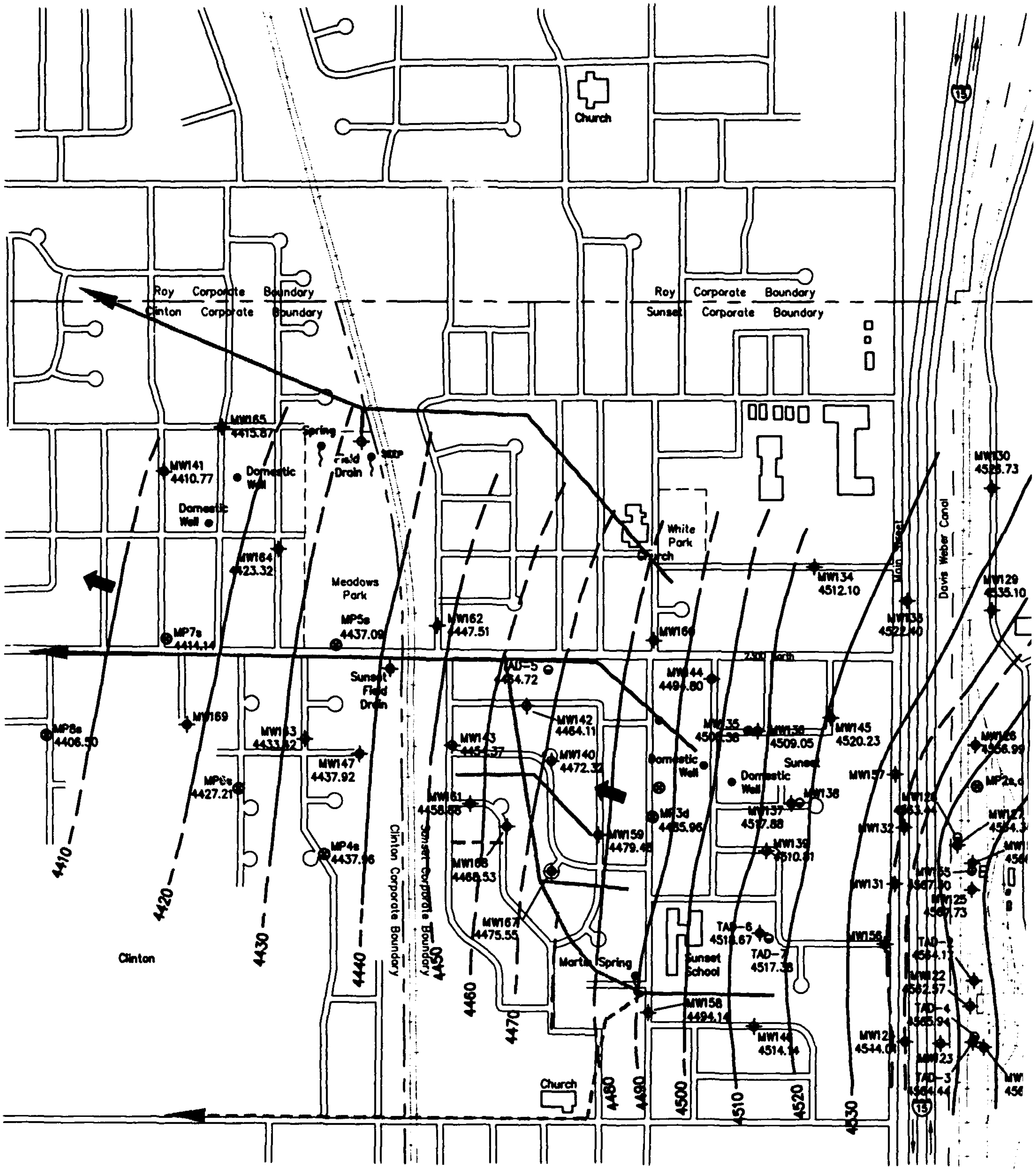
Well Location	Datum Elevation (ft msl)[a]	Depth to Water Oct-93 (ft btoc)[b]	Elevation of Water Table Oct-93 (ft msl)	Depth to Water Mar-96 (ft btoc)	Elevation of Water Table Mar-96 (ft msl)	Depth to Water Aug-96 (ft btoc)	Elevation of Water Table Aug-96 (ft msl)
MW-146	4517.71	3.41	4514.30	3.26	4514.45	3.57	4514.14
MW-147	4443.62	5.86	4437.76	NM	NM	5.70	4437.92
MW-148	4632.41	51.96	4580.45	NM	NM	50.95	4581.46
MW-149	4634.59	46.12	4588.47	NM	NM	43.69	4590.90
MW-150	4617.95	38.68	4579.27	NM	NM	38.32	4579.63
MW-151	4607.74	46.74	4561.00	NM	NM	46.48	4561.26
MW-152	4608.48	NA	NA	36.61	4571.87	NM	NM
MW-153	4642.51	NA	NA	24.48	4618.03	23.49	4619.02
MW-154	4582.44	NA	NA	15.82	4566.62	15.51	4566.93
MW-155	4582.44	NA	NA	15.63	4566.81	15.14	4567.30
MW-156	4552.25	NA	NA	9.41	4542.84	NM	NM
MW-157	4553.66	NA	NA	12.75	4540.91	NM	NM
MW-158	4502.02	NA	NA	6.34	4495.68	7.88	4494.14
MW-159	4487.63	NA	NA	7.47	4480.16	8.15	4479.48
MW-160	4494.63	NA	NA	11.90	4482.73	NM	NM
MW-161	4469.61	NA	NA	9.36	4460.25	10.73	4458.88
MW-162	4458.64	NA	NA	9.61	4449.03	11.13	4447.51
MW-163	4441.09	NA	NA	6.80	4434.29	7.67	4433.42
MW-164	4433.64	NA	NA	7.70	4425.94	10.32	4423.32
MW-165	4424.20	NA	NA	6.08	4418.12	8.33	4415.87
MW-166	4497.53	NA	NA	NM	NM	NM	NM
MW-167	4481.86	NA	NA	5.12	4476.74	6.31	4475.55
MW-168	4475.98	NA	NA	6.18	4469.80	7.45	4468.53
MW-169	4425.93	NA	NA	5.98	4419.95	NM	NM
MW-170	4413.33	NA	NA	NM	NM	NM	NM
MW-171	4411.00	NA	NA	NM	NM	NM	NM
TAD-1	4613.05	NM	NM	NM	NM	NM	NM
TAD-1A	4613.01	35.06	4577.95	NM	NM	32.88	4580.13
TAD-2	4588.29	25.58	4562.71	NM	NM	24.12	4564.17
TAD-3	4587.54	24.40	4563.14	NM	NM	23.10	4564.44
TAD-4	4587.69	23.17	4564.52	NM	NM	21.75	4565.94
TAD-5	4478.98	11.54	4467.44	NM	NM	NM	NM
TAD-6	4522.89	3.24	4519.65	NM	NM	4.22	4518.67
TAD-7	4522.89	5.00	4517.89	NM	NM	5.51	4517.38

[a] ft msl = feet above mean sea level.

[b] ft btoc = feet below top of casing.

[c] NA = not applicable, well/point not installed.

[d] NM = not measured or not reported.



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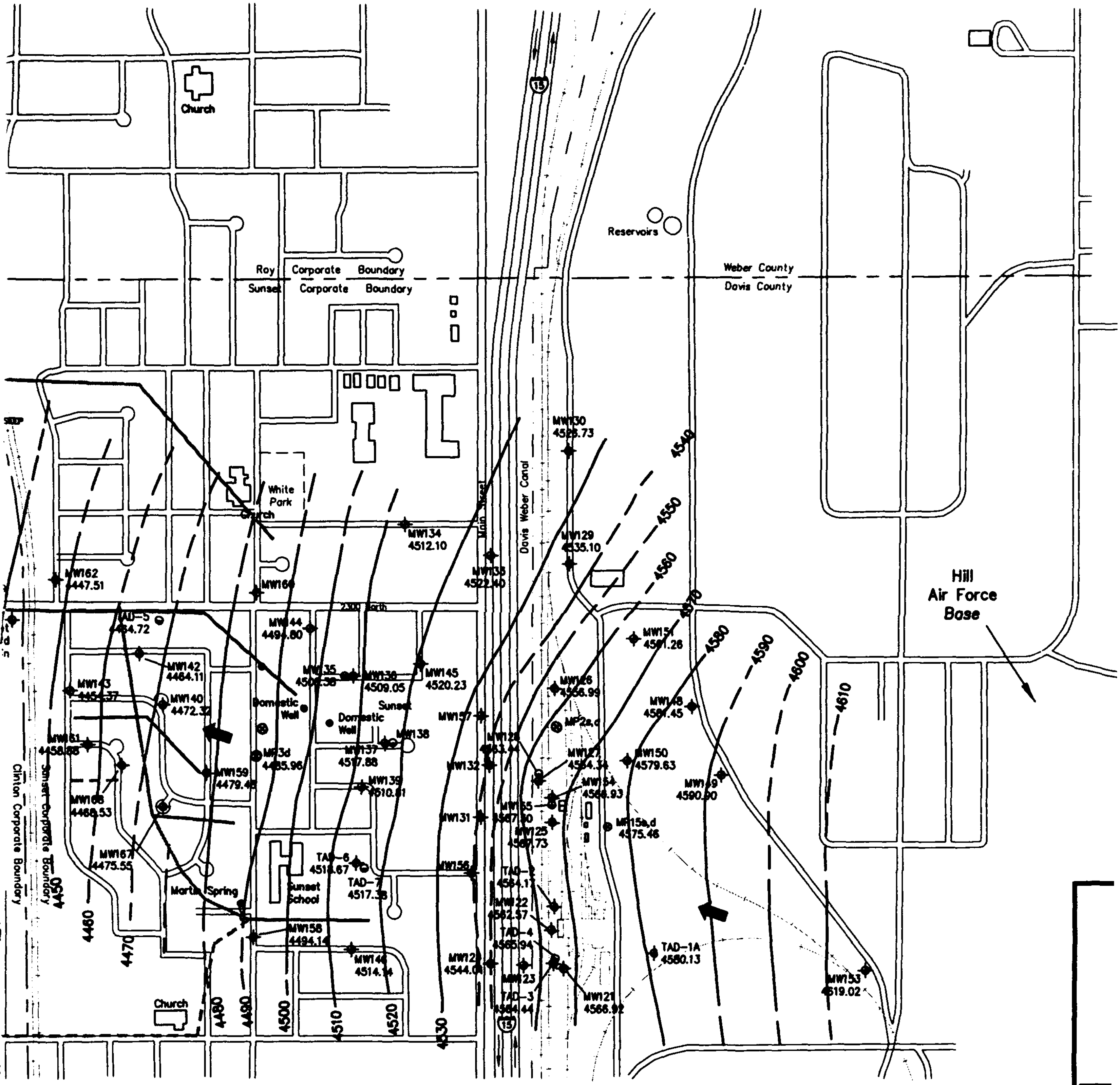
Church
Reservoirs
Roy Corporate Boundary
Sunset Corporate Boundary
Weber County
Davis County
15
White Park Church
Main Street
Davis Weber Canal
Hill Air Force Base
MW130 4528.73
MW134 4512.10
MW129 4535.10
MW133 4522.40
MW162 4447.51
MW160
2300 North
TAD-5 4464.72
MW144 4494.80
MW142 4464.11
MW135 4506.38
MW136 4509.05
MW145 4520.23
MW151 4561.26
MW126 4556.99
MW143 4454.37
MW140 4472.32
Domestic Well
Domestic Well
Sunset
MW157
MP2a,d
MW148 4581.45
MW161 4458.88
MW138
MW128 4563.44
MP3d 4485.96
MW137 4517.88
MW132
MW127 4564.34
MW150 4579.63
MW159 4479.45
MW139 4510.81
MW154 4566.93
MW149 4590.90
MW168 4468.53
MW155 4567.80
MW131
MP15a,d 4575.46
MW125 4567.73
MW167 4475.55
TAD-6 4518.67
MW156
TAD-7 4517.38
TAD-2 4564.17
Martin Spring
Sunset School
MW122 4562.57
MW158 4494.14
TAD-4 4565.94
TAD-1A 4580.13
MW146 4514.14
MW124 4544.04
MW123
MW153 4619.02
TAD-3 4564.44
MW121 4566.92
Church
Clinton Corporate Boundary
Sunset Corporate Boundary
4450
4460
4470
4480
4490
4500
4510
4520
4530
4540
4550
4560
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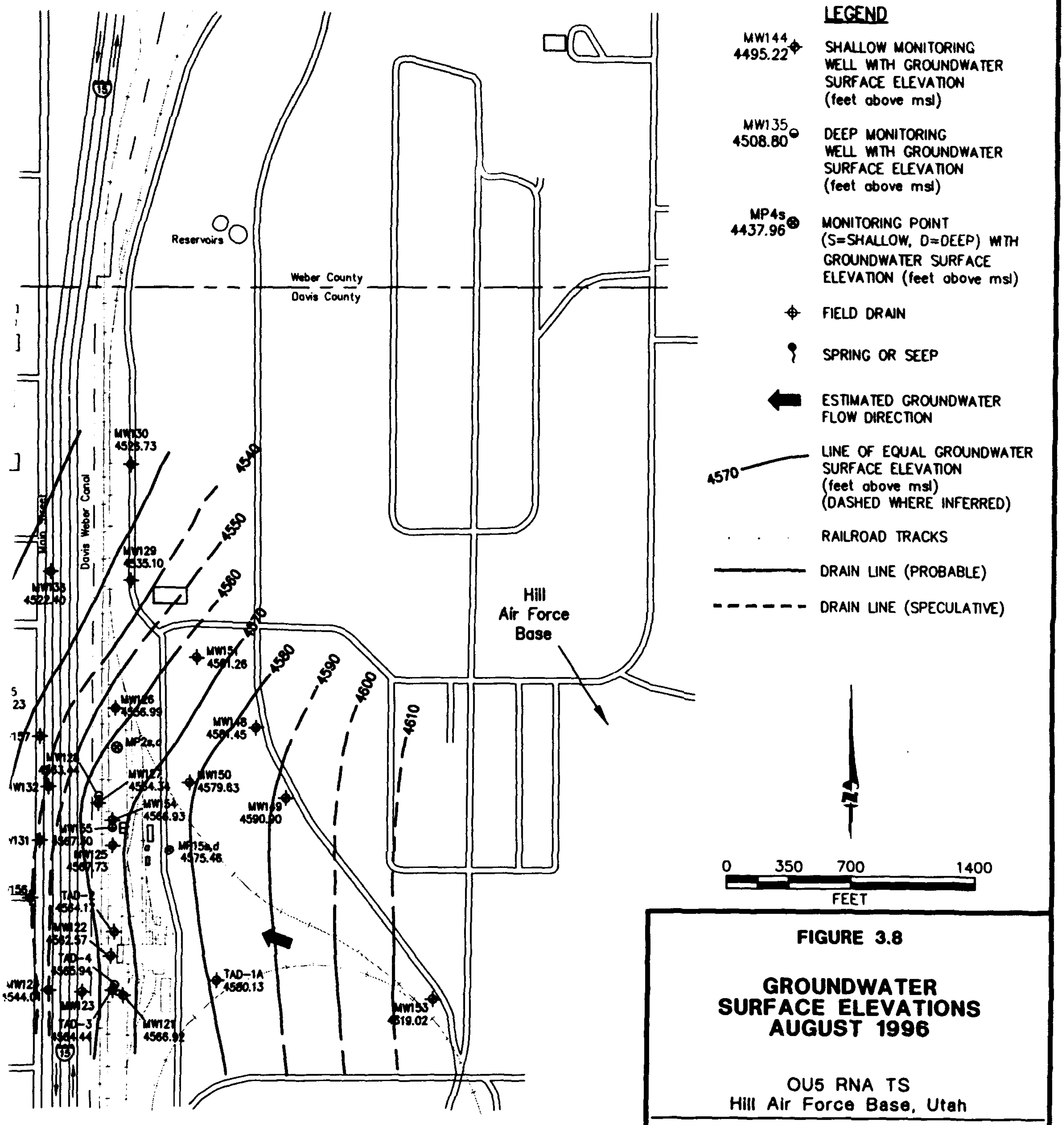


FIGURE 3.8

GROUNDWATER SURFACE ELEVATIONS AUGUST 1996

OU5 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

Across the OU5 area, the saturated thickness of the shallow aquifer ranges from about 5 to 50 feet.

On the basis of the hydrostratigraphic cross-sections (Figures 3.6 and 3.7), there appear to be no lateral hydrogeological constraints on plume migration. However, the silt/clay layer(s) beneath the plume may impede the downward migration of contaminants to deeper water-bearing zones. This is supported by analytical results for groundwater grab samples obtained during CPT sounding and data from nested monitoring well pairs MW-127/128, MW-135/136, and MW-154/155 (Radian, 1995).

As noted, relatively coarse-grained units may channel groundwater flow and plume migration in areas with complex and variable stratigraphy. Contaminants likely flow preferentially through zones with higher hydraulic conductivities relative to surrounding sediments. Given that the aquifers beneath Hill AFB consist of highly heterogeneous alluvial sediments deposited in a fan-delta complex, this potential for preferential and rapid migration in coarse-grained units must be considered when evaluating groundwater contaminant migration. For example, groundwater velocity measurements collected at OU5 using a borehole flowmeter (Wheeler, 1996) suggest that within a single well, velocities may vary by a factor as great as 10. Across the site, velocities reportedly may differ by a factor of nearly 70 (i.e., nearly two orders of magnitude). This has also been observed at underground storage tank (UST) Site 870 at Hill AFB [James M. Montgomery, Consulting Engineers, Inc. (JMM), 1993; Parsons ES, 1995]. At Site 870, slug and pumping tests were conducted in wells screened across different stratigraphic intervals (e.g., some fine-grained and some coarse). Results of these tests varied over two orders of magnitude, suggesting that for equivalent gradients and porosities, groundwater velocities at Site 870 could vary by two orders of magnitude. In general at Site 870, wells with higher measured conductivities were screened mostly across sandy intervals, while wells with lower measured conductivities were screened mostly across finer-grained intervals (containing more silt and clay).

Hydraulic conductivity values were calculated for the surficial aquifer at OU5 from 43 monitoring well slug tests analyzed using the Bouwer and Rice (1976) and Bouwer (1989) method (Radian, 1995). Hydraulic conductivity values reported by Radian (1995) ranged from 0.1 foot per day (ft/day) to 113 ft/day. Examination of the slug test results suggests these values may be somewhat high because the well casing and borehole diameters rather than the radii were used in the analytical solution. Sensitivity analysis using AQTESOLV® (Geraghty & Miller, Inc., 1994) indicates that the hydraulic conductivity estimates are about one-third of the reported values if well/borehole radii are used instead of diameters. In addition, it appears as though the actual casing radius was used to analyze slug tests where the water level was rising in the screen interval, instead of using a calculated effective casing radius as recommended by Bouwer and Rice (1976) and Bouwer (1989). Further sensitivity analysis indicated that use of an effective casing radius caused the resulting hydraulic conductivity value to increase by a factor of approximately 6.

Applying the two correction factors described above to the Radian (1995) slug test results (the correction for effective casing radius was applied only when the water level was rising in the screened interval of the well) yields hydraulic conductivity values for the shallow portion of the surficial aquifer (total of 37 tests) ranging from 0.07 ft/day to 225 ft/day (Table 3.2 and Appendix D). Hydraulic conductivity data sets are often

TABLE 3.2
SUMMARY OF SLUG TESTING RESULTS
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Well ID and Type of Slug Test	Total Depth of Well (feet btoc)[a]	Hydraulic Conductivity Reported by Radian (1995) (ft/min)[b]	Average Corrected Hydraulic Conductivity[c] (ft/min)	Average Corrected Hydraulic Conductivity[c] (ft/day)[d]
MW-121 FHT[e]	35.0	-		
RHT[f]		1.22E-03	2.44E-03	3.51
MW-122 FHT	26.9	3.15E-04		
RHT		-	6.30E-04	0.91
MW-123 FHT	26.9	1.45E-03		
RHT		2.02E-03	3.47E-03	5.00
MW-124 FHT	23.0	1.15E-03		
RHT		1.01E-03	2.16E-03	3.11
MW-125 FHT	27.5	4.03E-03		
RHT		3.24E-03	1.21E-03	1.74
MW-126 FHT	41.0	6.25E-04		
RHT		4.78E-04	1.84E-04	0.26
MW-127 FHT	26.4	2.86E-03		
RHT		2.81E-03	5.67E-03	8.16
MW-128 FHT	51.3	-		
RHT		-	-	
MW-129 FHT	65.0	-		
RHT		-	-	
MW-130 FHT	65.2	0.00019		
RHT		-	3.80E-04	0.55
MW-131 FHT	14.9	0.00705		
RHT		-	2.35E-03	3.38
MW-132 FHT	17.4	0.0066		
RHT		0.00656	2.19E-03	3.16
MW-133 FHT	35.0	0.00128		
RHT		0.000665	1.95E-03	2.80
MW-134 FHT	25.9	0.00247		
RHT		0.00892	1.90E-03	2.73
MW-135 FHT	30.2	0.000328		
RHT		0.000306	1.06E-04	0.15
MW-136 FHT	17.1	0.00247		
RHT		0.00353	3.94E-03	5.68

TABLE 3.2 (Continued)
SUMMARY OF SLUG TESTING RESULTS
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Well ID and Type of Slug Test	Total Depth of Well (feet btoc)[a/]	Hydraulic Conductivity Reported by Radian (1995) (ft/min) [b/]	Average Corrected Hydraulic Conductivity[c/] (ft/min)	Average Corrected Hydraulic Conductivity[c/] (ft/day) [d/]
MW-137 FHT	15.8	0.00144		
RHT		0.00104	4.13E-04	0.60
MW-138 FHT	38.8	-		
RHT		0.000292	9.73E-05	0.14
MW-139 FHT	17.0	0.000416		
RHT		0.000207	1.04E-04	0.15
MW-140 FHT	16.7	0.00248		
RHT		0.00153	6.68E-04	0.96
MW-141 FHT	18.4	0.00106		
RHT		0.00203	5.15E-04	0.74
MW-142 FHT	19.5	0.000303		
RHT		-	6.06E-04	0.87
MW-143 FHT	19.7	0.001		
RHT		0.00189	2.89E-03	4.16
MW-144 FHT	19.7	0.0393		
RHT		0.0422	1.36E-02	19.56
MW-145 FHT	22.1	0.00563		
RHT		-	1.88E-03	2.70
MW-146 FHT	15.3	0.00154		
RHT		0.00147	5.02E-04	0.72
MW-147 FHT	15.5	0.00712		
RHT		0.00377	1.82E-03	2.61
MW-148 FHT	61.8	0.00053		
RHT		0.000378	9.08E-04	1.31
MW-149 FHT	60.2	0.000684		
RHT		0.0000884	1.29E-04	0.19
MW-150 FHT	57.6	0.000192		
RHT		0.000118	5.17E-05	0.07
MW-151 FHT	62.5	0.000242		
RHT		0.0001	5.92E-05	0.09
TAD 1A FHT	47.4	-		
RHT		0.00171	5.70E-04	0.82
MW-152 RHT	47.3	8.30E-03	1.66E-02	23.90

TABLE 3.2 (Continued)
SUMMARY OF SLUG TESTING RESULTS
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Well ID and Type of Slug Test	Total Depth of Well (feet btoc)[a]	Hydraulic Conductivity Reported by Radian (1995) (ft/min)[b]	Average Corrected Hydraulic Conductivity[c] (ft/min)	Average Corrected Hydraulic Conductivity[c] (ft/day)[d]
MW-153 RHT	40.3	0.003	6.00E-03	8.64
MW-154 RHT	24.3	3.20E-03	6.40E-03	9.22
MW-155 RHT	60.3	1.20E-03	4.00E-04	0.58
MW-156 RHT	20.3	6.60E-04	1.32E-03	1.90
MW-157 RHT	22.3	6.90E-03	1.38E-02	19.87
MW-158 RHT	18.3	2.30E-03	7.67E-04	1.10
MW-159 RHT	19.2	2.00E-03	6.67E-04	0.96
MW-160 RHT	21.3	7.80E-02	1.56E-01	224.64
MW-161 RHT	20.3	1.40E-03	2.80E-03	4.03
MW-162 RHT	21.9	3.40E-03	6.80E-03	9.79
MW-163 RHT	18.3	1.20E-02	4.00E-03	5.76
MW-164 RHT	19.3	4.30E-03	8.60E-03	12.38
MW-165 RHT	19.3	5.00E-03	1.00E-02	14.40

a/ feet btoc = feet below top of casing.
b/ ft/min = feet per minute.
c/ Corrected to incorporate use of well radius instead of well diameter
and effective casing radius when water level rising in screened interval.
Average of FHT and RHT.
d/ ft/day = feet per day.
e/ FHT = falling head test.
f/ RHT = rising head test.

log-normally distributed, and therefore the geometric mean is generally a better representation of the average value than the arithmetic mean. The geometric mean hydraulic conductivity for the shallow portion of the surficial aquifer is 2.3 ft/day. Three slug tests were performed in wells screened in the lower portion of the surficial aquifer (wells MW135, MW138, and MW155). The resulting hydraulic conductivity values ranged from 0.1 to 0.6 ft/day and averaged 0.3 ft/day.

Hydraulic conductivity values estimated from 45 pore-fluid dissipation tests performed at 18 CPT locations ranged from 0.009 ft/day to 2.8 ft/day. Examination of CPT logs indicated that 27 tests were performed in sandy silt to silty sand material; 10 tests were performed in interlayered silty sand, sandy silt, and clayey silt; and 8 tests were performed in silty clay to clayey silt. The hydraulic conductivity range and geometric mean for the three categories of deposits described above are summarized in Table 3.3.

The lateral hydraulic gradient at OU5 ranged from 0.018 to 0.07 foot/foot (ft/ft) and averaged approximately 0.03 ft/ft, based on the August 1996 groundwater surface (Figure 3.8). Water level data from nested well pairs screened in the upper and lower portions of the surficial aquifer indicate downward vertical hydraulic gradients at well pairs MW127/128 (0.04 ft/ft) and MW135/136 (0.05 ft/ft), and an upward vertical gradient at well pair MW154/155 (0.01 ft/ft). Water level data collected in March 1996 by Radian indicate that the magnitude and direction of the vertical gradients during that measurement event were similar to those measured in August 1996.

The wide range of hydraulic conductivity values measured at OU5 indicates that the advective flow velocity is extremely variable spatially. Based on a hydraulic conductivity range of 0.009 to 225 ft/day (derived from results of slug and pore-fluid dissipation tests described above), an average hydraulic gradient of 0.03 ft/ft, and an estimated effective porosity ranging from 0.05 (for a clayey material) to 0.30 (for a sandy material), the advective groundwater flow velocity ranges from 0.005 ft/day to 22.5 ft/day [2 feet per year (ft/yr) to 8,212 ft/yr]. Assuming an average hydraulic conductivity of 0.21 ft/day (from pore-fluid dissipation tests) to 2.3 ft/day (from slug tests), the average hydraulic gradient of 0.03 ft/ft, and an estimated average effective porosity of 0.20 for a silty sand to sandy silt (the dominant lithology in the surficial aquifer) (Johnson, 1967; Barcelona *et al.* 1985), the average advective groundwater flow velocity in the surficial aquifer ranges from 0.03 ft/day to 0.3 ft/day (11 to 110 ft/yr).

Thirty horizontal groundwater velocity measurements were made in a total of 10 wells located within or near the air sparging curtain located adjacent to Main Street in the city of Sunset (Radian, 1996a). Horizontal flow velocities ranged from 0.1 to 3 ft/day in wells near the aeration curtain. The geometric mean for all velocity measurements was 0.6 ft/day, which is higher than the average flow velocities estimated using slug and pore-fluid dissipation test results. The higher flow velocities near Main Street may result from the higher hydraulic gradients present in this area (Figure 3.6).

TABLE 3.3
SUMMARY OF PORE-FLUID DISSIPATION TEST RESULTS
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Type of Deposit	Hydraulic Conductivity Range (feet per day)	Geometric Mean Hydraulic Conductivity (foot per day)
Sandy Silt to Silty Sand	0.009 to 2.8	0.4
Interlayered Silty Sand, Sandy Silt, and Clayey Silt	0.014 to 1.7	0.2
Silty Clay to Clayey Silt	0.02 to 0.85	0.06

Source: Radian, 1995

The advective velocity of groundwater in the direction parallel to groundwater flow is given by:

$$\bar{v} = \frac{K}{n_e}\frac{dH}{dL}$$

Where: $\bar{v}$ = Average advective groundwater velocity (seepage velocity) [L/T]

K = Hydraulic Conductivity [L/T]

dH/dL = Hydraulic Gradient [L/L]

n_e = Effective porosity

3.5 SURFACE AND GROUNDWATER USE

Groundwater from the shallow aquifer at Hill AFB is not extracted for beneficial use. Water used at the Base is supplied by deep (>600 feet) wells, occasionally supplemented by water purchased from the Weber Basin Water Conservancy District during summer months (Radian, 1995; SAIC, 1989). The cities of Sunset and Clinton also obtain potable water from deep wells screened in the Delta Aquifer, although some residents have shallow wells or use springs to irrigate gardens. Martin Spring, located in Sunset (Figure 3.8), is used to fill a swimming pool.

The Davis-Weber Canal Company provides irrigation water to the area from the Weber River via the Davis-Weber Canal, which flows past the OU 5 site (Figure 3.6). Water in the Davis-Weber Canal is used solely for irrigation. The relationship of surface water in this canal to shallow groundwater beneath the canal is not addressed in the RI report (Radian, 1995). A water rights search conducted by Radian (1995) indicates several points of diversion for shallow domestic wells, springs, and drains in the vicinity. No deep production wells were included in the water rights search, and the area encompassed by the survey is not given by the investigators.

Because of the shallow water table in the off-Base area, field drains were installed in the early 1900s in Sunset and Clinton to control shallow groundwater flow. These field drains are believed to locally alter shallow groundwater flow patterns. The construction and installation of the field drains by farmers did not conform to a plan and generally were not documented. The probable locations of field drains and historical wells in the Sunset and Clinton areas, as determined from a water rights survey and personal interviews with residents and city officials, are shown on Figure 3.8. The drains were usually installed in trenches excavated from 2 to 12 feet deep and 1 to 2 feet wide. Early drains were constructed of short sections of 6-inch-diameter clay pipe that were not connected. During the last 30 years, farmers began using 6-inch-diameter perforated plastic pipe that was available in 100-foot lengths. The current impact of these field drains on shallow groundwater flow and contaminant transport is not well understood; however, potential impacts suggested by the groundwater quality data are discussed in Section 4.3.1.

SECTION 4

CONTAMINANT DISTRIBUTION AND EVIDENCE OF BIODEGRADATION

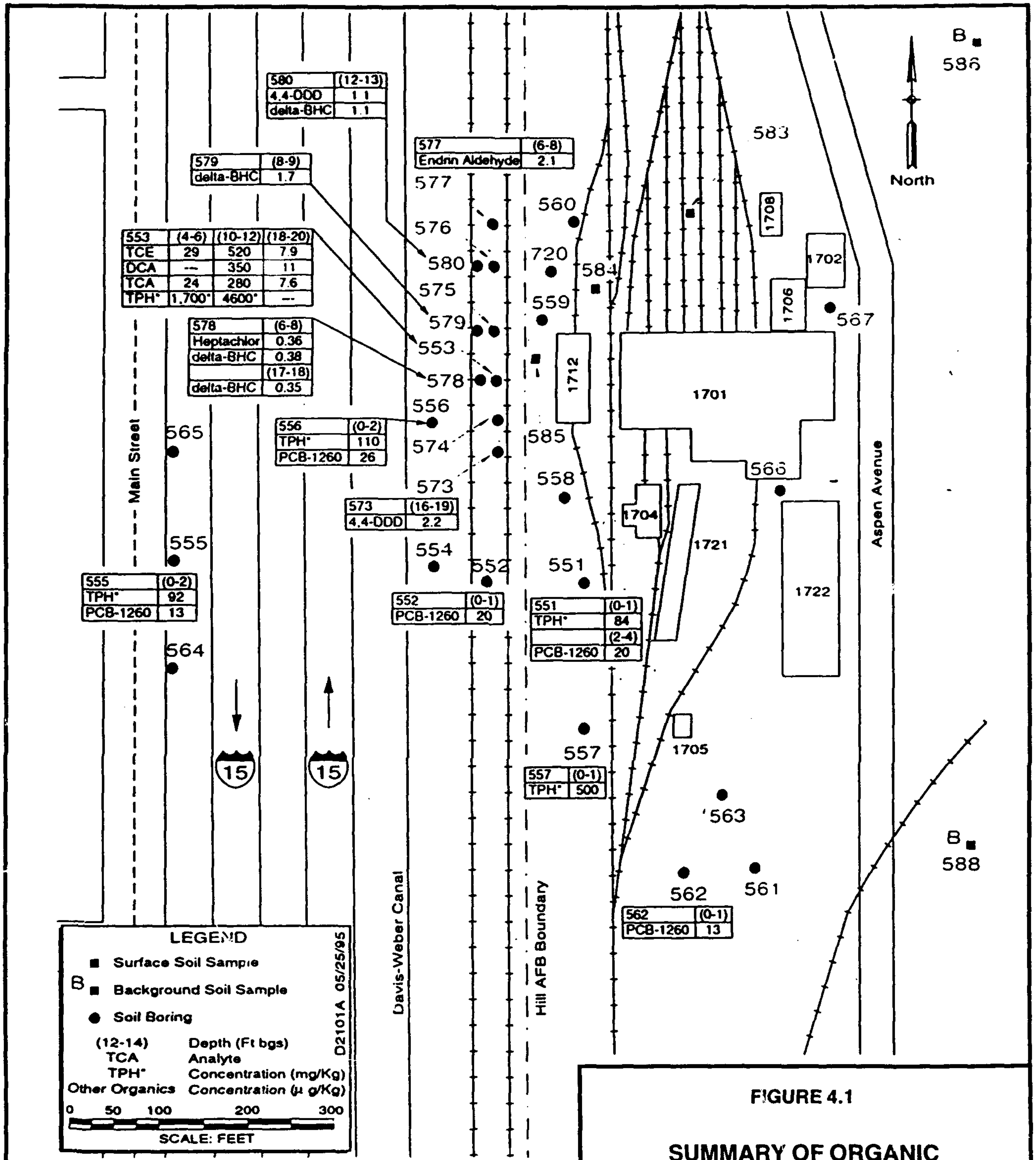
As discussed in Section 1, contaminants at OU5 were introduced as a result of discharge of wastewater containing solvents into a leachfield at the Tooele Rail Shop. The RI performed by Radian (1995) focused on defining the nature and extent of contamination at the site. Results of the RI that are useful for the objectives of this TS are summarized in the following subsections, along with data collected during the field phase of this work. In particular, this section will focus on data useful for evaluating and modeling natural attenuation of CAHs.

4.1 RESULTS OF SOIL SAMPLING

4.1.1 Organic Contaminants Detected in Soils

Soil samples collected during this RNA field investigation were not analyzed for contaminants due to the substantial volume of soil quality data obtained during the RI (Radian, 1995). During the RI, 24 surface soil samples and 131 subsurface soil samples were analyzed for VOCs; most of these samples also were analyzed for semivolatile organic compounds (SVOCs), including polynuclear aromatic hydrocarbons (PAHs). Selected samples also were analyzed for pesticides, polychlorinated biphenyls (PCBs), and total petroleum hydrocarbons (TPH). Figures 4.1 and 4.2 show the distributions of these analytes in soil.

Organic contaminants were detected at concentrations exceeding maximum background levels throughout the Tooele Rail Shop area during the RI. Soil contamination was most prevalent near Buildings 1701 and 1723A. In the Building 1701 area, CAHs were detected in soil samples from borehole 553, located just downslope from the former outdoor parts cleaning operations and oil/water separator (Figure 4.1). CAHs detected (and their maximum concentrations) included TCE (520 micrograms per kilogram [μg/kg]); 1,1-dichloroethane (DCA) (350 μg/kg); and 1,1,1-TCA (280 μg/kg). Maximum CAH concentrations were detected in borehole 553 at 10 to 12 feet bgs; concentrations in the sample collected from 18 to 20 feet bgs at this location were one to two orders of magnitude lower. The highest TPH concentration detected in this area (4,600 milligrams per kilogram [mg/kg]) also was detected in a sample from this borehole at 10 to 12 feet bgs. The depth to groundwater in this area in August 1996 was approximately 23 feet bgs.



NOTES:

BHC= hexachlorocyclohexane
DCA= dichloroethane
DDD= 1,1-dichloro-2,2-bis(4-chlorophenyl)ethane
PCB= Polychlorinated biphenyl
TCA= Trichloroethane
TCE= Trichloroethene
TPH= Total petroleum hydrocarbons

Source: Radian, 1995.

FIGURE 4.1

SUMMARY OF ORGANIC CONSTITUENTS DETECTED IN SOIL AT BUILDING 1701

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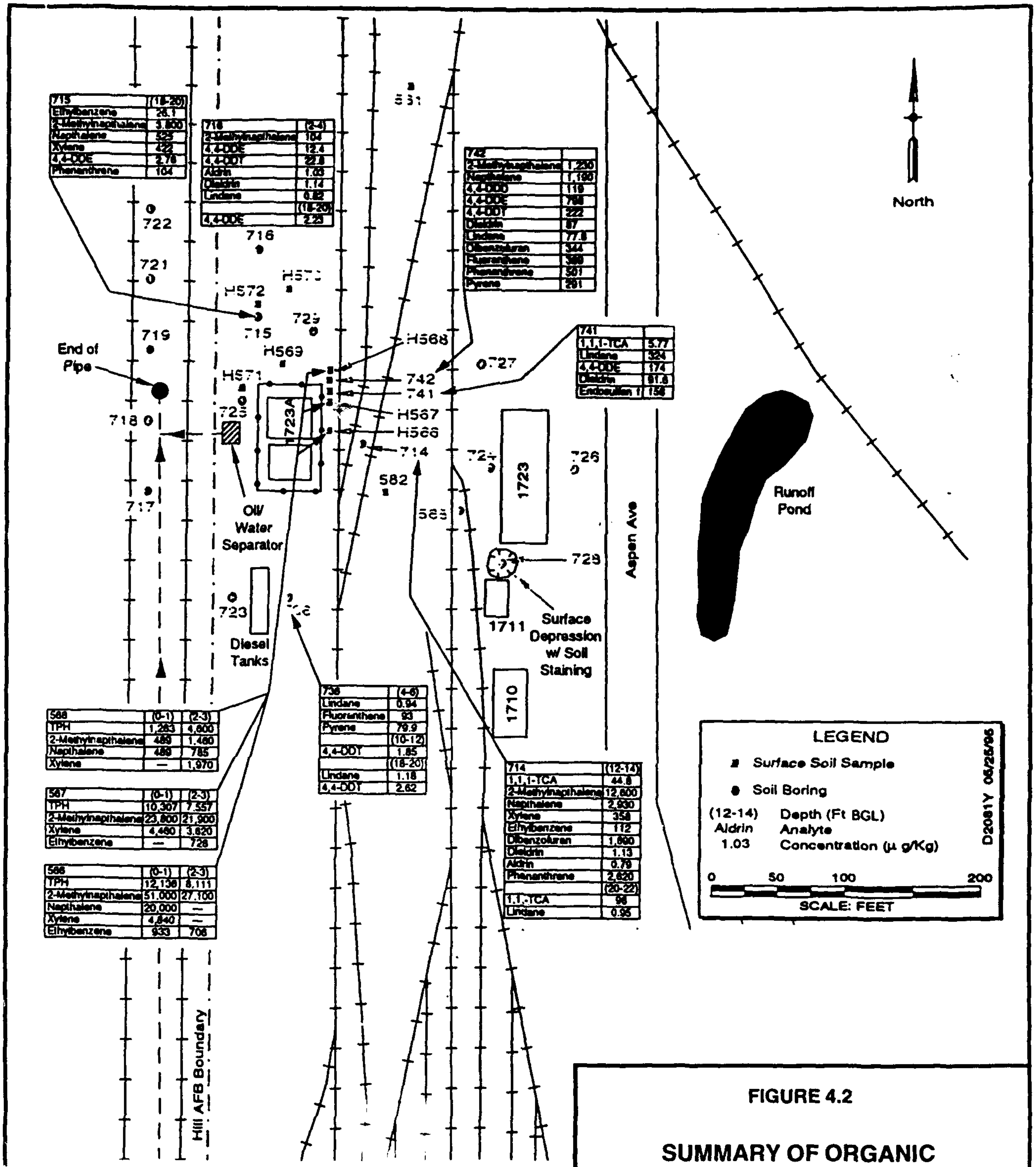

715	(18-20)
Ethylbenzene	26.1
2-Methylnapthalene	3,800
Napthalene	325
Xylene	422
4,4-DDE	2.78
Phenanthrene	104

716	(2-4)
2-Methylnapthalene	104
4,4-DDE	12.4
4,4-DDT	22.8
Aldrin	1.03
Dieldrin	1.14
Lindane	0.82
	(18-20)
4,4-DDE	2.23

742	
2-Methylnapthalene	1,230
Napthalene	1,190
4,4-DDD	119
4,4-DDE	785
4,4-DDT	222
Dieldrin	87
Lindane	77.8
Dibenzofuran	344
Fluoranthene	389
Phenanthrene	501
Pyrene	291

741	
1,1,1-TCA	5.77
Lindane	324
4,4-DDE	174
Dieldrin	91.8
Endosulfan I	158

588	(0-1)	(2-3)
TPH	1,283	4,600
2-Methylnapthalene	489	1,460
Napthalene	489	785
Xylene	—	1,970

587	(0-1)	(2-3)
TPH	10,307	7,557
2-Methylnapthalene	23,800	21,900
Xylene	4,460	3,620
Ethylbenzene	—	728

586	(0-1)	(2-3)
TPH	12,138	8,111
2-Methylnapthalene	51,000	27,100
Napthalene	20,000	—
Xylene	4,840	—
Ethylbenzene	933	706

738	(4-6)
Lindane	0.94
Fluoranthene	93
Pyrene	79.9
	(10-12)
4,4-DDT	1.85
	(18-20)
Lindane	1.18
4,4-DDT	2.62

714	(12-14)
1,1,1-TCA	44.8
2-Methylnapthalene	12,800
Napthalene	2,930
Xylene	358
Ethylbenzene	112
Dibenzofuran	1,890
Dieldrin	1.13
Aldrin	0.79
Phenanthrene	2,620
	(20-22)
1,1,1-TCA	98
Lindane	0.95

NOTES:

DDE= 1,1-Dichloro-2,2-bis(4-ethylphenyl)ethane
DDD= 1,1-Dichloro-2,2-bis(4-chlorophenyl)ethane
TCA= Trichloroethane
TPH= Total petroleum hydrocarbons
DDT= 1,1-(2,2,2-Trichloroethylidene)bis[4-chlorobenzene]

Source: Radian, 1995.

FIGURE 4.2

SUMMARY OF ORGANIC CONSTITUENTS DETECTED IN SOIL AT BUILDING 1723 AREA

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As shown on Figure 4.2, the CAH 1,1,1-TCA was detected in three samples obtained from two soil boreholes near Building 1723A. Other targeted CAHs were not detected. The maximum 1,1,1-TCA concentration of 96 µg/kg was detected in a sample from borehole 714 at a depth of 20 to 22 feet bgs. Groundwater was encountered during soil borehole drilling in this area at depths of approximately 20 to 24 feet bgs. Elevated concentrations of TPH, PAHs, and aromatic VOCs also were detected near Building 1723A from the ground surface to 20 feet bgs. The maximum TPH concentration of 12,136 mg/kg was detected in surface soil (0 to 1 foot bgs) from borehole 566. Maximum PAH and aromatic VOC concentrations were also detected in this sample, or in surface samples from adjacent boreholes 567 and 568.

4.1.2 Total Organic Carbon in Soil

TOC concentrations are used to estimate the amount of organic matter sorbed to soil particles or trapped in the interstitial passages of a soil matrix. The TOC concentration in the saturated zone is an important parameter used to estimate the amount of contaminant that could potentially be sorbed to the aquifer matrix. Sorption results in retardation of the contaminant plume relative to the average advective groundwater velocity. In addition, TOC can be used as a gross indicator of organic compounds that are available as a source of carbon and electrons (i.e., substrate) for microbial activity.

Soil TOC concentrations were measured in seven samples collected outside or near the margins of the TCE plume during monitoring point installation in August 1996. Each sample was collected over a 3- to 4-foot interval from the saturated zone within or near the monitoring point screen interval; the samples were each split into two subsamples at the analytical laboratory. Results for each subsample are presented in Table 4.1. Soil TOC concentrations ranged from 0.024 percent to 0.293 percent, with the highest concentrations occurring in the silty clay soils from monitoring point MP3d. TOC concentrations in soils consisting primarily of sand or silt (all samples except for MP3) ranged from 0.024 percent to 0.058 percent, with a mean concentration of 0.043 percent. Groundwater and dissolved contaminants would preferentially migrate through these more permeable deposits rather than through more clayey zones.

The TOC concentrations measured in OU5 soil samples are similar to the concentrations of 0.069 to 0.094 percent measured in fluvial-deltaic sands collected at the Hill AFB petroleum, oils, and lubricants (POL) storage facility and reported by Wiedemeier *et al.* (1996a). TOC concentrations measured in 19 Hill AFB OU1 soil samples ranged from less than 0.05 to 2.4 percent and averaged 0.81 percent (Montgomery Watson, 1995). Petroleum hydrocarbon (fuel) contamination is present in soils at this OU, and it is not known whether fuel-contaminated soils were sampled for TOC analysis, resulting in elevated TOC values.

4.2 OVERVIEW OF CAH BIODEGRADATION IN GROUNDWATER

Groundwater quality data obtained during the RI (Radian, 1995) and this TS indicate that CAH compounds are the primary contaminants of concern in groundwater; dissolved petroleum hydrocarbons are not present in sufficient concentrations in

TABLE 4.1
SOIL TOTAL ORGANIC CARBON CONCENTRATIONS
AUGUST 1996
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Sample Location	Depth (feet bgs)	Soil Type	Total Organic Carbon[a] (%)	Mean TOC (%)
MP-1 s	20-24	fine sand	0.024 0.027	0.026
MP-2 s	24-28	fine sand/occ. silty	0.04 0.037	0.039
MP-3 d	31.5-35.5	silty clay	0.293 0.286	0.29
MP-4 s	11-15	sandy, clayey silt	0.053 0.055	0.054
MP-6 s	11-15	sandy, clayey silt	0.046 0.043	0.045
MP-7 s	11-15	sandy, clayey silt	0.056 0.058	0.057
MP-8 s	11-14	sandy, clayey silt	0.039 0.038	0.039

a/ Moisture-adjusted result for two subsamples from each depth.

Note: Analysis method was SW9060, modified.

groundwater to be considered contaminants of concern. Therefore, this section focuses on natural attenuation (specifically biodegradation) of CAHs. Mechanisms for natural attenuation of CAHs include biodegradation, dispersion, dilution from recharge and upgradient flow, sorption, and volatilization. Of these processes, biodegradation is the only mechanism working to transform contaminants into innocuous byproducts. When indigenous microorganisms work to bring about a reduction in the total mass of contamination in the subsurface without the addition of nutrients, these biodegradation processes are considered intrinsic.

In the past several years, numerous studies have demonstrated the effectiveness of biodegradation at remediating dissolved benzene, toluene, ethylbenzene, and xylenes (BTEX) concentrations (Wiedemeier *et al.*, 1995). Chlorinated solvents also can be transformed, directly or indirectly, by biological processes (e.g., Bouwer *et al.*, 1981; Miller and Guengerich, 1982; Wilson and Wilson, 1985; Nelson *et al.*, 1986; Bouwer and Wright, 1988; Little *et al.*, 1988; Mayer *et al.*, 1988; Arciero *et al.*, 1989; Cline and Delfino, 1989; Freedman and Gossett, 1989; Folsom *et al.*, 1990; Harker and Kim, 1990; Alvarez-Cohen and McCarty, 1991a, 1991b; DeStefano *et al.*, 1991; Henry, 1991; McCarty *et al.*, 1992; Hartmans and de Bont, 1992; McCarty and Semprini, 1994; Vogel, 1994). Biodegradation of CAHs, while similar in principle to biodegradation of BTEX, typically results from a more complex series of processes.

Microorganisms produce energy for life processes (i.e., cell production and maintenance) by oxidizing organic matter. Microorganisms facilitate the degradation of these organic compounds by transferring electrons from an electron donor to available electron acceptors. The amount of energy that can be released when a reaction occurs or that is required to drive the reaction to completion is quantified by the free energy of the reaction (Stumm and Morgan, 1981; Bouwer, 1994; Chapelle, 1993; Godsey, 1994; Mueller *et al.*, 1994). Microorganisms will facilitate only those reduction/oxidation (redox) reactions that will yield energy. By coupling the oxidation of the electron donor (e.g., fuel hydrocarbon compounds, native organic carbon, low-molecular weight CAHs), which requires energy, to the reduction of the electron acceptor (e.g., oxygen, nitrate, manganese, ferric iron, sulfate, carbon dioxide, and possibly CAHs), which yields energy, the overall reaction will yield energy.

In a pristine aquifer, native organic carbon is utilized as an electron donor, and DO is utilized first as the prime electron acceptor. Where anthropogenic carbon (e.g., fuel hydrocarbons or low-molecular-weight CAHs) is present, it also will be utilized as an electron donor. After the DO is consumed, anaerobic microorganisms typically use native electron acceptors (as available) in the following order of preference: nitrate, ferric iron oxyhydroxide, sulfate, and finally carbon dioxide.

Whereas BTEX is biodegraded in essentially one step by acting as an electron donor/carbon source, CAHs may undergo several types of biodegradation involving several steps. CAHs may undergo biodegradation through three different pathways: use as an electron acceptor, use as an electron donor, or cometabolism, which is degradation resulting from exposure to a catalytic enzyme fortuitously produced during an unrelated process. At a given site, one or all of these processes may be operating, although at many sites the use of CAHs as electron acceptors appears to be most likely. Because CAHs may be used as electron acceptors or electron donors (in competition with other acceptors or donors), isopleth maps showing the distribution of these compounds can provide evidence of the types and locations of biodegradation processes acting at a site. In order to provide a foundation for interpreting site data, the following subsections review the major bioremediation processes that act upon CAHs.

4.2.1 Electron Acceptor Reactions (Reductive Dehalogenation)

Under anaerobic conditions, biodegradation of chlorinated solvents usually proceeds through a process called reductive dehalogenation. During this process, the halogenated hydrocarbon is used as an electron acceptor, not as a source of carbon, and a halogen atom (i.e., chlorine) is removed and replaced with a hydrogen atom. Figure 4.3 illustrates the transformation of chlorinated ethenes via reductive dehalogenation. In general, reductive dehalogenation occurs by sequential dehalogenation from tetrachloroethene (PCE) to TCE to dichloroethene (DCE) to vinyl chloride (VC) to ethene. Depending upon environmental conditions, this sequence may be interrupted, with other processes then acting upon the products. During reductive dehalogenation, all three isomers of DCE can theoretically be produced; however, Bouwer (1994) reports that under the influence of biodegradation, *cis*-1,2-DCE is a more common intermediate than *trans*-1,2-DCE, and that 1,1-DCE is the least prevalent intermediate of the three DCE isomers. Reductive dehalogenation of chlorinated solvent compounds is associated with the accumulation of daughter products and an increase in chloride.

Reductive dehalogenation affects each of the chlorinated ethenes differently. Of these compounds, PCE is the most susceptible to reductive dehalogenation because it is the most oxidized. Conversely, VC is the least susceptible to reductive dehalogenation because it is the least oxidized of these compounds. The rate of reductive dehalogenation also has been observed to decrease as the degree of chlorination decreases (Vogel and McCarty, 1985; Bouwer, 1994). Murray and Richardson (1993) have postulated that this rate decrease may explain the accumulation of VC in PCE and TCE plumes that are undergoing reductive dehalogenation.

In addition to being affected by the degree of chlorination of the CAH, reductive dehalogenation can also be controlled by the redox conditions of the site groundwater system. In general, reductive dehalogenation has been demonstrated under anaerobic nitrate- and sulfate-reducing conditions, but the most rapid biodegradation rates, affecting the widest range of CAHs, occur under methanogenic conditions (Bouwer, 1994). Dehalogenation of PCE and TCE to DCE can proceed under mildly reducing conditions such as nitrate reduction or iron (III) reduction (Vogel *et al.*, 1987), while the transformation of DCE to VC, or the transformation from VC to ethene requires more strongly reducing conditions (Freedman and Gossett, 1989; DeStefano *et al.*, 1991; De Bruin *et al.*, 1992).

Because CAH compounds are used as electron acceptors, there must be an appropriate source of carbon for microbial growth in order for reductive dehalogenation to occur (Bouwer, 1994). Potential carbon sources can include low-molecular-weight compounds (e.g., lactate, acetate, methanol, or glucose) present in natural organic matter, or anthropogenic sources such as fuel hydrocarbons.

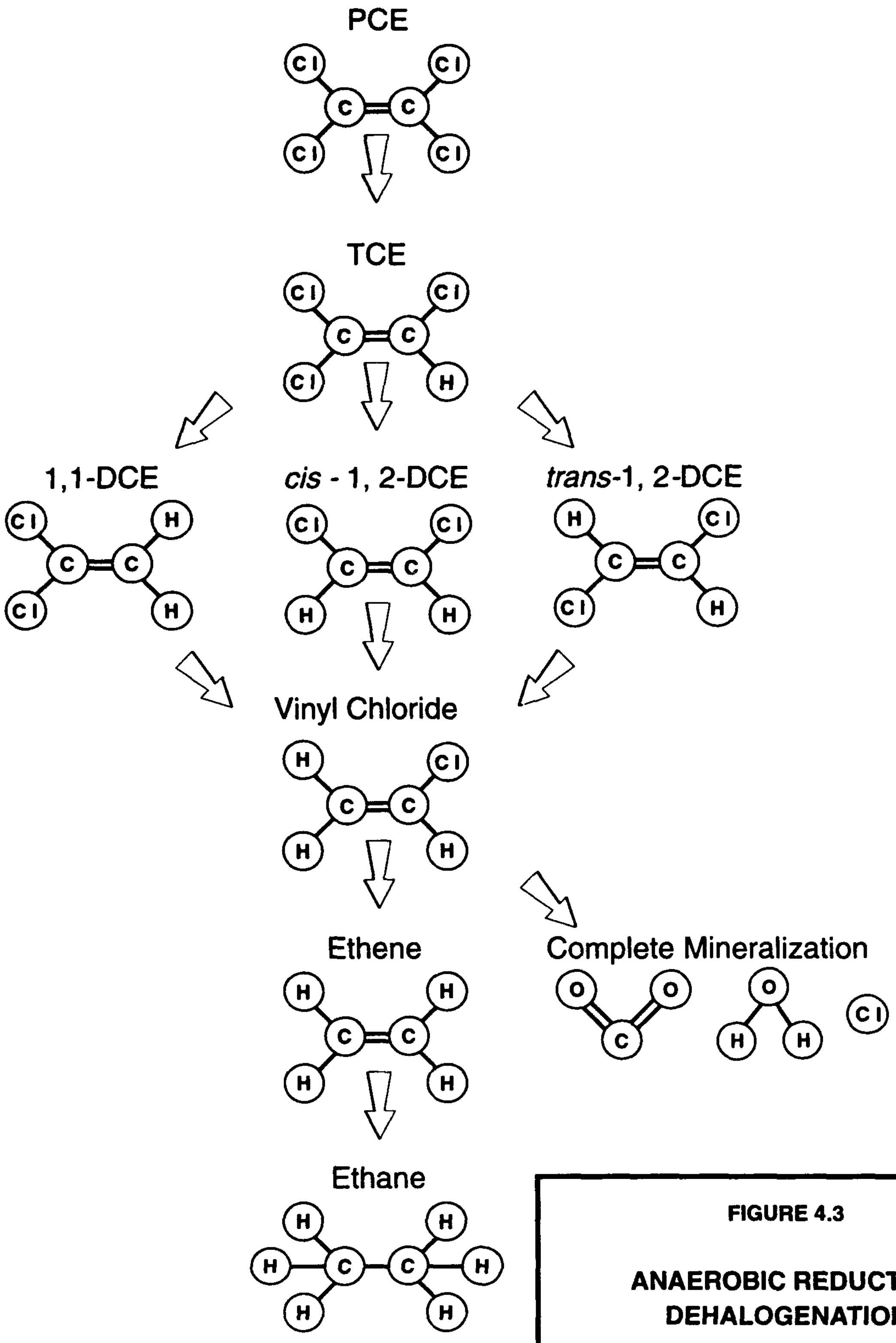

FIGURE 4.3

ANAEROBIC REDUCTIVE DEHALOGENATION

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4.2.2 Electron Donor Reactions

Under aerobic conditions some CAH compounds can be utilized as the primary substrate (i.e., electron donor) in biologically mediated redox reactions (McCarty and Semprini, 1994). In this type of reaction, the facilitating microorganism obtains energy and organic carbon from the degraded CAH. In contrast to reactions in which the CAH is used as an electron acceptor, only the least oxidized CAHs (e.g., VC, DCE, or chlorobenzene) may be utilized as electron donors in biologically mediated redox reactions.

For example, while Murray and Richardson (1993) write that microorganisms are generally believed to be incapable of growth using TCE and PCE, other less chlorinated CAHs have been shown to be used as substrates. Davis and Carpenter (1990) describe the aerobic oxidation of VC in groundwater. McCarty and Semprini (1994) describe investigations in which VC and 1,2-DCA were shown to serve as primary substrates. These authors also document that dichloromethane has the potential to function as a primary substrate under either aerobic or anaerobic environments. Klier *et al.* (1996) describe aerobic mineralization of all three isomers of DCE. In addition, Bradley and Chapelle (1996) show evidence of oxidation of VC under iron-reducing conditions so long as there is sufficient bioavailable iron (III).

4.2.3 Cometabolism

When a CAH is biodegraded through cometabolism, it serves as neither an electron acceptor nor a primary substrate in a biologically mediated redox reaction. Instead, the degradation of the CAH is catalyzed by an enzyme or cofactor that is fortuitously produced by organisms for other purposes. The organism receives no known benefit from the degradation of the CAH; rather the cometabolic degradation of the CAH may in fact be harmful to the microorganism responsible for the production of the enzyme or cofactor (McCarty and Semprini, 1994).

Cometabolism is best documented in aerobic environments, although it potentially could occur under anaerobic conditions. Aerobic biodegradation pathways for chlorinated ethenes are illustrated in Figure 4.4. It has been reported that under aerobic conditions chlorinated ethenes, with the exception of PCE, are susceptible to cometabolic degradation (Murray and Richardson, 1993; Vogel, 1994; McCarty and Semprini, 1994). Vogel (1994) further elaborates that the cometabolism rate increases as the degree of dehalogenation decreases.

In the cometabolic process, TCE is indirectly transformed by bacteria as they use BTEX or another substrate to meet their energy requirements. Therefore, TCE does not enhance the degradation of BTEX or other carbon sources, nor will its cometabolism interfere with the use of electron acceptors involved in the oxidation of those carbon sources. It is likely that depletion of suitable substrates (BTEX or other organic carbon sources) limits cometabolism of CAHs.

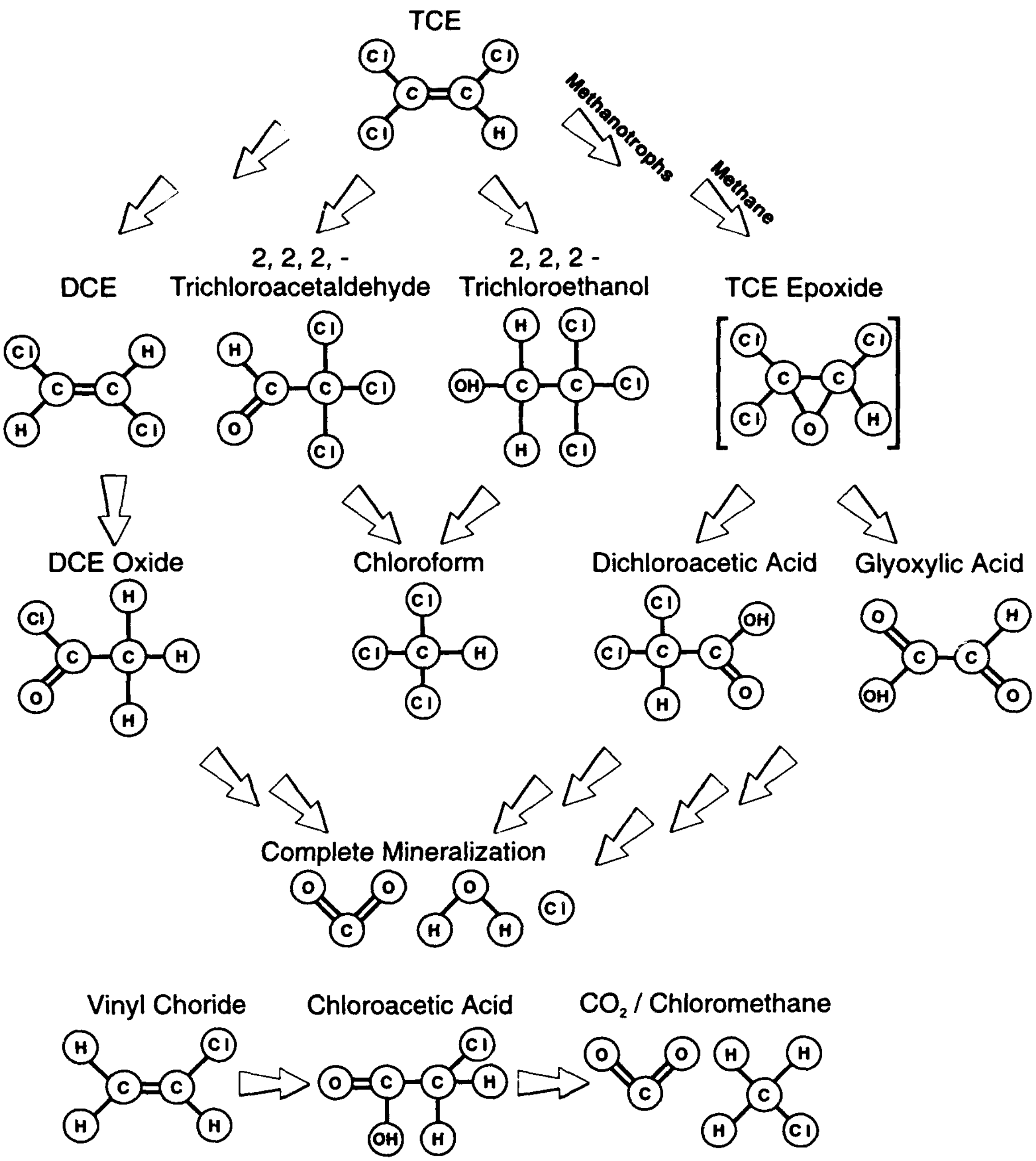

FIGURE 4.4

AEROBIC DEGRADATION

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Denver, Colorado

4.2.4 Behavior of Chlorinated Solvent Plumes

Chlorinated solvent plumes can exhibit three types of behavior depending on the amount of solvent, the amount of organic (native and/or anthropogenic) carbon in the aquifer, the distribution and concentration of natural electron acceptors, and the types of electron acceptors being utilized. Individual plumes may exhibit all three types of behavior in different portions of the plume. The different types of plume behavior are summarized below.

4.2.4.1 Type 1 Behavior

Type 1 behavior occurs where the primary substrate is anthropogenic carbon (e.g., BTEX or landfill leachate), and this anthropogenic carbon drives reductive dechlorination. When evaluating natural attenuation of a plume exhibiting type 1 behavior the following questions must be answered:

1) Is the electron donor supply adequate to allow microbial reduction of the chlorinated organic compounds? In other words, will the microorganisms "strangle" before they "starve" [i.e., will they run out of chlorinated aliphatic hydrocarbons (electron acceptors) before they run out of primary substrate (anthropogenic carbon)]?

2) What is the role of competing electron acceptors (e.g., DO, nitrate, iron (III), and sulfate)?

3) Is VC oxidized, or is it reduced?

Type 1 behavior results in the rapid and extensive degradation of the highly chlorinated solvents such as PCE, TCE, and DCE.

4.2.4.2 Type 2 Behavior

Type 2 behavior dominates in areas that are characterized by relatively high concentrations of biologically available native organic carbon. This natural carbon source drives reductive dehalogenation (i.e., the primary substrate for microorganism growth is native organic carbon). When evaluating natural attenuation of a type 2 chlorinated solvent plume, the same questions as those posed in the description of type 1 behavior must be answered. Type 2 behavior generally results in slower biodegradation of the highly chlorinated solvents than Type 1 behavior, but under the right conditions (e.g., areas with high natural organic carbon contents), this type of behavior also can result in rapid degradation of these compounds.

4.2.4.3 Type 3 Behavior

Type 3 behavior dominates in areas that are characterized by low concentrations of native and/or anthropogenic carbon, and concentrations of DO that are greater than 1.0 milligram per liter (mg/L). Under these aerobic conditions reductive dehalogenation will not occur. Thus there is little or no removal of PCE and TCE. Biodegradation may proceed via the much slower process of cometabolism, but will be limited by the low concentrations of native or anthropogenic carbon. The most significant natural attenuation mechanisms for CAHs will be advection, dispersion, and sorption. However, VC can be rapidly oxidized under these conditions, DCE may be oxidized, and cometabolism also may occur.

4.2.4.4 Mixed Behavior

As mentioned above, a single chlorinated solvent plume can exhibit all three types of behavior in different portions of the plume. This can be beneficial for natural biodegradation of CAH plumes. For example, Wiedemeier *et al.* (1996b) describe a plume at Plattsburgh AFB, New York that exhibits Type 1 behavior in the source area and Type 3 behavior downgradient from the source. The best scenario involves a plume in which PCE, TCE, and DCE are reductively dehalogenated (Type 1 or Type 2 behavior), then VC is oxidized (Type 3 behavior), either aerobically or via iron reduction. VC is oxidized to carbon dioxide in this type of plume and does not accumulate. The following sequence of reactions occurs in a plume that exhibits this type of mixed behavior.

PCE → TCE → DCE → VC →Carbon Dioxide

In general, the TCE, DCE, and VC may attenuate at approximately the same rate, and thus these reactions may be confused with simple dilution. Note that no ethene is produced during this reaction. VC is removed from the system much faster under these conditions than it is under VC-reducing conditions.

A less desirable scenario, but one in which all contaminants may be entirely biodegraded, involves a plume in which all CAHs are reductively dehalogenated via Type 1 or Type 2 behavior. VC is reduced to ethene, which may be further reduced to ethane or methane. The following sequence of reactions occur in this type of plume.

PCE → TCE → DCE → VC → Ethene or Ethane

This sequence has been investigated by Freedman and Gossett (1989). In this type of plume, VC degrades more slowly than TCE, and thus tends to accumulate.

4.3 DISTRIBUTION OF CAHS AND DAUGHTER PRODUCTS

One of the most straightforward methods for evaluating the site-specific occurrence and method(s) of biodegradation of CAHs is to measure the distribution of target CAHs and their biodegradation byproducts. At the same time, it is also useful to measure the distribution of other contaminants that may be acting as sources of electron donors (e.g., BTEX).

Because reductive dehalogenation is the most common biodegradation reaction, a typical pattern (for example, as presented by Vogel, 1994) would have TCE (and or PCE) concentrations being highest in the source area, with elevated DCE concentrations (consisting mostly of *cis*-1,2-DCE) in and just downgradient from the source area. Vinyl chloride concentrations could be present along the entire plume length, with the highest VC concentrations likely to be found near the downgradient end of the CAH plume. If VC is being reductively dehalogenated, dissolved ethene will also be present downgradient of the source area, in the vicinity of the highest concentrations of VC. Data collected at OU5 are discussed in the following subsections.

4.3.1 Distribution of TCE in Groundwater

As described in Section 1.2, TCE was reportedly used at the Tooele Rail Shop from approximately 1949 to 1964. Similar to previous investigations, the August 1995 groundwater quality data show that TCE is the most widespread CAH present in groundwater at OU5, and is also the CAH present at the highest concentrations. Analytical results for TCE dissolved in groundwater samples are summarized in Table 4.2, and the areal distribution of TCE concentrations measured in August 1996 is shown on Figure 4.5. The August 1996 distribution of TCE is very similar to that measured during previous sampling events. The primary solvent source appears to be the former leachfield near Building 1723A. However, the presence of TCE dissolved in groundwater north of the Tooele Rail Shop in the vicinity of Building 1781 and upgradient (east) from the shop at wells MW148 and MW149 indicate the presence of other, relatively minor sources. The TCE detected north and east of the Rail Shop may be related to the former wastewater treatment plant and waste disposal practices at the former Base housing area, respectively (Radian, 1995).

The substantial decrease in TCE concentrations between wells MW159 (227 micrograms per liter [μg/L]) and MW143 (90 μg/L), near the western end of the 100-μg/L TCE isopleth, may be related to the (probable) presence of a north/south-trending drain line between the two wells (Figure 4.5). Groundwater contaminated with TCE may discharge to the drain line, causing it to act as a partial barrier to contaminant migration. The source of the TCE detected north of the main plume and west of the north end of Meadows Park (wells MW141 and MW165) is not known, but may be related to leakage from a second, nearby field drain that is believed to trend southeast/northwest (Figure 4.5). TCE also was detected at a concentration of 5.2 μg/L in a surface water sample collected from a concrete-lined channel that bounds Meadows Park on the north side. Radian (1995) reports that it is unclear (though possible) that this water is related to the field drain.

A vertical profile of the August 1996 TCE plume along cross-section line A-A' (Figure 4.5) is shown on Figure 4.6. Field gas chromatograph (GC) screening results of discrete pore fluid samples collected in 1993 by Radian (1995) are also shown on this figure. The highest dissolved TCE concentrations in the vicinity of the former gravel leachfield (the primary source area) appear to occur in the shallow portion of the surficial aquifer. This is evidenced by the TCE concentrations in shallow well MW154 (259 μg/L) and deep well MW155 (61.9 μg/L). The 1993 detection of 250 μg/L TCE in the pore fluid sample collected from upgradient CPT borehole C829 is anomalous and does not agree with water quality data from adjacent well MW148.

At well pair MW137/138, TCE concentrations are higher in the deeper well, indicating that the plume has migrated vertically as well as horizontally to the west.

TABLE 4.2
CHLORINATED ALIPHATIC HYDROCARBONS IN GROUNDWATER
AUGUST 1996
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Sample Location	Sample Date	VC[a/] (µg/L)[b/]	1,1-DCE[a/] (µg/L)	Methylene Chloride (µg/L)	trans-1,2-DCE (µg/L)	1,1-DCA[a/] (µg/L)	cis-1,2-DCE (µg/L)	Chloroform (µg/L)	1,1,1-TCA[a/] (µg/L)
MW-122	8/8/96	ND[c/]	< 1.0	< 5.0	ND	3.4	1.1	< 1.0	16.1
MW-124	8/7/96	ND	ND	< 5.0	ND	ND	ND	ND	ND
MW-125	8/8/96	ND	ND	< 5.0	ND	ND	< 1.0	< 1.0	< 1.0
MW-126	8/8/96	ND	ND	< 5.0	ND	ND	ND	2.2	ND
MW-127	8/9/96	ND	< 1.0	< 5.0	ND	< 1.0	1.9	1.0	20.3
MW-128	8/9/96	ND	ND	< 5.0	ND	ND	< 1.0	ND	ND
MW-129	8/10/96	ND	ND	< 5.0	ND	ND	ND	< 1.0	ND
MW-130	8/9/96	ND	ND	< 5.0	ND	ND	ND	ND	ND
MW-133	8/7/96	ND	ND	< 5.0	ND	ND	ND	ND	ND
MW-134	8/7/96	ND	ND	< 5.0	ND	ND	ND	ND	ND
MW-135	8/10/96	ND	ND	< 5.0	ND	ND	ND	ND	ND
MW-136	8/8/96	ND	< 1.0	< 5.0	ND	ND	ND	< 1.0	1.8
MW-136(dup)[d/]	8/8/96	ND	< 1.0	< 5.0	ND	ND	ND	< 1.0	1.9
MW-137	8/9/96	ND	2.1	< 5.0	ND	2.6	13.9	< 1.0	15.8
MW-137A[d/]	8/9/96	ND	2.0	< 5.0	ND	2.7	14.5	< 1.0	15.7
MW-138	8/9/96	ND	1.9	< 5.0	ND	< 1.0	1.2	ND	3.3
MW-139	8/6/96	ND	ND	< 5.0	ND	ND	ND	ND	ND
MW-140	8/8/96	ND	ND	< 5.0	ND	ND	< 1.0	ND	< 1.0
MW-141	8/7/96	ND	ND	< 5.0	ND	ND	ND	ND	ND
MW-142	8/8/96	ND	ND	< 5.0	ND	ND	ND	ND	< 1.0
MW-143	8/8/96	ND	ND	< 5.0	ND	< 1.0	2.5	ND	< 1.0
MW-144	8/7/96	ND	ND	< 5.0	ND	ND	ND	ND	< 1.0
MW-144(dup)[d/]	8/7/96	ND	ND	< 5.0	ND	ND	ND	< 1.0	< 1.0
MW-145	8/7/96	ND	ND	< 5.0	ND	ND	ND	ND	< 1.0
MW-146	8/6/96	ND	< 1.0	< 5.0	ND	2.1	< 1.0	ND	6.9
MW-147	8/8/96	ND	ND	< 5.0	ND	ND	< 1.0	ND	ND
MW-147A[d/]	8/8/96	ND	ND	< 5.0	ND	ND	< 1.0	ND	ND
MW-148	8/10/96	ND	ND	< 5.0	ND	ND	ND	< 1.0	ND
MW-149	8/8/96	ND	ND	< 5.0	ND	ND	ND	< 1.0	ND
MW-150	8/9/96	ND	ND	< 5.0	ND	ND	ND	1.1	ND

TABLE 4.2 (Continued)
CHLORINATED ALIPHATIC HYDROCARBONS IN GROUNDWATER
AUGUST 1996
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Sample Location	Sample Date	Carbon Tetrachloride (µg/L)	1,2-DCA (µg/L)	TCE[a] (µg/L)	1,1,2-TCA (µg/L)	PCE[a] (µg/L)	Chlorobenzene (µg/L)	1,3-DCB[a] (µg/L)	1,4-DCB (µg/L)	1,2-DCB (µg/L)
MW-122	8/8/96	ND	ND	1.3	ND	< 1.0	ND	ND	ND	ND
MW-124	8/7/96	ND	ND	ND	ND	< 1.0	ND	ND	ND	ND
MW-125	8/8/96	ND	ND	7.4	ND	ND	ND	ND	ND	ND
MW-126	8/8/96	ND	ND	1.0	ND	ND	ND	ND	ND	ND
MW-127	8/9/96	ND	ND	186	ND	ND	ND	ND	ND	ND
MW-128	8/9/96	ND	ND	12.7	ND	ND	ND	ND	ND	ND
MW-129	8/10/96	ND	ND	55.8	ND	ND	ND	ND	ND	ND
MW-130	8/9/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-133	8/7/96	ND	ND	1.5	ND	ND	ND	ND	ND	ND
MW-134	8/7/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-135	8/10/96	ND	ND	1.7	ND	ND	ND	ND	ND	< 1.0
MW-136	8/8/96	ND	ND	19.9	ND	ND	ND	ND	ND	ND
MW-136(dup)[d]	8/8/96	ND	ND	21.1	ND	ND	ND	ND	ND	ND
MW-137	8/9/96	ND	ND	228	ND	ND	ND	ND	ND	ND
MW-137A[d]	8/9/96	ND	ND	240	ND	ND	ND	ND	ND	ND
MW-138	8/9/96	ND	ND	355	ND	ND	ND	ND	ND	ND
MW-139	8/6/96	ND	ND	3.7	ND	ND	ND	ND	ND	ND
MW-140	8/8/96	ND	ND	37.1	ND	ND	ND	ND	ND	ND
MW-141	8/7/96	ND	ND	5.1	ND	253	ND	ND	ND	ND
MW-142	8/8/96	ND	ND	19.6	ND	ND	ND	ND	ND	ND
MW-143	8/8/96	ND	ND	89.6	ND	ND	ND	ND	ND	ND
MW-144	8/7/96	ND	ND	11.6	ND	ND	ND	ND	ND	ND
MW-144(dup)[d]	8/7/96	ND	ND	11.2	ND	ND	ND	ND	ND	ND
MW-145	8/7/96	ND	ND	6.9	ND	ND	ND	ND	< 1.0	< 1.0
MW-146	8/6/96	ND	ND	1.6	ND	< 1.0	ND	ND	ND	ND
MW-147	8/8/96	ND	ND	27.6	ND	ND	ND	ND	ND	ND
MW-147A[d]	8/8/96	ND	ND	25.9	ND	ND	ND	ND	ND	ND
MW-148	8/10/96	ND	ND	17.2	ND	ND	ND	ND	ND	ND
MW-149	8/8/96	ND	ND	1.4	ND	ND	ND	ND	ND	ND
MW-150	8/9/96	ND	ND	4.6	ND	ND	ND	ND	ND	ND

TABLE 4.2
CHLORINATED ALIPHATIC HYDROCARBONS IN GROUNDWATER
AUGUST 1996
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Sample Location	Sample Date	VC[a] (µg/L)[b]	1,1-DCE[a] (µg/L)	Methylene Chloride (µg/L)	trans-1,2-DCE (µg/L)	1,1-DCA[a] (µg/L)	cis-1,2-DCE (µg/L)	Chloroform (µg/L)	1,1,1-TCA[a] (µg/L)
MW-151	8/9/96	ND	ND	< 5.0	ND	ND	ND	ND	ND
MW-151(dup)[d]	8/9/96	ND	ND	< 5.0	ND	ND	ND	ND	ND
MW-153	8/13/96	ND	ND	< 5.0	ND	ND	ND	ND	ND
MW-154	8/10/96	ND	2.3	< 5.0	< 1.0	5.6	15.6	1.2	64.2
MW-155	8/10/96	ND	ND	< 5.0	ND	ND	ND	< 1.0	ND
MW-155(dup)[d]	8/10/96	ND	ND	< 5.0	ND	ND	ND	< 1.0	ND
MW-158	8/6/96	ND	1.0	< 5.0	ND	1.7	1.1	1.2	12.7
MW-159	8/9/96	ND	1.5	< 5.0	ND	1.0	3.5	1.0	6.0
MW-160	8/7/96	ND	ND	< 5.0	ND	ND	ND	< 1.0	ND
MW-161	8/6/96	ND	< 1.0	< 5.0	ND	< 1.0	ND	ND	1.1
MW-162	8/7/96	ND	ND	< 5.0	ND	ND	ND	< 1.0	< 1.0
MW-163	8/10/96	ND	ND	< 5.0	ND	ND	1.0	ND	ND
MW-164	8/7/96	ND	ND	< 5.0	ND	ND	ND	< 1.0	ND
MW-164(dup)[d]	8/7/96	ND	ND	< 5.0	ND	ND	ND	< 1.0	ND
MW-165	8/7/96	ND	ND	< 5.0	ND	ND	ND	2.1	ND
MW-167	8/6/96	ND	ND	< 5.0	ND	ND	ND	1.2	ND
MW-168	8/10/96	ND	ND	< 5.0	ND	ND	ND	ND	< 1.0
MW-169	8/10/96	ND	ND	< 5.0	ND	ND	ND	ND	ND
TAD-4	8/12/96	ND	ND	< 5.0	ND	ND	ND	ND	ND
TAD-6	8/10/96	ND	ND	< 5.0	ND	ND	ND	ND	ND
MP-1s	8/12/96	ND	ND	< 5.0	ND	ND	ND	ND	ND
MP-1d	8/12/96	ND	ND	< 5.0	ND	ND	ND	ND	ND
MP-1d(dup)[d]	8/12/96	ND	ND	< 5.0	ND	ND	ND	< 1.0	ND
MP-2s	8/13/96	ND	ND	< 5.0	ND	ND	ND	1.1	ND
MP-2d	8/13/96	ND	ND	< 5.0	ND	ND	5.1	ND	ND
MP-3d	8/13/96	ND	ND	< 5.0	ND	ND	ND	ND	ND
MP-5s	8/12/96	ND	ND	< 5.0	ND	ND	ND	ND	1.2
MP-15[d]	8/12/96	ND	ND	< 5.0	ND	ND	ND	< 1.0	1.2
MP-6s	8/12/96	ND	ND	< 5.0	ND	ND	ND	< 1.0	ND
MP-6s(dup)[d]	8/12/96	ND	ND	< 5.0	ND	ND	ND	ND	ND

TABLE 4.2 (Continued)
CHLORINATED ALIPHATIC HYDROCARBONS IN GROUNDWATER
AUGUST 1996
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Sample Location	Sample Date	Carbon Tetrachloride (µg/L)	1,2-DCA (µg/L)	TCE[a] (µg/L)	1,1,2-TCA (µg/L)	PCE[a] (µg/L)	Chlorobenzene (µg/L)	1,3-DCB[a] (µg/L)	1,4-DCB (µg/L)	1,2-DCB (µg/L)
MW-151	8/9/96	ND	ND	3	ND	ND	ND	ND	ND	ND
MW-151(dup)[d]	8/9/96	ND	ND	2.9	ND	ND	ND	ND	ND	ND
MW-153	8/13/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-154	8/10/96	ND	ND	259	ND	ND	ND	ND	ND	ND
MW-155	8/10/96	ND	ND	61.9	ND	ND	ND	ND	ND	ND
MW-155(dup)[d]	8/10/96	ND	ND	58.9	ND	ND	ND	ND	ND	ND
MW-158	8/6/96	ND	ND	2.0	ND	ND	ND	ND	ND	ND
MW-159	8/9/96	ND	ND	227	ND	ND	ND	ND	ND	ND
MW-160	8/7/96	ND	ND	1.6	ND	ND	ND	ND	ND	ND
MW-161	8/6/96	ND	ND	4.7	ND	ND	ND	ND	ND	ND
MW-162	8/7/96	ND	ND	4.6	ND	ND	ND	ND	ND	ND
MW-163	8/10/96	ND	ND	35.8	ND	ND	ND	ND	ND	ND
MW-164	8/7/96	ND	ND	< 1.0	ND	ND	ND	ND	ND	ND
MW-164(dup)[d]	8/7/96	ND	ND	< 1.0	ND	ND	ND	ND	ND	ND
MW-165	8/7/96	5.3	ND	8.9	ND	ND	ND	ND	ND	ND
MW-167	8/6/96	ND	ND	< 1.0	ND	ND	ND	ND	ND	ND
MW-168	8/10/96	ND	ND	< 1.0	ND	ND	ND	ND	ND	ND
MW-169	8/10/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
TAD-4	8/12/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
TAD-6	8/10/96	ND	ND	2.2	ND	ND	ND	ND	ND	ND
MP-1s	8/12/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-1d	8/12/96	ND	ND	12.6	ND	ND	ND	ND	ND	ND
MP-1d(dup)[d]	8/12/96	ND	ND	13.0	ND	ND	ND	ND	ND	ND
MP-2s	8/13/96	ND	ND	6.1	ND	ND	ND	ND	ND	ND
MP-2d	8/13/96	ND	ND	5.4	ND	ND	ND	ND	ND	ND
MP-3d	8/13/96	ND	ND	< 1.0	ND	ND	ND	ND	ND	ND
MP-5s	8/12/96	ND	ND	12.4	ND	ND	ND	ND	ND	ND
MP-15[d]	8/12/96	ND	ND	11.9	ND	ND	ND	ND	ND	ND
MP-6s	8/12/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-6s(dup)[d]	8/12/96	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 4.2
CHLORINATED ALIPHATIC HYDROCARBONS IN GROUNDWATER
AUGUST 1996
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Sample Location	Sample Date	VC[a/] (µg/L)[b/]	1,1-DCE[a/] (µg/L)	Methylene Chloride (µg/L)[c/]	trans-1,2-DCE (µg/L)	1,1-DCA[a/] (µg/L)	cis-1,2-DCE (µg/L)	Chloroform (µg/L)	1,1,1-TCA[a/] (µg/L)
MP-7s	8/12/96	ND	ND	< 5.0	ND	ND	ND	ND	ND
MP-8s	8/12/96	ND	ND	< 5.0	ND	ND	ND	< 1.0	ND
MP-18[d/]	8/12/96	ND	ND	< 5.0	ND	ND	ND	< 1.0	ND
MPS[e/]	8/12/96	ND	ND	< 5.0	ND	ND	ND	3.1	ND
MPFD[f/]	8/12/96	ND	ND	< 5.0	ND	ND	ND	1.5	ND
MS[e/]	8/12/96	ND	<1.0	< 5.0	ND	1.4	2.2	ND	4.1
MS(dup)[d/]	8/12/96	ND	<1.0	< 5.0	ND	1.3	2.2	ND	3.7
OU5-FB1	8/12/96	ND	ND	< 5.0	ND	ND	ND	7.5	ND
OU5-FB1(dup)[d/]	8/12/96	ND	ND	< 5.0	ND	ND	ND	7.8	ND

TABLE 4.2 (Continued)
CHLORINATED ALIPHATIC HYDROCARBONS IN GROUNDWATER
AUGUST 1996
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Sample Location	Sample Date	Carbon Tetrachloride (µg/L)	1,2-DCA (µg/L)	TCE[a/] (µg/L)	1,1,2-TCA (µg/L)	PCE[a/] (µg/L)	Chlorobenzene (µg/L)	1,3-DCB[a/] (µg/L)	1,4-DCB (µg/L)	1,2-DCB (µg/L)
MP-7s	8/12/96	ND	ND	3.5	ND	ND	ND	ND	< 1.0	< 1.0
MP-8s	8/12/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-18[d/]	8/12/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
MPS[e/]	8/12/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
MPFD[f/]	8/12/96	2.1	ND	5.2	ND	ND	ND	ND	ND	ND
MS[g/]	8/12/96	ND	ND	1.0	ND	ND	ND	ND	ND	ND
MS(dup)[d/]	8/12/96	ND	ND	1.0	ND	ND	ND	ND	ND	ND
OU5-FB1	8/12/96	ND	ND	ND	ND	ND	ND	ND	< 1.0	ND
OU5-FB1(dup)[d/]	8/12/96	ND	ND	ND	ND	ND	ND	ND	ND	ND

[a/] VC = vinyl chloride, DCE = dichloroethene, DCA = dichloroethane, TCA = trichloroethane, TCE = trichloroethene, PCE = tetrachloroethene, DCB=dichlorobenzene.

[b/] µg/L = micrograms per liter.

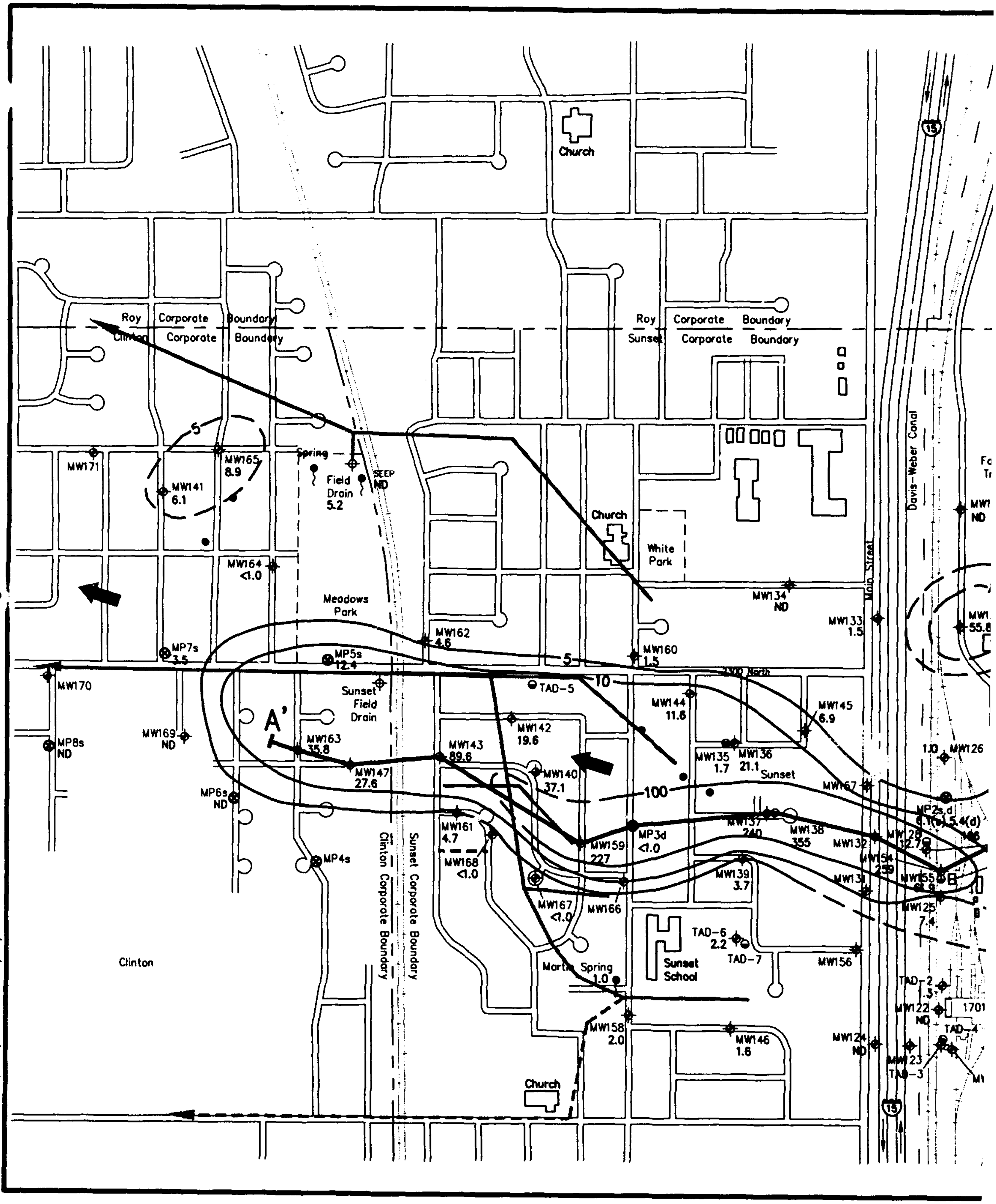
[c/] ND = not detected.

[d/] Duplicate of preceding sample.

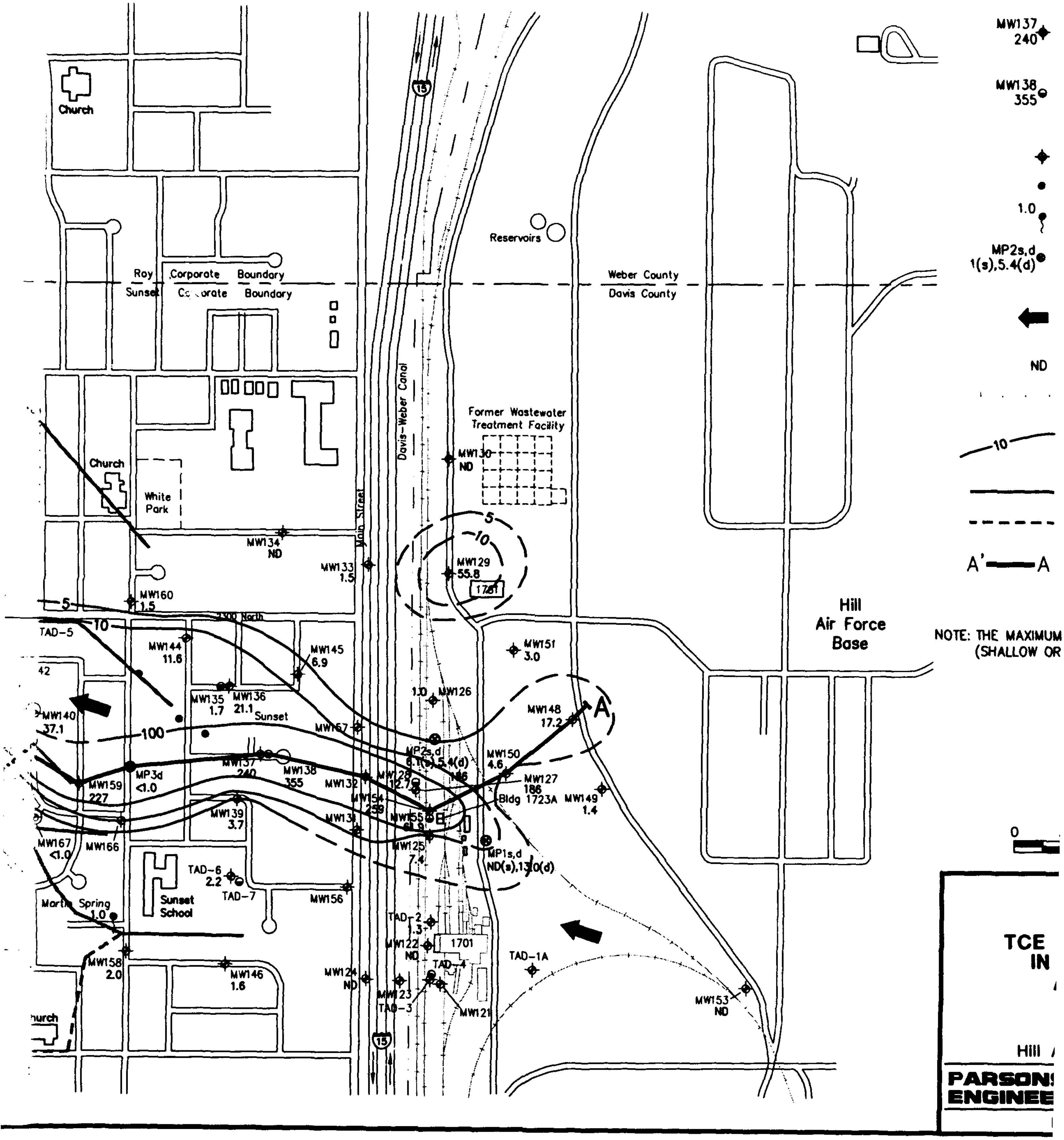
[e/] MPS = Seep in northeastern corner of Meadows Park.

[f/] MPFD = Meadow Park field drainage; sample collected at downstream end of open, concrete-lined channel at north end of Meadows Park.

[g/] MS = Martin Spring.



K:\AFCEE\72 HILL\97DN0099, 04/23/97 at 12:34



Church
Reservoirs
Roy Corporate Boundary
Sunset Corporate Boundary
Weber County
Davis County
Davis-Weber Canal
Main Street
15
Former Wastewater Treatment Facility
Church
White Park
MW130 ND
MW134 ND
MW133 1.5
MW129 55.8
1701
MW160 1.5
2300 North
TAD-5
MW144 11.6
MW145 6.9
MW151 3.0
Hill Air Force Base
MW135 1.7
MW136 21.1
Sunset
MW157
1.0
MW126
MW148 17.2
A
MW140 37.1
100
MP2s,d 6.1(s),5.4(d)
MW150 4.6
186
MW127 186
MW137 240
MW138 355
MW132
MW128 12.7
MW159 227
MP3d <1.0
MW154 259
Bldg 1723A
MW149 1.4
MW139 3.7
MW131
MW155 61.9
MW167 <1.0
MW166
MW125 7.4
MP1s,d ND(s),13.0(d)
TAD-6 2.2
TAD-7
Sunset School
Martin Spring 1.0
MW156
TAD-2 1.3
MW122 ND
1701
TAD-4
TAD-1A
MW158 2.0
MW146 1.6
MW124 ND
MW123
TAD-3
MW121
MW153 ND
Church
5
10
MW137 240
MW138 355
1.0
MP2s,d 1(s),5.4(d)
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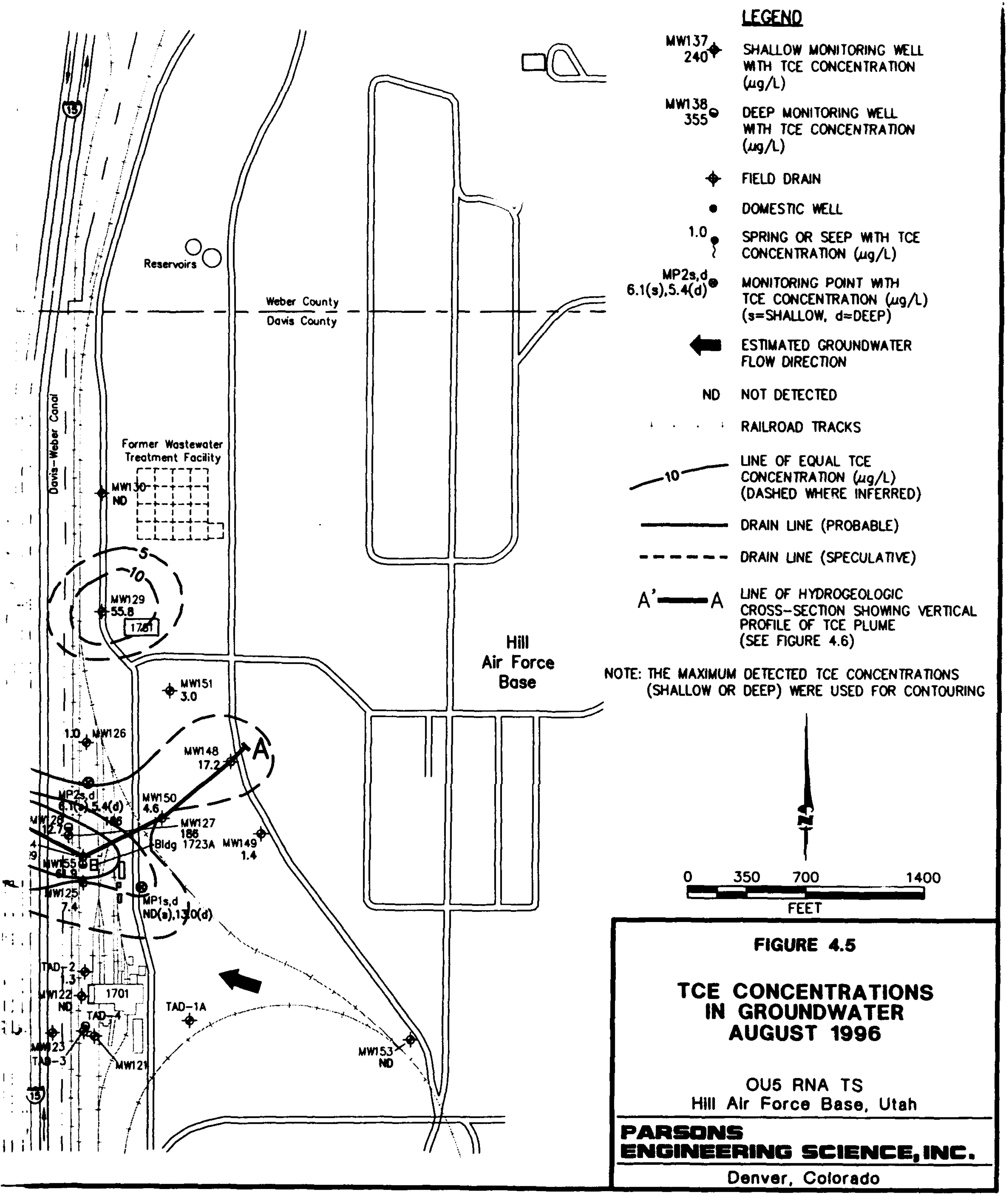

FIGURE 4.5

TCE CONCENTRATIONS IN GROUNDWATER AUGUST 1996

OU5 RNA TS
Hill Air Force Base, Utah

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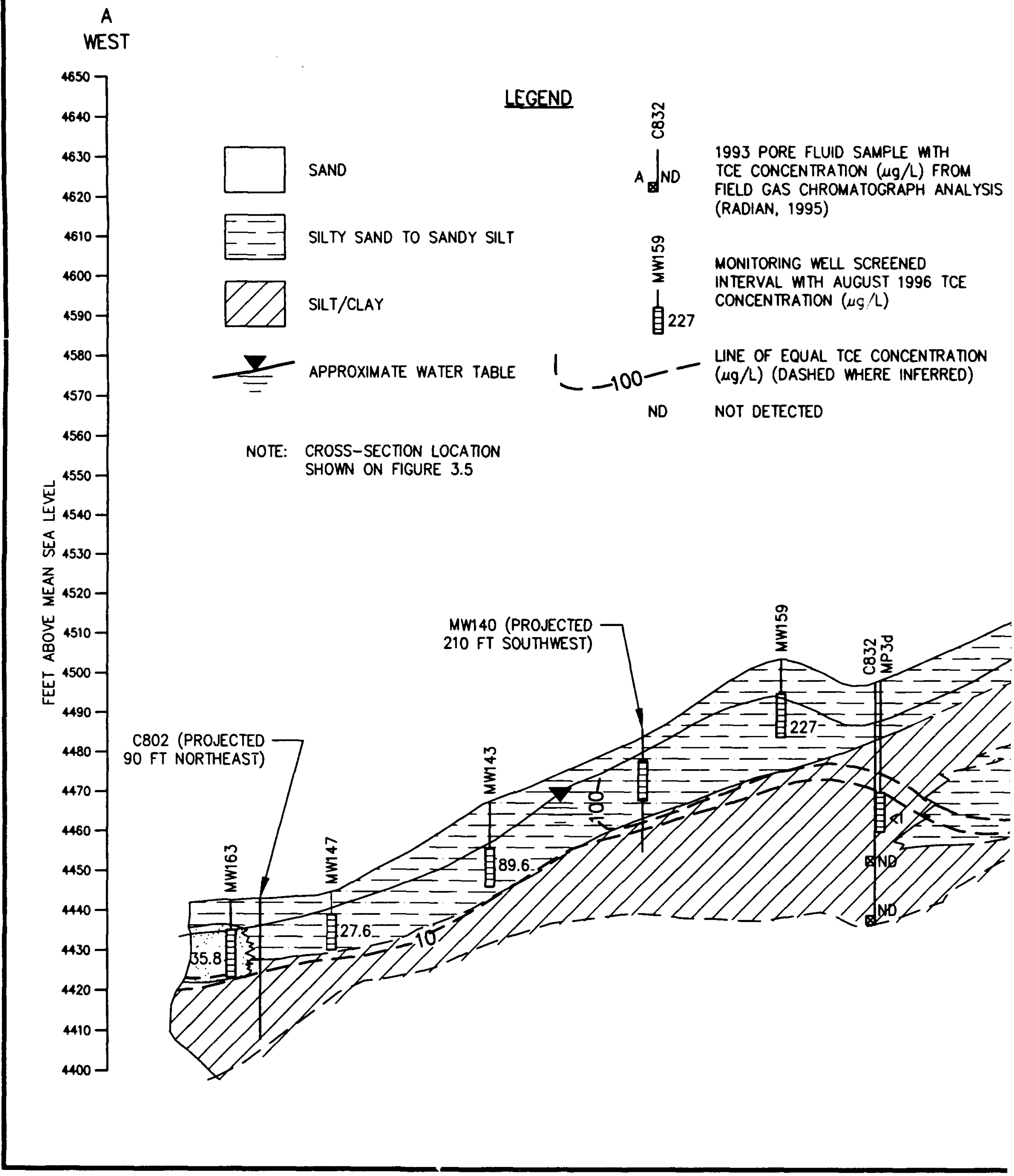
Denver, Colorado



NOTE: CROSS-SECTION LOCATION SHOWN ON FIGURE 3.5

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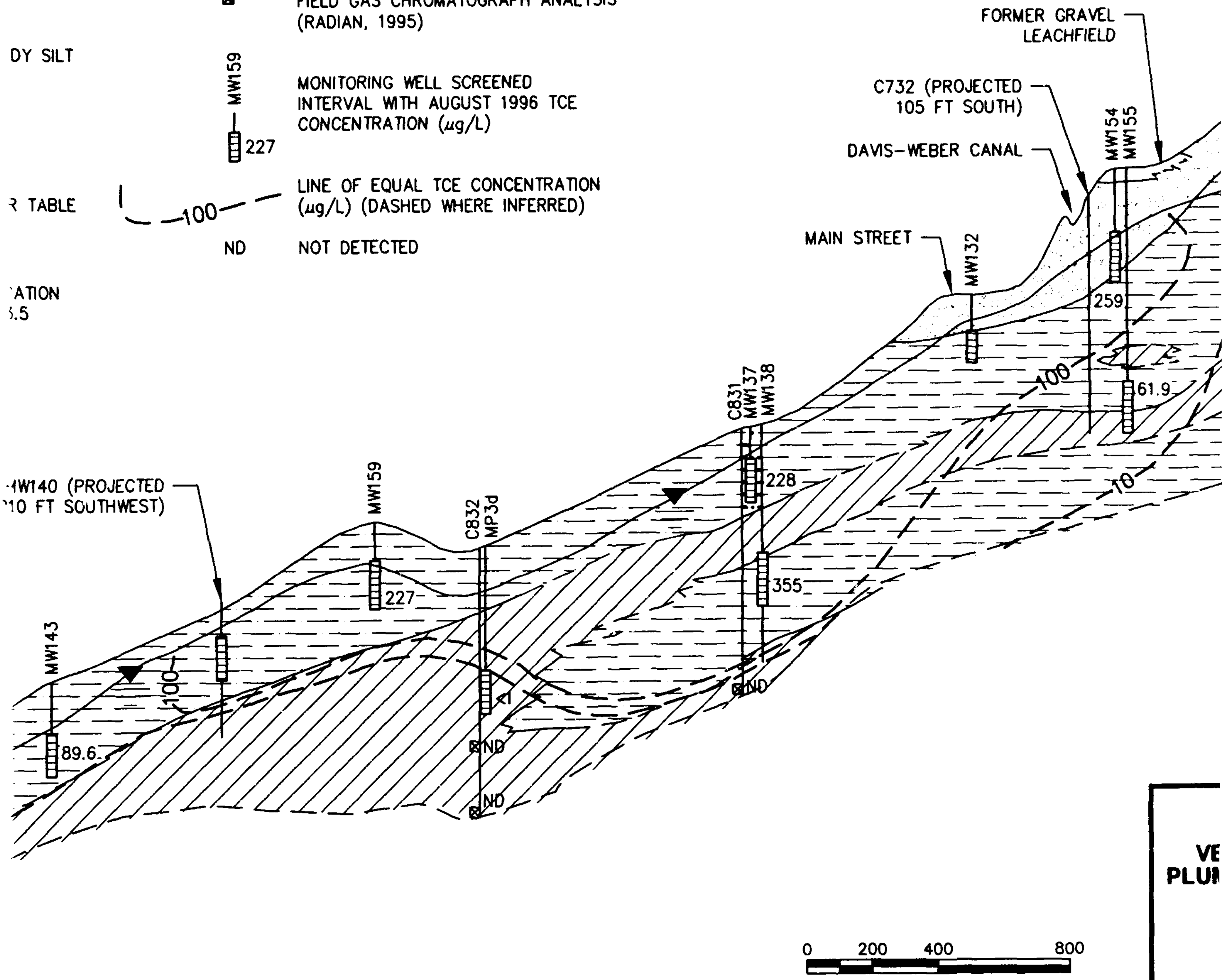
C832 A ⊠ ND	1993 PORE FLUID SAMPLE WITH TCE CONCENTRATION (µg/L) FROM FIELD GAS CHROMATOGRAPH ANALYSIS (RADIAN, 1995)
MW159 227	MONITORING WELL SCREENED INTERVAL WITH AUGUST 1996 TCE CONCENTRATION (µg/L)
100	LINE OF EQUAL TCE CONCENTRATION (µg/L) (DASHED WHERE INFERRED)
ND	NOT DETECTED



HORIZONTAL SCALE: 1" = 400'
VERTICAL SCALE: 1" = 30'
VERTICAL EXAGGERATION: 13.3x

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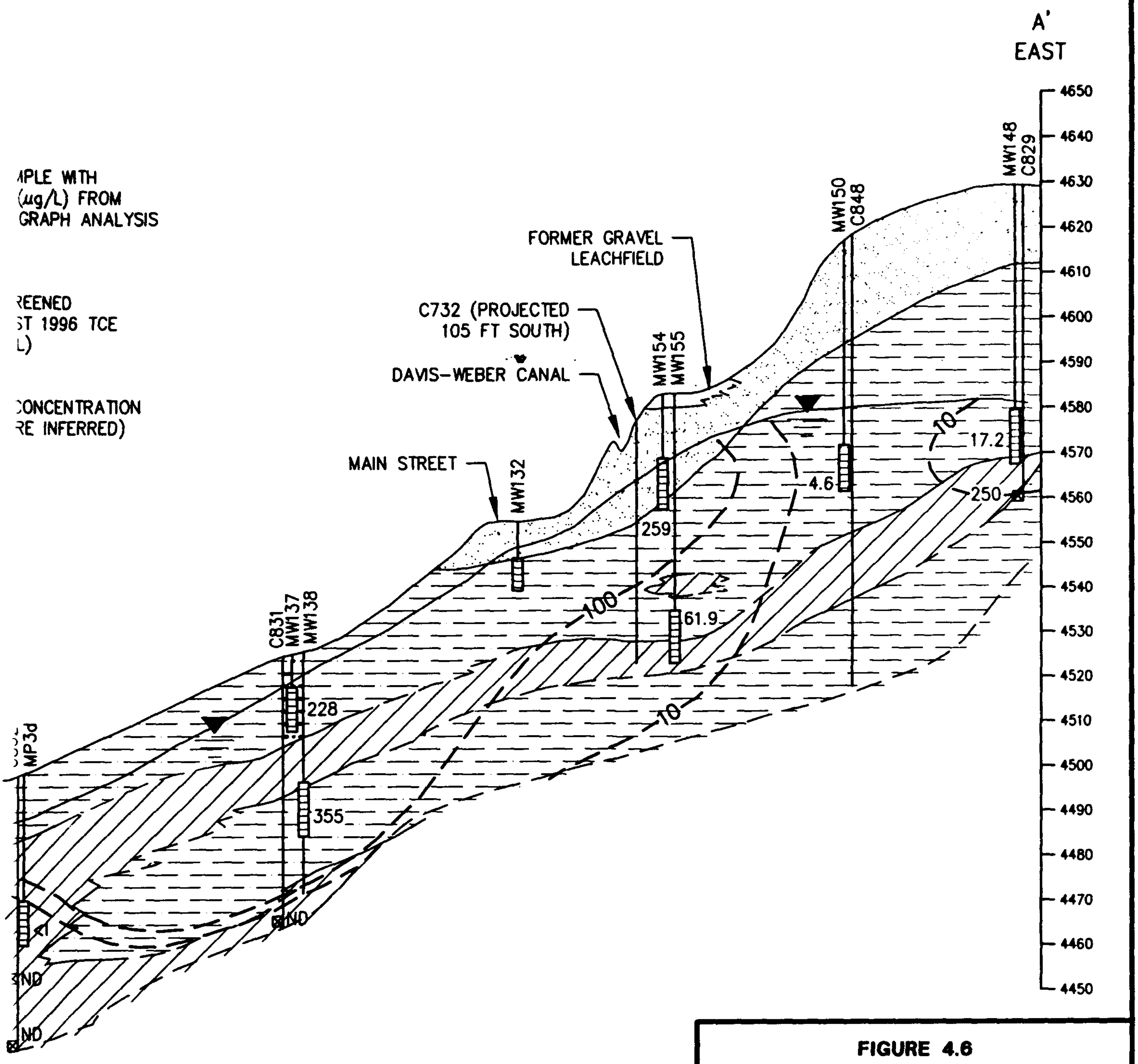

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HORIZONTAL SCALE: 1" = 400'
VERTICAL SCALE: 1" = 30'
VERTICAL EXAGGERATION: 13.3x

FIGURE 4.6

VERTICAL PROFILE OF TCE PLUME ALONG HYDROGEOLOGIC CROSS-SECTION A-A'
AUGUST 1996

OU5 RNA TS
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This vertical migration may be caused primarily by the presence of a downward vertical hydraulic gradient in this area. In addition, stratigraphic information presented by Radian (1995) indicates that the uppermost silt/clay layer depicted on Figure 4.6 is not a continuous aquitard, but is composed of silty to clayey interbeds that may be laterally discontinuous. Therefore, this finer-grained zone is not an effective, laterally continuous barrier to downward migration of contaminants.

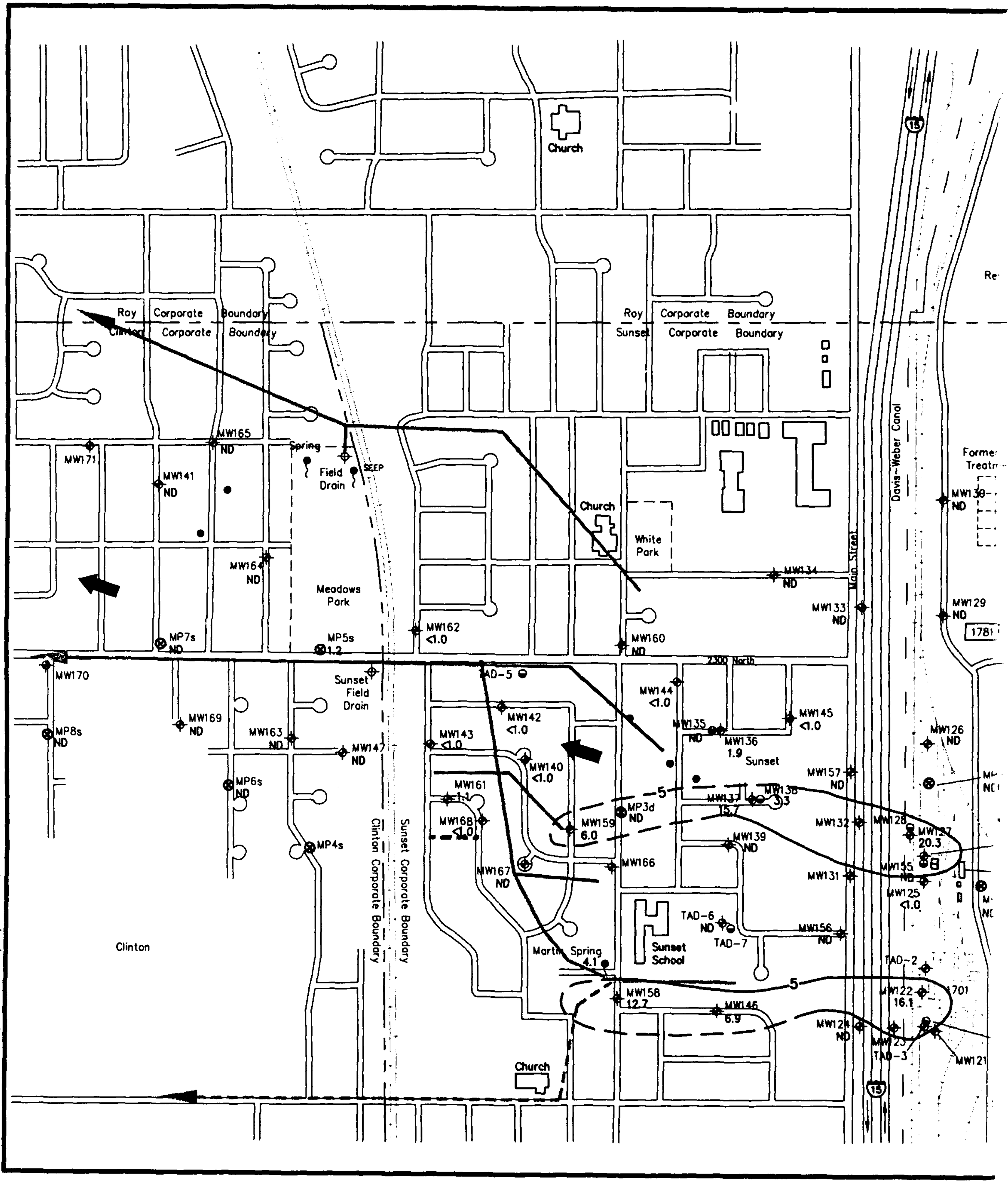
Further to the west in the vicinity of monitoring point MP3, stratigraphic and water quality data suggest that the plume migrates to shallower portions of the surficial aquifer due to the pinching out of the deeper sandy zone. This interpretation is supported by the sampling results from monitoring point MP3 (TCE <1 µg/L) and the lack of TCE detections in the two pore fluid samples obtained from the adjacent CPT borehole C832. In addition, the soil sample collected from a depth of 31.5 to 35.5 feet bgs (just below the screen of MP3) was described as silty clay, indicating that the sandy zone encountered further to the east is not continuous at this location and depth.

4.3.2 Distribution of PCE in Groundwater

As shown on Figure 1.4, PCE was used at Hill AFB starting in the late 1960s. Historically, trace concentrations of PCE (<1 µg/L) have been detected in wells MW122, MW123, MW146, MW158, and at Martin Spring, south of the main TCE plume. During the September/October 1993 and September 1995 sampling events performed by Radian (1995 and 1996b), PCE was detected in well MW141 at concentrations of 133 µg/L and 333 µg/L, respectively. This well is located in the northwestern portion of the study area, north of the main TCE plume (Figure 4.5). As described above for TCE, the source of this solvent contamination west of the north end of Meadows Park is not known. Given that PCE was not detected elsewhere except for the five trace detections south of the TCE plume listed above, this secondary plume may be associated with a different source than the main TCE plume to the south, such as leakage from a nearby northwest/southeast-trending field drain. During this TS, PCE was detected only in wells MW141 (253 µg/L), MW146 (<1 µg/L), MW122(<1 µg/L), and MW124 (<1 µg/L) (Table 4.2).

4.3.3 Distribution of TCA in Groundwater

Figure 1.4 indicates that TCA has been used as a solvent at Hill AFB since the late 1960s. The CAH 1,1,1-TCA was detected during the RI (Radian, 1995) and this TS, but at generally lower concentrations and covering a smaller areal extent than TCE. August 1996 analysis results for 1,1,1-TCA are summarized in Table 4.2. As shown on Figure 4.7, the August 1996 sampling results indicate the presence of two discrete, narrow plumes of 1,1,1-TCA having concentrations exceeding 5 µg/L. One plume appears to be sourced at the former leachfield near Building 1723A, and extends to thewest beneath the city of Sunset. Like TCE, which appears to migrate to deeper portions of the surficial aquifer west of Main Street, concentrations of 1,1,1-TCA are present in deeper portions of the aquifer, though they appear to remain most elevated in the shallow portion of the surficial aquifer (see data for well pair MW137/MW138, Figure 4.7). The second 1,1,1-TCA plume appears to be sourced in the vicinity of Building 1701. Concentrations of 1,1,1-TCA in this plume exceed the TCE



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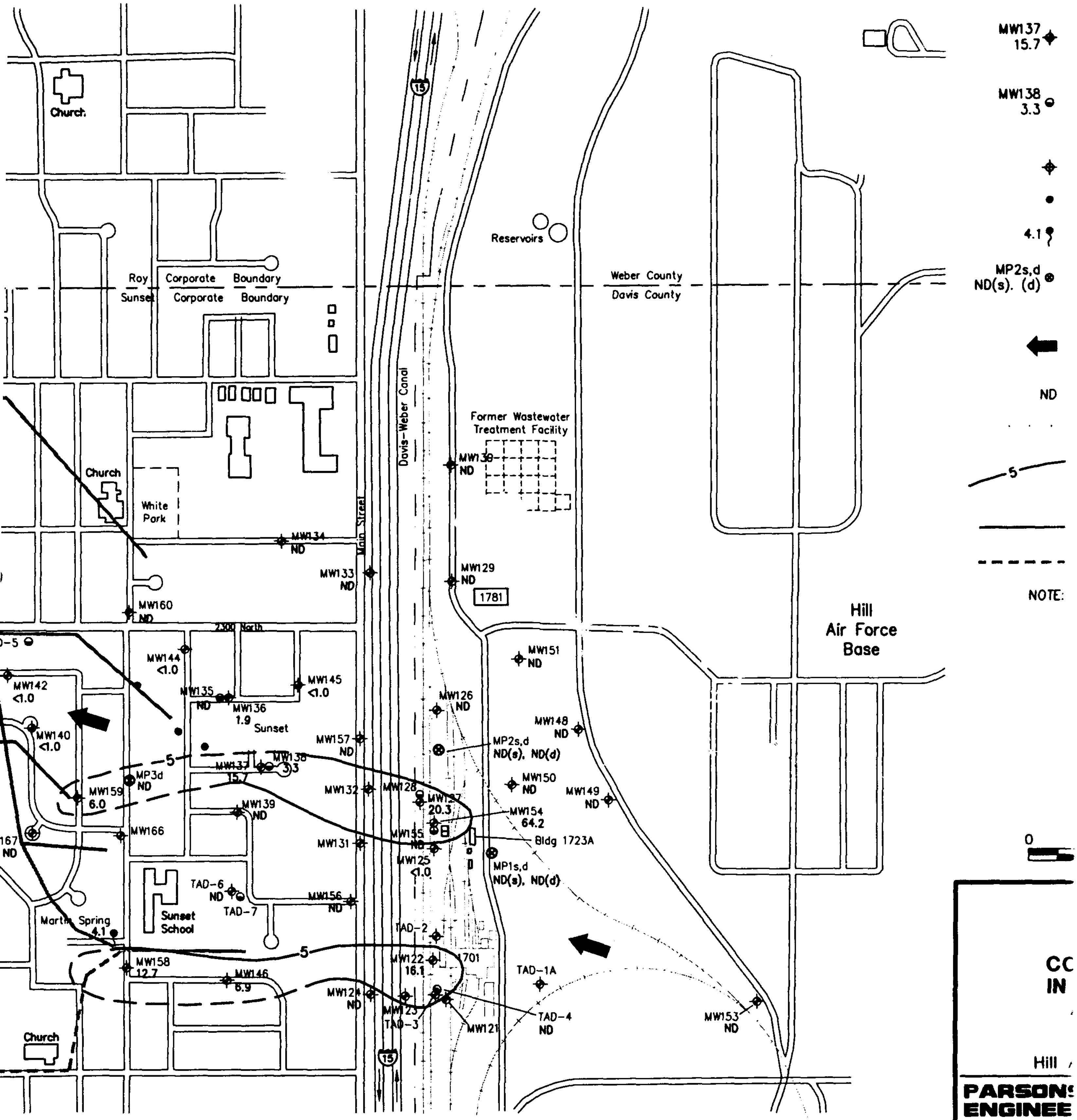

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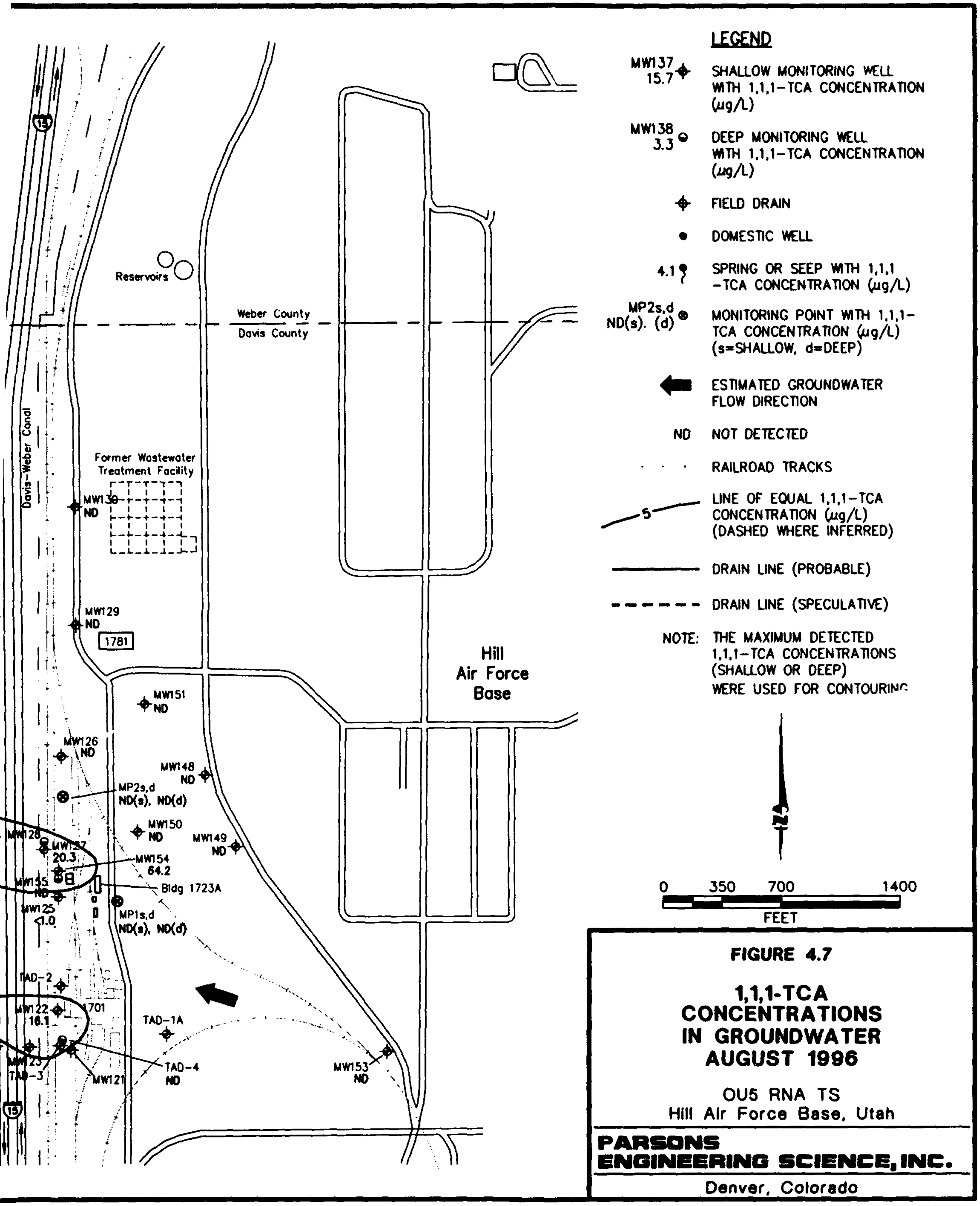

FIGURE 4.7

1,1,1-TCA CONCENTRATIONS IN GROUNDWATER AUGUST 1996

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concentrations detected in this area. The USEPA maximum contaminant level (MCL) and State of Utah water quality standard for 1,1,1-TCA are both 200 μg/L; therefore, neither of these plumes is of regulatory concern.

4.3.4 Distribution of DCE in Groundwater

Isomers of DCE detected in August 1996 groundwater samples include 1,1-DCE, *cis*-1,2-DCE, and *trans*-1,2-DCE. The DCE isomer detected most often and at the highest concentrations was *cis*-1,2-DCE. As measured in August 1996, the *cis*-1,2-DCE concentrations detected in site groundwater ranged from less than 1 μg/L to 15.6 μg/L, with the highest concentration detected in the primary source area at well MW154 (Table 4.2 and Figure 4.8). Low levels of *cis*-1,2-DCE (less than 5 μg/L) were detected as far downgradient as well MW163, located approximately 560 feet west of the Sunset/Clinton corporate boundary. The sampling data indicate that *cis*-1,2-DCE concentrations exceeding 5 μg/L do not extend more than approximately 1,900 feet west of the source area, as shown on Figure 4.8.

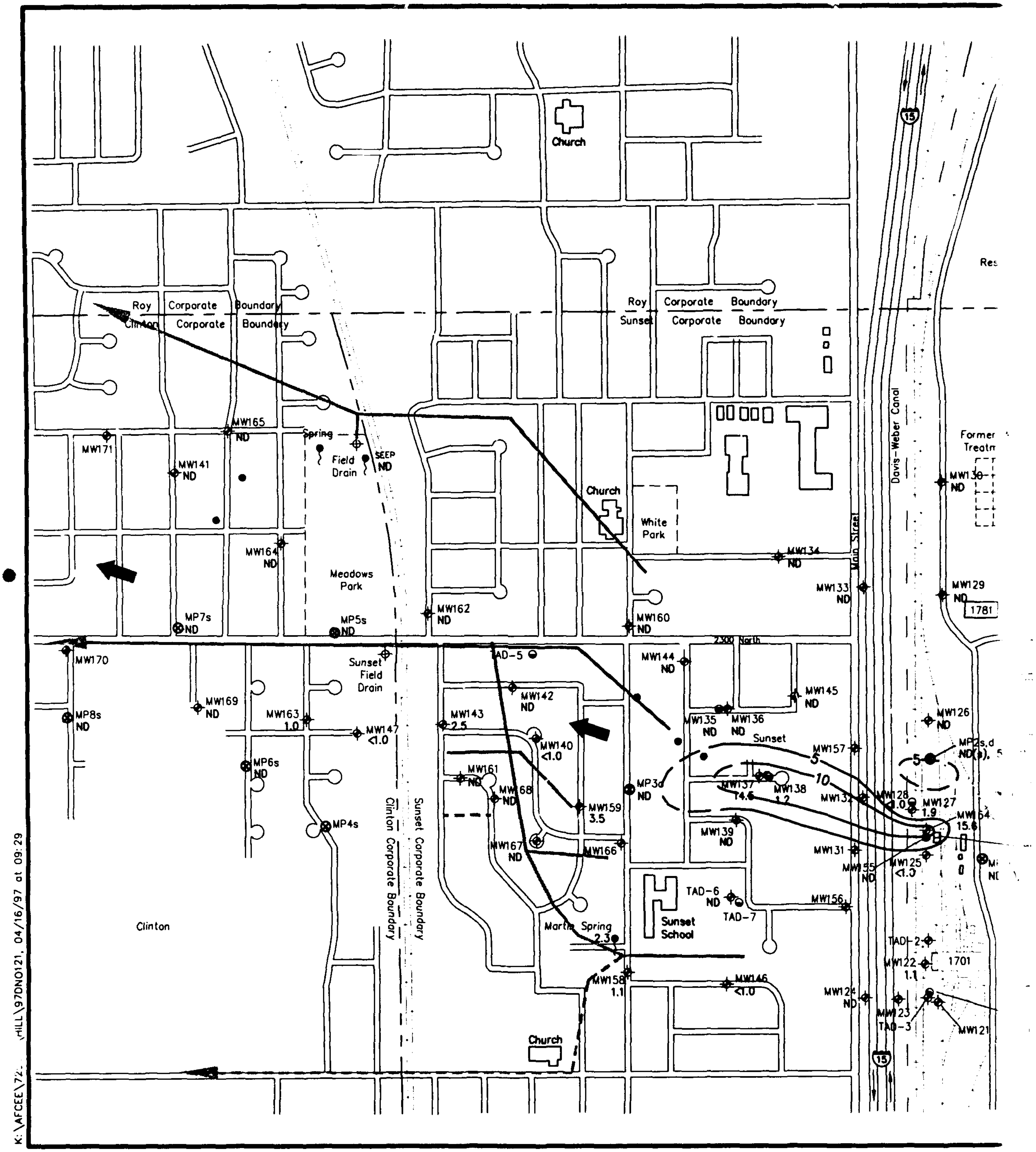
Data for well pairs in the DCE plume indicate that this chemical has penetrated the deeper portions of the surficial aquifer. The location and shape of the August 1996 *cis*-1,2-DCE plume coincides with that of the TCE plume (Figure 4.5), suggesting that TCE is being degraded to DCE via reductive dehalogenation in groundwater at OU5. However, the low magnitude of DCE concentrations relative to TCE concentrations, and the substantially greater areal extent of the TCE plume, suggests that only a minor fraction of the TCE is being reductively dehalogenated. As noted in Section 4.2.1, *cis*-1,2-DCE is a more common daughter product of this process than the other DCE isomers. The sample from MW154, which had the highest *cis*-1,2-DCE concentration in August 1996, also had the only detectable concentration of *trans*-1,2-DCE (<1 μg/L).

A *cis*-1,2-DCE concentration of 50 μg/L was detected in well MW132 in October 1995, indicating that reductive dehalogenation rates are higher immediately downgradient from the source area. This well, which was located along Main Street, was not found during the August 1996 sampling event, and appears to have been destroyed during construction of the air sparging system along the east side of Main Street. The higher reductive dehalogenation rate appears to be very localized, and is not sustained in more downgradient portions of the plume. The rapid reduction in *cis*-1,2-DCE concentrations west of MW132 suggests that this compound is being aerobically degraded.

Low concentrations of the CAH 1,1-DCE (ranging from <1.0 μg/L to 2.3 μg/L) were detected in 10 wells. Each of these wells also contained detectable concentrations of 1,1,1-TCA, and 1,1-DCE was most likely produced as a result of abiotic (without microbial mediation) transformation of 1,1,1-TCA (Vogel, 1994).

4.3.5 Distribution of VC in Groundwater

Vinyl chloride was not detected in OU5 groundwater samples collected in August 1996. During the RI sampling performed in September and October 1993, trace



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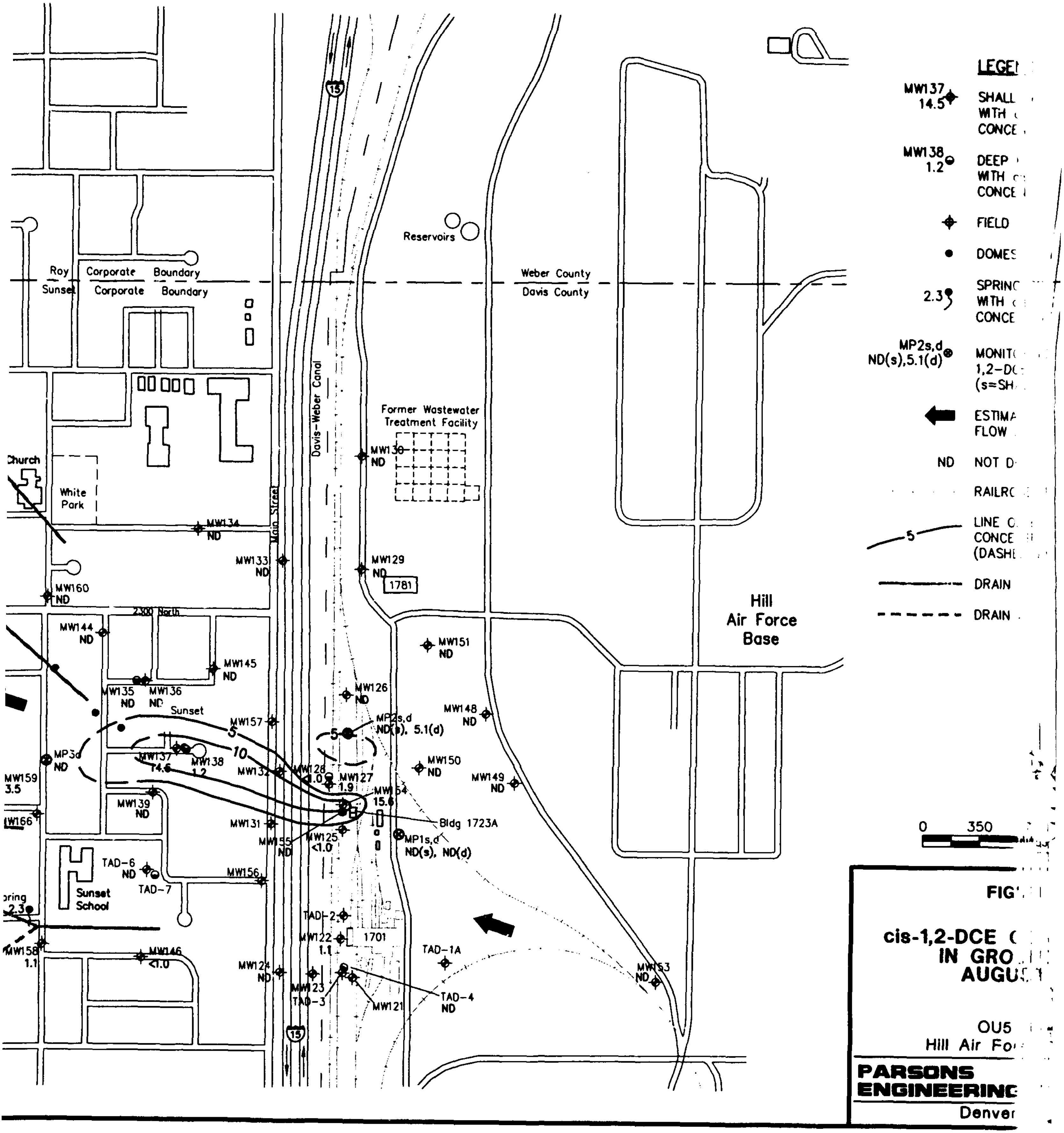

FIG

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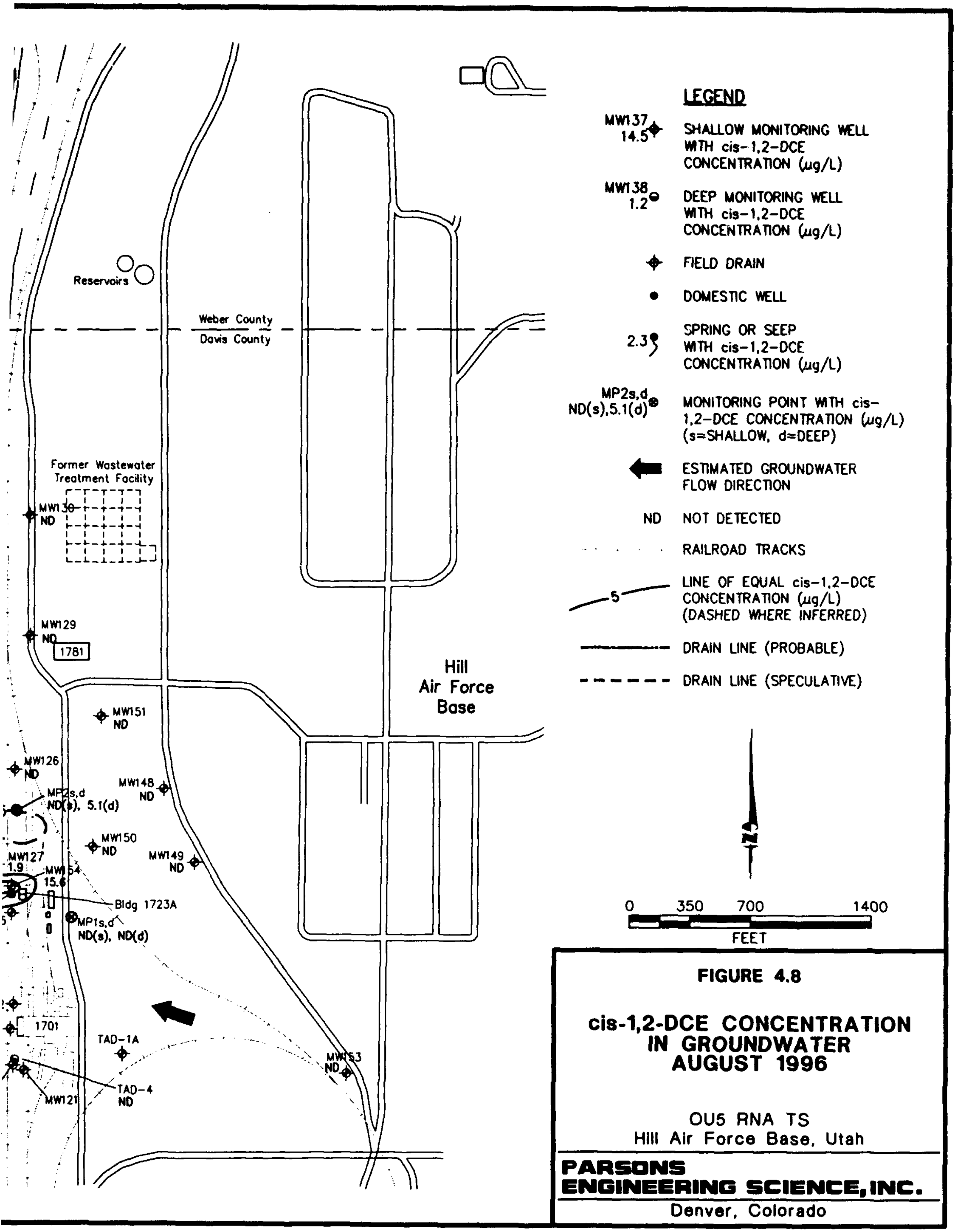

FIGURE 4.8

cis-1,2-DCE CONCENTRATION IN GROUNDWATER AUGUST 1996

OU5 RNA TS
Hill Air Force Base, Utah

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Denver, Colorado

concentrations of VC were detected in wells MW126 (0.114 µg/L), MW135 (0.156 µg/L), and TAD-7 (0.0159J µg/L) (Radian, 1995). The detections were reported for the GC analysis of the samples using USEPA Method SW8010; VC was not detected by the GC/mass spectrometer (MS) analyses performed on these same samples using USEPA Method SW8240. During the June-July 1994 RI sampling, 6.16 µg/L of VC was reported for well MW158 using USEPA Method SW8010. Similar to the 1993 detections described above, VC was not detected by the accompanying GC/MS analysis using Method SW8240. VC was not detected during the spring and fall 1995 sampling events performed by Radian (1996). The overall lack of VC detections in groundwater at OU5 suggests that reductive dehalogenation is generally not proceeding past the initial step that involves the transformation of TCE to DCE (see Figure 4.3).

4.3.6 Distribution of Ethene in Groundwater

Ethene is the end product in the series of reductive dehalogenation reactions that begin with TCE. The lack of VC detections in OU5 groundwater, described in Section 4.3.5, indicates that ethene (which is produced during the biodegradation of VC) also should be scarce to non-existent in the groundwater. As shown in Table 4.3, ethene was not detected in the groundwater samples collected for this TS in August 1996.

4.3.7 Distribution of Other CAHs in Groundwater

Other CAHs detected in the August 1996 groundwater samples include 1,1-DCA, methylene chloride, and chloroform (Table 4.2). Low concentrations of 1,1-DCA (ranging from <1 µg/L to 5.6 µg/L) were detected in 10 wells. Each of these wells also contained detectable concentrations of 1,1,1-TCA, and the DCA detections generally coincided with detections of 1,1-DCE. DCA is an intermediate product of the microbially mediated reductive dehalogenation of TCA, with the ultimate end product of this series of reactions being chloroethane (Bouwer, 1994). As described in Section 4.3.4, 1,1-DCE was most likely produced as a result of abiotic transformation of 1,1,1-TCA. Methylene chloride, a common laboratory contaminant, was detected in every sample at concentrations below the calibration limit of 5 µg/L, and is thought to be representative of laboratory-introduced contamination. Chloroform was detected in many samples at concentrations ranging up to 2.2 µg/L, including the field blank (sample OU5-FB1, Table 4.2) that was comprised of distilled water. Therefore, detections of this compound most likely indicate that chloroform was a contaminant in the distilled water used to decontaminate sampling equipment.

4.3.8 CAHs in Surface Water

In August 1996, surface water samples for VOC analysis were collected from Martin Spring, located just west of Sunset School, and from a surface seep in the northeastern corner of Meadows Park. Previous sampling of Martin Spring, performed from 1989 to 1994 by Hill AFB personnel, detected TCE (1.5 to 6.2 µg/L), TCA (not detected to 33 µg/L), and PCE (not detected to 0.5 µg/L) (Radian, 1995). The CAHs detected in the August 1996 sample from Martin Spring included 1,1-DCA (1.4 µg/L), cis-1,2-DCE (2.2 µg/L), 1,1,1-TCA (4.1 µg/L), and TCE (1.0 µg/L) (Table 4.2). Water discharging at Martin Spring is reportedly supplied by a field drain that is

TABLE 4.3
GROUNDWATER GEOCHEMICAL DATA
AUGUST 1996
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Sample Location	Temp (°C)[a]	pH	Conductivity (μs/cm)[b]	Dissolved Oxygen (mg/L)[c]	Redox Potential (mV)[d]	Total Alkalinity (mg/L)	Chloride (mg/L)	Ammonia (mg/L)	Ferrous Iron (mg/L)	Nitrate + Nitrite (mg/L)	Sulfate (mg/L)	Manganese (mg/L)	Phenols (mg/L)	Carbon Dioxide (mg/L)	TOC (mg/L)	Methane (mg/L)	Ethene (mg/L)
MP-1 s	16.2	7.24	550	4.06	156.0	250	19.5	<0.05	<0.1	<0.05	14.6	<0.1	0.1	30	0.79	<0.001	<0.003
MP-1d	17.0	7.35	590	2.36	160.2	250	42.2	<0.05	<0.1	2.46	34	<0.1	<0.1	21	0.65	<0.001	<0.003
MP-2 s	22.1	7.16	610	2.11	-30.2	250	45	<0.05	<0.1	4.37	34.1	NM[e]	<0.1	40	NM	<0.001	<0.003
MP-2d	23.0	7.17	500	0.50	-170.1	250	36.7	0.06	1.0	<0.05	45.2	<0.1	<0.1	25	1.11	<0.001	<0.003
MP-3d	20.4	7.77	660	2.26	NM	230	81.6	1.8	1.0	<0.05	2.37	NM	<0.1	NM	8.26	0.018	<0.003
MP-5 s	18.4	7.07	1150	0.89	138.4	275	129	0.06	<0.1	8.02	81.9	<0.1	<0.1	55	NM	0.005	<0.003
MP-6 s	21.0	7.40	1270	3.70	157.7	220	69	<0.05	<0.1	1.3	95.7	NM	<0.1	40	3.06	0.003	<0.003
MP-7 s	17.7	7.20	1220	0.27	73.8	500	86.9	<0.05	0.1	9.39	84.5	<0.1	0.1	70	3.93	<0.001	<0.003
MP-8 s	20.1	7.33	1330	3.52	111.3	>500	83.3	<0.05	0.2	4.53	91.2	<0.1	0.1	40	3.37	0.006	<0.003
MW-122	16.6	7.18	1120*	5.02	15.1	270	138	<0.05	<0.05	7.94	49.7	<0.2	0.2	148	2.37	<0.001	<0.003
MW-124	15.7	7.35	820*	4.32	64.8	199	100	<0.05	<0.05	11.2	44.4	<0.2	0.3	178	1.70	<0.001	<0.003
MW-125	15.2	7.46	605*	0.86	165.1	255	33.2	<0.05	<0.05	0.96	21.5	<0.2	0.1	110	1.62	0.021	<0.003
MW-126	14.5	7.62	646*	1.70	31.6	217	44.3	<0.05	<0.05	2.75	35.8	<0.2	<0.1	158	1.53	<0.001	<0.003
MW-127	15.1	7.17	578*	2.48	210.2	208	27.2	<0.05	<0.05	0.59	21.4	<0.2	0.4	40	2.10	0.012	<0.003
MW-128	16.7	7.57	649*	1.65	116.6	214	36	<0.05	<0.05	0.07	49.9	<0.2	0.6	160	2.15	<0.001	<0.003
MW-129	16.5	7.58	751*	4.52	39.6	206	70.8	<0.05	<0.05	4.15	31.7	<0.2	NM	110	3.23	<0.001	<0.003
MW-130	15.0	7.74	571*	4.90	136.9	205	16.1	<0.05	<0.05	3.91	29.2	<0.2	0.1	184	4.29	<0.001	<0.003
MW-133	15.5	6.87	2850*	3.80	-21.0	269	629	<0.05	<0.05	27.8	57.1	<0.2	0.6	302	2.07	<0.001	<0.003
MW-134	17.3	6.94	1173*	4.70	216.0	433	79.8	<0.05	<0.05	3.76	54.9	<0.2	0.1	228	2.05	<0.001	<0.003
MW-135	15.9	7.44	763*	0.28	-143.3	251	37.8	0.32	0.9	0.19	61.4	<0.2	<0.1	146	1.18	0.089	<0.003
MW-136	19.2	7.53	1076*	3.30	160.0	230	116	<0.05	<0.05	3.46	38.5	<0.2	0.1	176	1.54	<0.001	<0.003
MW-137	19.7	6.84	1040	1.40	111.0	377	151	<0.05	<0.05	4.1	51.7	<0.2	0.2	210	2.41	<0.001	<0.003
MW-138	16.0	7.35	730	0.60	-122.0	305	59.3	0.93	0.4	0.32	43.2	<0.2	0.2	162	2.25	0.035	<0.003
MW-139	18.5	7.49	910	1.20	84.0	388	118	0.72	<0.05	0.17	61.1	0.3	0.4	128	2.88	0.428	<0.003
MW-140	19.3	7.50	920	3.70	92.0	389	45.8	<0.05	<0.05	11.8	47.3	<0.2	0.1	142	1.92	<0.001	<0.003
MW-141	18.2	7.41	1164*	1.51	141.0	456	53.4	<0.05	<0.05	3.23	52.3	<0.2	0.2	142	2.14	<0.001	<0.003
MW-142	18.3	7.41	1110	1.40	154.0	435	100	<0.05	<0.05	5.55	69.3	<0.2	0.2	222	2.79	<0.001	<0.003
MW-143	17.1	7.55	1220	0.97	136.2	512	92	<0.05	<0.05	9.42	88.6	<0.2	1.0	170	2.82	<0.001	<0.003
MW-144	17.3	7.26	980	3.80	142.0	320	131	<0.05	<0.05	8.02	59.8	<0.2	0.1	190	1.97	<0.001	<0.003
MW-145	18.7	7.17	1040	3.80	185.0	287	161	<0.05	<0.05	17.9	44.6	<0.2	0.4	186	1.94	<0.001	<0.003

TABLE 4.3 (Continued)
GROUNDWATER GEOCHEMICAL DATA
AUGUST 1996
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Sample Location	Temp (°C)[a]	pH	Conductivity (μs/cm)[b]	Dissolved Oxygen (mg/L)[c]	Redox Potential (mV)[d]	Total Alkalinity (mg/L)	Chloride (mg/L)	Ammonia (mg/L)	Ferrous Iron (mg/L)	Nitrate + Nitrite (mg/L)	Sulfate (mg/L)	Manganese (mg/L)	Phenols (mg/L)	Carbon Dioxide (mg/L)	TOC (mg/L)	Methane (mg/L)	Ethene (mg/L)
MW-146	19.0	7.58	1060	4.20	160.0	262	196	<0.05	<0.05	7	37.3	NM	NM	132	2.59	<0.001	<0.003
MW-147	18.6	7.49	1020	3.40	169.0	484	61.1	<0.05	<0.05	7.58	65.3	<0.2	1.0	186	4.62	<0.001	<0.003
MW-148	14.2	7.64	670*	5.25	101.3	225	40.8	<0.05	<0.05	3.53	37.2	<0.2	0.6	106	6.84	<0.001	<0.003
MW-149	16.1	7.48	689*	4.56	189.9	241	52.3	<0.05	<0.05	3.33	25.2	<0.2	0.1	94	1.53	<0.001	<0.003
MW-150	14.9	7.48	689*	4.52	93.1	204	73.4	<0.05	<0.05	4	35.9	<0.2	0.4	80	1.25	<0.001	<0.003
MW-151	14.8	7.53	558*	3.15	92.3	169	56.7	<0.05	<0.05	2.00	17.7	<0.2	0.4	90	0.90	<0.001	<0.003
MW-153	14.2	7.83	NM	5.39	132.0	70	132	<0.05	0.3	8.44	33.0	<0.1	<0.1	35	2.69	<0.001	<0.003
MW-154	14.2	7.11	689*	0.45	83.0	273	25	<0.05	<0.05	0.53	24.5	<0.2	0.3	150	3.61	0.041	<0.003
MW-155	14.1	7.26	699*	0.61	69.4	234	72.2	<0.05	<0.05	1.85	49.3	<0.2	0.2	128	2.35	0.006	<0.003
MW-158	16.7	7.30	830	2.80	185.0	300	108	<0.05	<0.05	6.56	45.2	<0.2	<0.1	96	2.89	<0.001	<0.003
MW-159	23.7	7.47	1180	2.10	111.0	427	122	<0.05	<0.05	7.31	73	<0.2	<0.1	104	2.89	<0.001	<0.003
MW-160	15.6	7.09	941*	3.27	151.5	321	81.1	<0.05	<0.05	3.34	45.3	<0.2	0.2	96	2.09	<0.001	<0.003
MW-161	17.9	7.25	1070	2.50	208.2	487	88.5	<0.05	<0.05	9.01	83.8	<0.2	<0.1	204	1.90	<0.001	<0.003
MW-162	15.7	7.10	1360	4.10	167.7	420	264	<0.05	<0.05	7.31	69.4	<0.2	0.4	236	106.00	<0.001	<0.003
MW-163	15.1	7.65	1120	0.80	84.0	444	78	<0.05	<0.05	9.60	80.8	<0.2	0.3	222	5.38	<0.001	<0.003
MW-164	16.8	7.49	980	4.80	137.4	475	85.6	<0.05	<0.05	7.35	79.5	<0.2	0.3	156	2.23	<0.001	<0.003
MW-165	17.9	7.40	1046*	0.70	94.5	386	68.7	<0.05	<0.05	5.18	55.6	<0.2	<0.1	200	1.26	<0.001	<0.003
MW-167	20.9	7.21	1040	1.00	119.0	444	86	<0.05	<0.05	4.21	65.7	<0.2	0.6	180	1.77	<0.001	<0.003
MW-168	21.8	7.38	NM	1.80	98.0	NM	86.8	<0.05	NM	5.33	73.1	NM	NM	NM	2.27	<0.001	<0.003
MW-169	17.8	7.55	1160	2.90	137.0	501	71.4	<0.05	<0.05	7.13	77.6	<0.2	0.1	230	2.77	<0.001	<0.003
TAD-4	15.5	5.80	NM	0.15	-48.1	250	50.4	0.38	1.0	1.09	35.0	<0.1	0.1	25	6.09	0.009	<0.003
TAD-6	19.2	7.95	977*	2.90	75.0	260	111	<0.05	<0.5	1.04	35.5	<0.2	NM	130	1.69	<0.001	<0.003

a/ °C = degrees Centigrade.
b/ μs/cm = microsiemens per centimeter.
c/ mg/L = milligrams per liter.
d/ mV = millivolts.
e/ NM = not measured.
* = well head measurement not made; value reported is measurement made in on-base field laboratory.

inferred to be located to the south (Figure 4.8). Therefore, contaminated groundwater migrating from the Building 1701 area at the Tooele Rail Shop appears to discharge to the eastern portion of the field drain, which is upstream from Martin Spring.

Other than methylene chloride (<5 μg/L), the only analyte detected in the Meadows Park seep sample was chloroform (3.1 μg/L), which was probably sourced in the distilled water used to decontaminate the sampling device. Periodic sampling of a spring located in the northwestern corner of Meadows Park from 1990 to 1996 has detected TCE (4.6 to 18.5 μg/L) and 1,1,1-TCA (not detected to 0.4 μg/L) (Radian 1995 and 1996b). The relationship of this spring to the nearby northwest/southeast-trending field drain is not known.

4.4 RNA ANALYSIS

Limited biodegradation of the TCE plume in OU5 groundwater appears to be occurring, primarily by reductive dehalogenation of TCE to DCE. Available information indicates that the TCE plume originating at the Tooele Rail Shop exhibits mixed behavior (see Section 4.2.4). The aerobic nature of the groundwater throughout most of the plume area, combined with a marked lack of evidence that CAH biodegradation is occurring, indicates that type 3 behavior is prevalent. Type 2 behavior is indicated in limited areas where DO concentrations are sufficiently low and native organic carbon concentrations are sufficiently high to allow reductive dehalogenation to proceed (see Section 4.4.6.1 for discussion of DO concentrations). Available evidence further suggests that type 1 behavior has occurred in the source area in the past, perhaps driven by leaching of petroleum hydrocarbons (anthropogenic organic carbon) from source area soils. In general, analytical data reveal that only a small fraction of TCE is being transformed to DCE, and the process is not sufficient to transform the parent CAHs and chlorinated daughter products to nonchlorinated end products such as ethene. However, limited oxidation of DCE to carbon dioxide, water, and chlorine ions (Figure 4.4) may be occurring. The contaminant and geochemical analytical data that indicate the type(s) of biodegradation processes operating in OU5 groundwater, and the degree to which biodegradation is occurring, are discussed in the following subsections.

4.4.1 Field-Scale Contaminant Mass Losses

One line of evidence that should be assessed to evaluate the occurrence of natural attenuation of contaminants in groundwater at OU5 is changes in dissolved concentrations of contaminants over time. Groundwater quality data for 12 monitoring wells, collected between May 1993 and August 1996, were reviewed to assess temporal changes in TCE concentrations. The wells are located along or near the longitudinal axis of the TCE plume from the source area to near the downgradient edge of the plume, and include MW127, MW128, MW154, MW155, MW132, MW137, MW138, MW159, MW140, MW143, MW147, and MW163. As shown in Figure 4.9, TCE concentrations in source area well MW127 appear to have decreased since 1993, perhaps indicating that TCE in source area soils is being depleted. Similar reductions also have occurred in well MW132, located immediately downgradient from the source

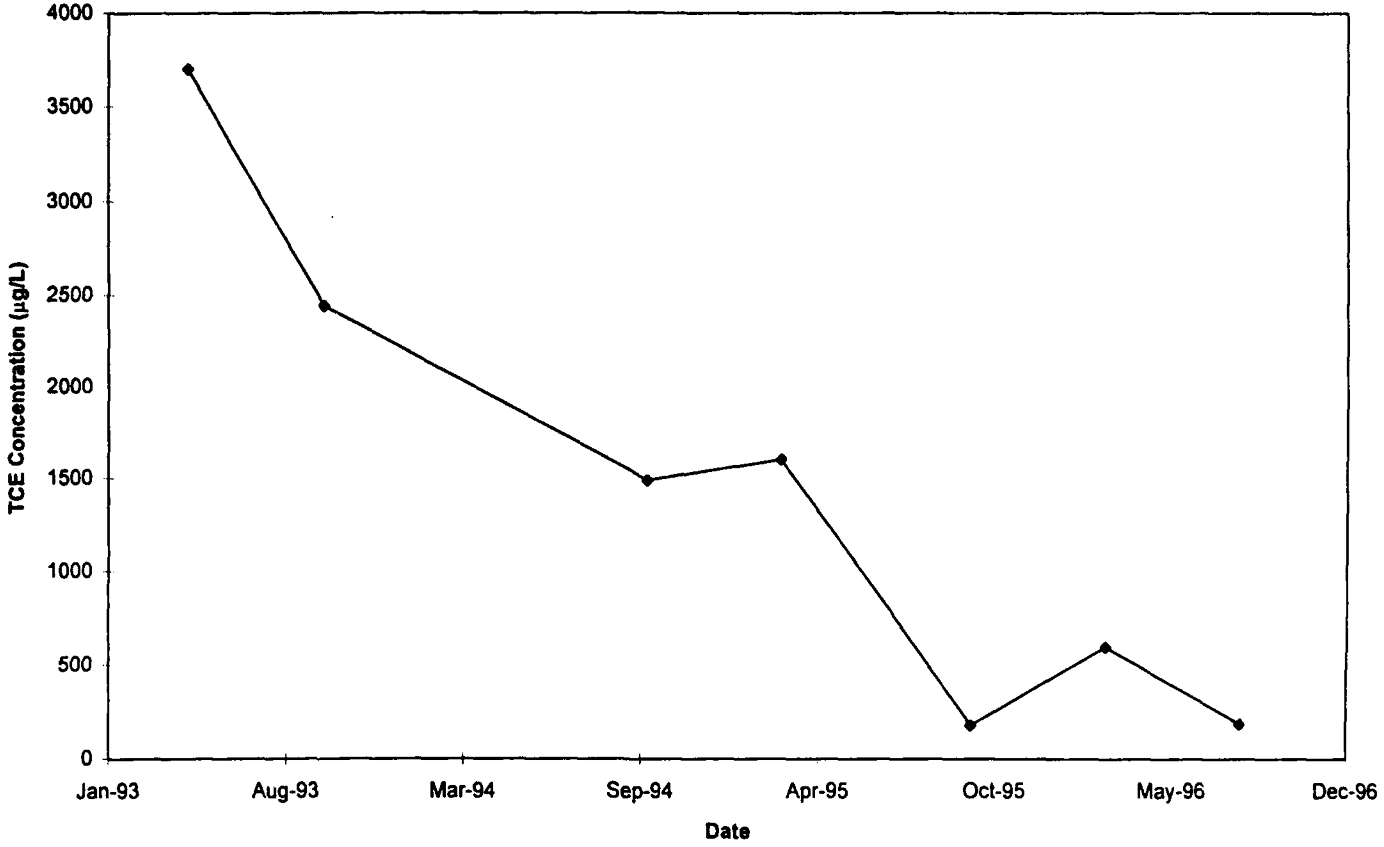

FIGURE 4.9

TCE CONCENTRATIONS IN SOURCE AREA WELL MW127 MAY 1993 TO AUGUST 1996

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area. However, TCE concentrations in the remaining 10 wells either have been relatively uniform during this period, or have fluctuated. Therefore, the available data do not indicate overall decreases in dissolved TCE concentrations during the past 3 years. However, if source area concentrations continue to decrease, TCE concentrations in more downgradient locations also would be expected to decrease in the future.

4.4.2 Presence of Daughter Products

As described in Section 4.3.3, the presence of daughter products that were not used in Base operations, particularly *cis*-1,2-DCE, is strong evidence that TCE is being reductively dehalogenated. However, as described above, the low magnitude of daughter product concentrations relative to TCE indicate that the degree to which this transformation is occurring is limited.

Progressive transformation of TCE to *cis*-1,2-DCE as the contamination migrates away from the source area can be indicated by computing the ratio of daughter products to parent compounds at different distances from the source area. The ratios of *cis*-1,2-DCE to TCE in groundwater samples from six wells located along the axis of the TCE plume (MW154, MW132, MW137, MW159, MW143, and MW163) during three different sampling events are shown on Figure 4.10. In August 1996, the ratio remained relatively constant from source area well MW154 to downgradient well MW137, indicating that reductive transformation of TCE to *cis*-1,2-DCE was not becoming more prevalent with distance from the source area. However, well MW132, located between wells MW154 and MW137, was not sampled in August 1996. Data from the October 1995 and March 1996 sampling events performed by Radian (1996b) reveal conflicting trends. In each case, however, the ratios for the farthest downgradient wells (MW159, MW143, and MW163) were uniformly low, indicating that reductive dehalogenation is not a significant process in the downgradient region of the TCE plume. Instead, DCE may act as an electron donor in downgradient portionsof the plume, and be aerobically transformed to carbon dioxide, water, and chlorine ions.

4.4.3 Chloride as an Indicator of Dehalogenation

Chlorine is removed from CAHs during reductive dehalogenation and enters solution. Therefore, chloride concentrations in groundwater should increase above background levels in areas where reductive dehalogenation is taking place. At OU5, the mass of CAHs undergoing reductive dehalogenation may be sufficiently low that chloride concentrations may not be substantially enhanced.

Chloride concentrations measured in August 1996 are presented in Table 4.3. Background chloride concentrations in groundwater ranged from 16 to 132 mg/L and averaged 66 mg/L based on data from wells MW130, MW151, MW150, MW149, and MW153. Each of these wells is upgradient or crossgradient from areas containing significant dissolved CAH concentrations. The highest chloride concentration (132 mg/L) was detected at well MW153, located southeast of the TCE plume. The

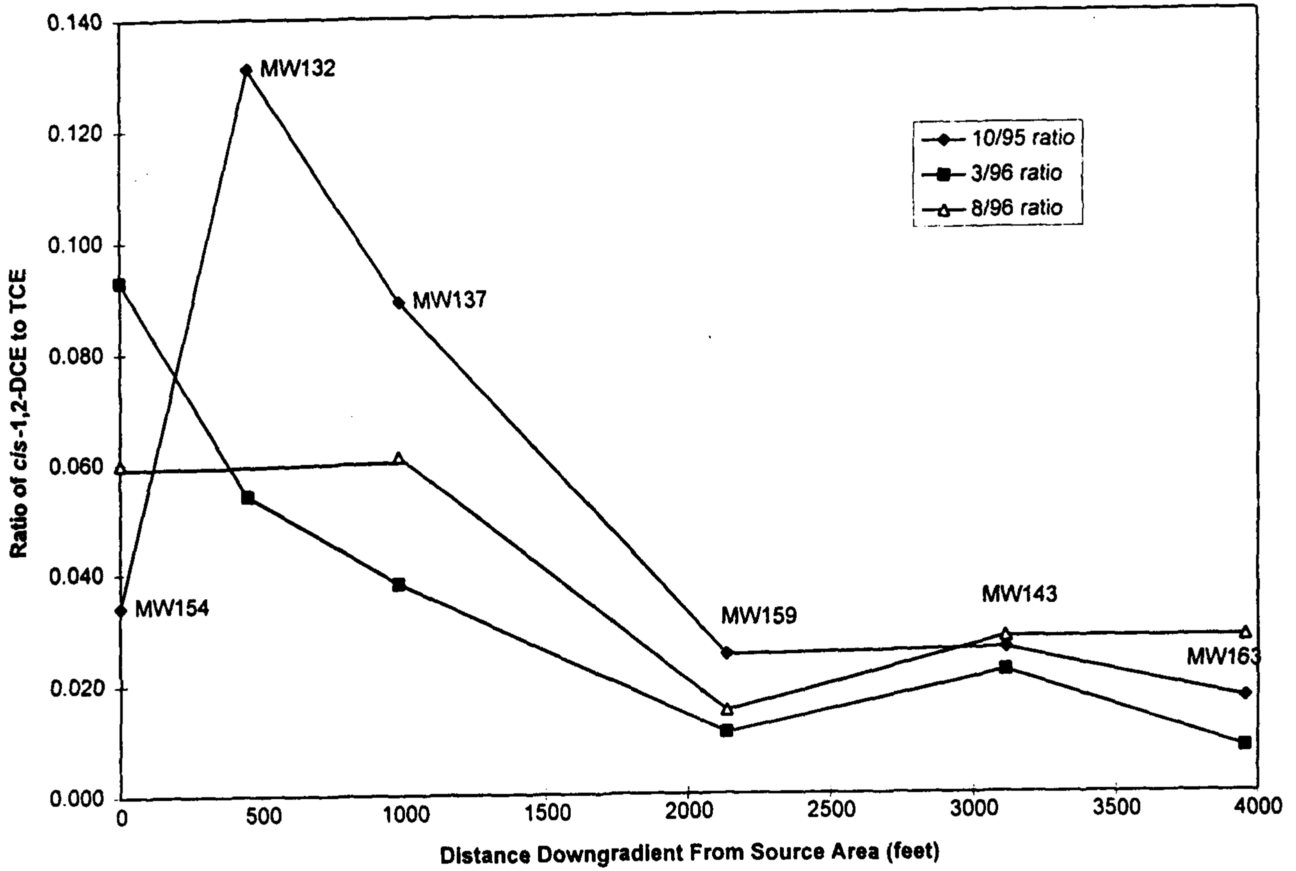

FIGURE 4.10

RATIO OF *cis*-1,2-DCE TO TCE
OCTOBER 1995 TO AUGUST 1996

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remaining four background chloride concentrations ranged from 16 to 73 mg/L and averaged 50 mg/L.

August 1996 chloride concentrations detected along the axis of the main TCE plume are shown on Figure 4.11. The August 1996 TCE concentrations detected in the same monitoring wells/points, and the average background chloride concentration, are also shown on this figure. Chloride concentrations in the primary TCE source area near Building 1723A are relatively low, as evidenced by chloride data from wells MW127 (27.2 mg/L) and MW154 (25 mg/L). The low magnitude of these values suggests that the reductive dehalogenation process in the source area is not prominent enough to cause a noticeable increase in chloride concentrations. Chloride concentrations farther downgradient at wells MW137 and MW159 are higher, and correspond to the presence of elevated TCE concentrations. Chloride concentrations are similar to backgroundconcentrations in the downgradient portion of the contaminant plume where TCE concentrations are relatively low. These data suggest that limited reductive dehalogenation is occurring in at least a portion of the main TCE plume.

4.4.4 ORP and Dissolved Hydrogen as Indicators of Redox Processes

As described in Section 4.2, microorganisms will facilitate only those r reactions that will yield energy. For example, by coupling the oxidation of hydrocarbon compounds (or native organic carbon), which requires energy, to the reduction of other compounds (e.g., oxygen, nitrate, manganese, ferric iron, sulfate, carbon dioxide, and possibly *cis*-1,2-DCE), which yields energy, the overall reaction will yield energy.

Figure 4.12 illustrates the sequence of microbially mediated redox processes and identifies the approximate ranges of ORPs that are favorable for each process. In general, reactions yielding more energy tend to take precedence over processes that yield less energy (Stumm and Morgan, 1981; Godsey, 1994; Reinhard, 1994). As Figure 4.12 shows, oxygen reduction would be expected to occur in an aerobic environment with microorganisms capable of aerobic respiration because oxygen reduction yields significant energy (Bouwer, 1992; Chapelle, 1993). However, once the available oxygen is depleted and anaerobic conditions dominate the interior regions of a contaminant plume, anaerobic microorganisms can utilize other electron acceptors in the following order of preference: nitrate (denitrification), manganese (manganese reduction), ferric iron (iron reduction), sulfate (sulfate reduction), and finally carbon dioxide (methanogenesis). Each successive redox reaction provides less energy to the system, and each step down in redox energy yield would have to be paralleled by an ecological succession of microorganisms capable of facilitating the pertinent redox reactions.

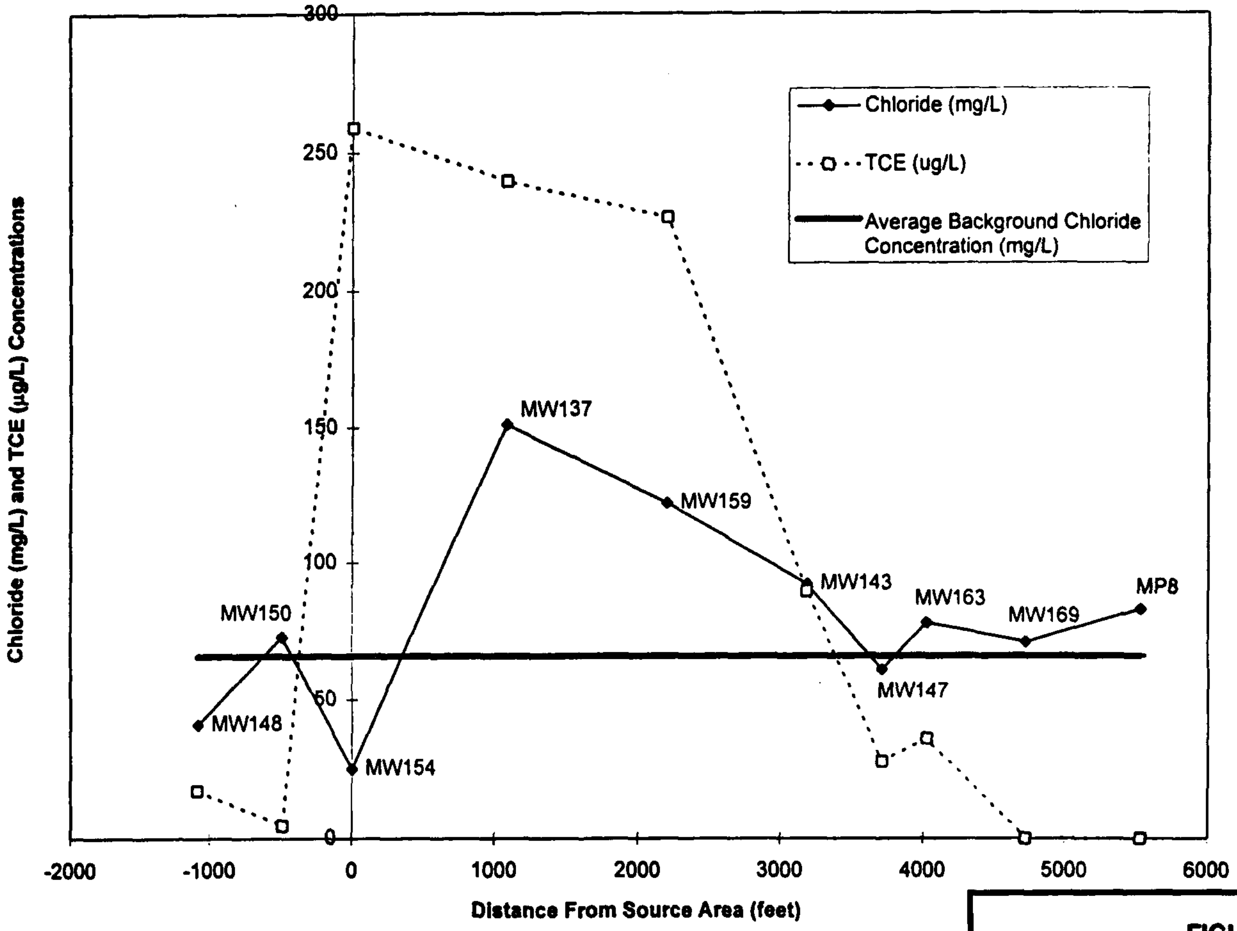

FIGURE 4.11

CHLORIDE AND TCE CONCENTRATIONS ALONG TCE PLUME AXIS AUGUST 1996

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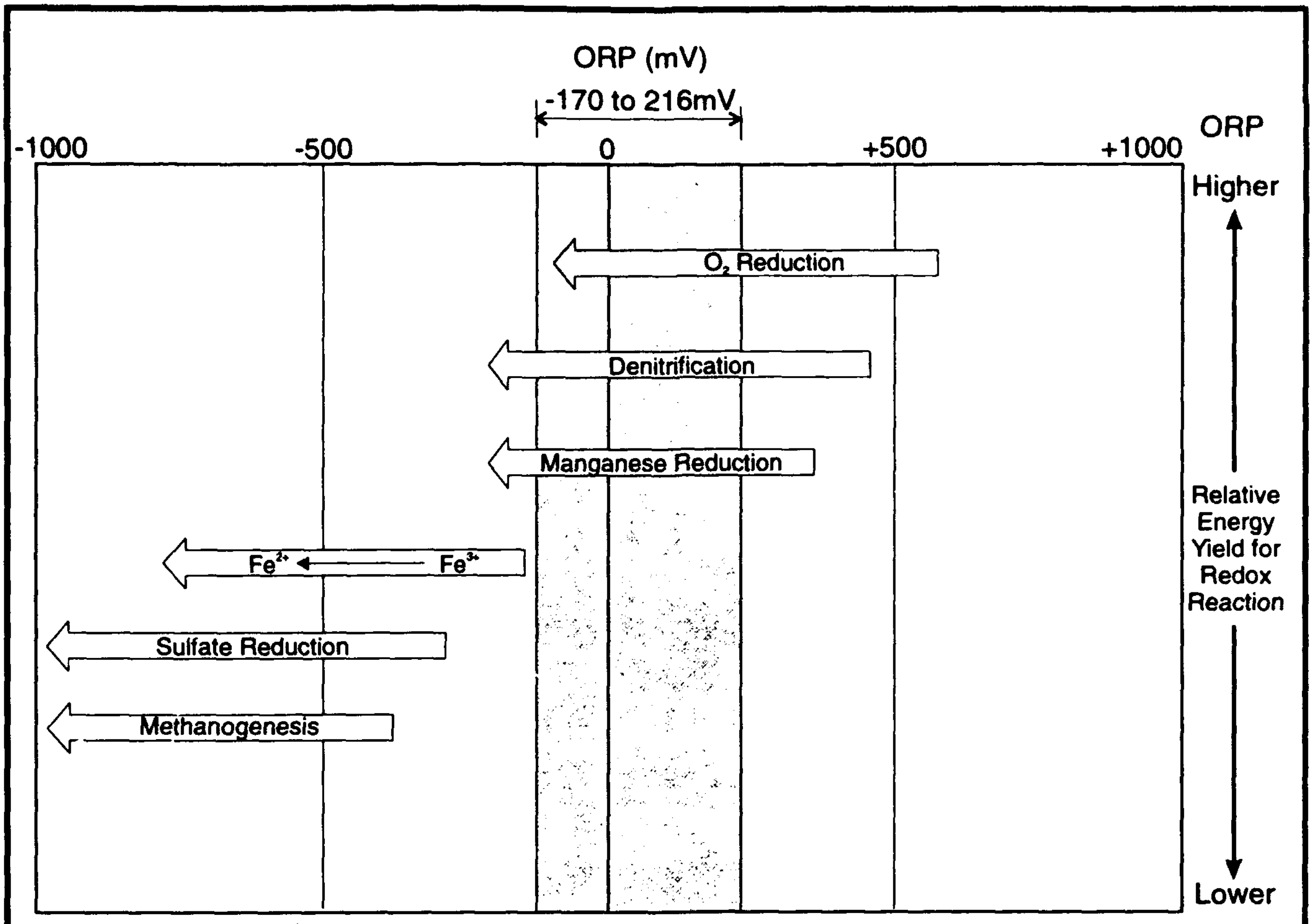

Notes

ORP = Oxidation Reduction Potential

☐ Range of ORP measured at OU5

1. These reactions would be expected to occur in sequence if the system is moving toward equilibrium.
2. These redox processes occur in order of their energy-yielding potential (provided microorganisms are available to mediate a specific reaction). Reduction of a highly oxidized species decreases the ORP of the system.
3. The ORP of the system determines which electron acceptors are available for organic carbon oxidation.
4. Redox reaction sequence is paralleled by an ecological succession of biological mediators.

Adapted from Stumm and Morgan, 1981.

FIGURE 4.12

SEQUENCE OF MICROBIALLY MEDIATED REDOX PROCESSES

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ORPs measured in OU5 groundwater in August 1996 ranged from -170 millivolts (mV) to 216 mV. Occurrences of negative ORPs in shallow groundwater were infrequent and limited to the areas of MW133 and MP2s/2d. The remainder of the shallow values ranged from 15 to 216 mV, which is outside the optimal range for reductive dehalogenation (although within the possible range). ORPs measured in three wells screened deeper in the surficial aquifer (MW135, MW138, and TAD-4) were lower, ranging from -48 mV to -143 mV. The low magnitude of these values suggests that deeper groundwater tends to be more reducing (and more conducive to the occurrence of reductive dehalogenation) than shallower groundwater. Many authors have noted that field ORP data alone cannot be used to reliably predict the electron acceptors that may be operating at a site, because the platinum electrode probes are not sensitive to some redox couples (e.g., sulfate/sulfide) (Stumm and Morgan, 1981; Godsey, 1994; Lovley *et al.*, 1994).

Concentrations of dissolved hydrogen (H_2) also can be used to evaluate redox processes in groundwater systems (Lovley and Goodwin, 1988; Lovley *et al.*, 1994; Chapelle *et al.*, 1995). H_2 is continuously produced in anaerobic groundwater systems by fermentative microorganisms that decompose natural and anthropogenic organic matter. This H_2 is then consumed by respiratory microorganisms that use nitrate, ferric iron, sulfate, or carbon dioxide (CO_2) as terminal electron acceptors. Significantly, nitrate-, ferric iron-, sulfate- and CO_2-reducing (methanogenic) microorganisms exhibit different efficiencies in utilizing the H_2 that is being continually produced. Nitrate reducers are highly efficient H_2 utilizers and maintain very low steady-state H_2 concentrations. Ferric iron reducers are slightly less efficient and thus maintain somewhat higher H_2 concentrations. Sulfate reducers and methanogenic bacteria are progressively less efficient and maintain even higher H_2 concentrations. Because each terminal electron accepting process has a characteristic H_2 concentration associated with it, H_2 concentrations can be an indicator of predominant redox processes. These characteristic ranges are given in Table 4.4.

TABLE 4.4
RANGE OF HYDROGEN CONCENTRATIONS FOR A GIVEN TERMINAL ELECTRON-ACCEPTING PROCESS
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Terminal Electron-Accepting Process	Dissolved Hydrogen Concentration (nanomoles per liter)
Denitrification	<0.1
Ferric Iron Reduction	0.2 to 0.8
Sulfate Reduction	1 to 4
Methanogenesis	5 to 20

Dissolved H_2 concentrations measured in OU5 groundwater in August 1996 are summarized in Table 4.5. Concentrations ranged from <0.1 nanomoles per liter (nM/L) to 5.0 nM/L. The two highest H_2 concentrations were measured outside of the main TCE plume at wells MW158 (2.7 nM/L) and MW160 (5.0 nM/L). The remaining H_2 values, which ranged from <0.1 to 0.4 nM/L, were obtained at wells primarily located within the TCE plume. The low magnitude of these values suggests that denitrification or ferric iron reduction should be the dominant electron accepting process in the plume area.

TABLE 4.5
DISSOLVED HYDROGEN CONCENTRATIONS IN GROUNDWATER
AUGUST 1996
OU5 RNA TS
Hill AIR FORCE BASE, UTAH

Well	Dissolved Hydrogen Concentration (nanomoles per liter)
MW122	0.4
MW124	<0.1
MW125	0.2
MW127	0.2
MW136	<0.1
MW138	<0.1
MW140	0.2
MW142	0.3
MW143	0.2
MW145	0.4
MW147	0.3
MW158	2.7
MW160	5.0
MW161	0.2
MW162	<0.1

The relatively high ORPs and low dissolved H_2 concentrations measured in OU5 groundwater indicate that, although reductive dehalogenation is possible, conditions are not optimal for this process. The most rapid biodegradation rates, affecting the widest range of CAHs, occurs under more highly reducing, methanogenic conditions (Bouwer, 1994).

4.4.5 Electron Donors

When investigating the biodegradation of CAHs, it is also necessary to look at the distribution of other compounds that are used in the microbially mediated reactions that facilitate CAH degradation. The distributions of potential electron donors, including BTEX compounds and dissolved native organic carbon, are useful for evaluating the feasibility of reductive dehalogenation or cometabolism (i.e., CAH degradation reactions involving another substrate).

4.4.5.1 BTEX in Groundwater

The presence of BTEX in the same area as the CAH plume would create favorable conditions for reductive dehalogenation, because the BTEX can provide a source of electron donors and facilitate microbial reactions that drive down the local groundwater ORP. However, despite the detection of BTEX compounds in source area soils (see Section 4.1.1), none of the petroleum compounds targeted for analysis during the TS (BTEX, trimethylbenzenes, and fuel carbon) were detected in groundwater samples. As discussed in Section 4.4.6, the distributions of some electron acceptors and metabolic byproducts in OU5 groundwater suggest that limited microbial biodegradation of petroleum hydrocarbons may be occurring in the vicinity of Building 1723A. However, petroleum compounds do not appear to be a significant factor in the biodegradation of CAHs at OU5.

4.4.5.2 Organic Carbon in Groundwater

Dissolved native organic carbon can also act as a source of electron donors (an energy source) during the reductive dehalogenation of CAHs. Dissolved TOC concentrations can be used as an indicator of the presence of such native carbon compounds in wells outside of the area containing dissolved contamination (anthropogenic organic compounds, such as BTEX and CAHs, also will be measured by this method). At OU5 however, the CAH concentrations in groundwater (measured in μg/L) are sufficiently low that TOC concentrations collected in the plume areas should be reasonably reflective of native organic carbon concentrations.

TOC dissolved in groundwater was measured in samples collected in August 1996. These concentrations are presented in Table 4.3. Dissolved TOC concentrations in shallow groundwater at OU5 range from 0.65 mg/L to 106 mg/L. Forty-eight of the 50 dissolved TOC concentrations measured in OU5 groundwater were within a range from 0.65 mg/L to 6.84 mg/L. A slightly higher dissolved TOC concentration of 8.26 mg/L was detected in monitoring point MP3d, which is screened in clayey deposits. Clays often have more native organic carbon than more sandy deposits. A substantially elevated TOC concentration of 106 mg/L, detected at well MW162, is anomalous. Background concentrations of dissolved TOC, inferred using data from the same five upgradient or crossgradient wells used to estimate background chloride concentrations in Section 4.4.3, ranged from 0.90 to 4.29 mg/L, and averaged 2.13 mg/L. Dissolved TOC concentrations in samples that also contained relatively elevated CAH concentrations were not noticeably higher than background due to the overall low magnitude of CAH concentrations in OU5 groundwater. For example, dissolved TOC concentrations in wells MW127, MW137, MW138, and MW159 ranged from 2.10 to 2.89 mg/L. Dissolved TOC concentrations in the upper and lower portions of the surficial aquifer are similar, based on data from monitoring well pairs MW137/138 and MW135/136.

The background concentrations of dissolved TOC are noteworthy because they represent additional organic matter that is available for use as a substrate in biodegradation reactions in the absence of detectable concentrations of petroleum compounds in groundwater. The background concentrations likely represent compounds dissolved from organic matter dispersed throughout the aquifer. In addition to the soil TOC, this native carbon source should provide a continuing source of electron donors to be used in microbial redox reactions. Dissolved TOC concentrations in excess of 20 mg/L are desirable to drive dehalogenation reactions (Wiedemeier *et al.*, 1996c). This condition is not fulfilled at OU5; therefore, dissolved TOC concentrations may limit biotransformation reactions.

4.4.6 Alternate Electron Acceptors and Metabolic Byproducts

Biodegradation of organic compounds, whether natural or anthropogenic, brings about measurable changes in the chemistry of groundwater in the affected area. Concentrations of compounds used as electron acceptors (e.g., DO, nitrate, and sulfate) are depleted, and byproducts of electron acceptor reduction (e.g., ferrous iron, methane, and sulfide) are enhanced. By measuring these changes, it is possible to evaluate the importance of natural attenuation at a site.

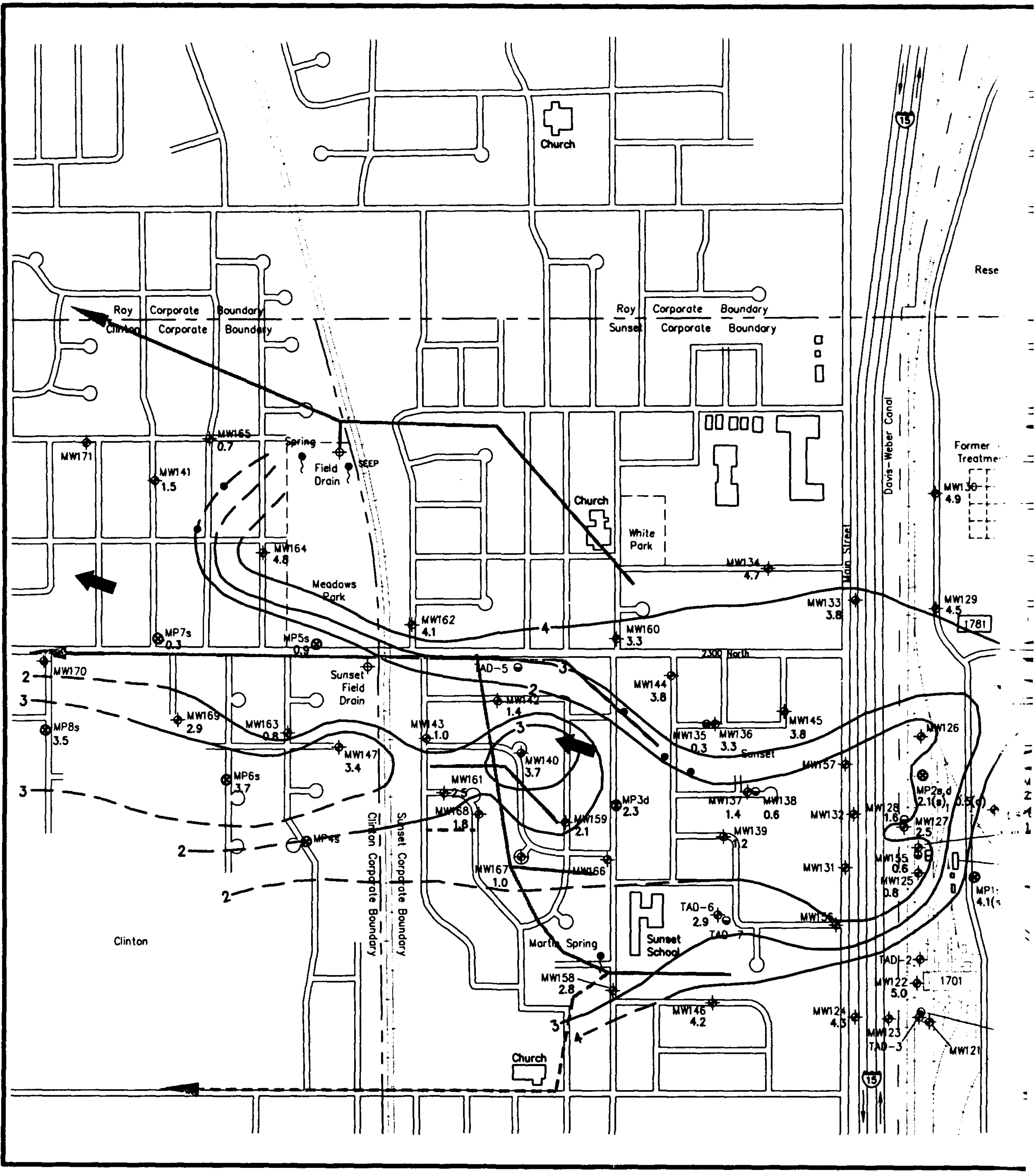
4.4.6.1 Dissolved Oxygen

Reductive dehalogenation is an anaerobic process, and DO concentrations in excess of 0.5 mg/L may cause the reductive transformation pathway to be suppressed. Therefore, highly chlorinated compounds such as PCE, TCE, and TCA, are biologically recalcitrant under aerobic conditions. DO concentrations were measured at monitoring wells and points during the August 1996 sampling event. These concentrations are summarized in Table 4.3 and displayed on Figure 4.13. DO concentrations measured in the shallow portion of the surficial aquifer ranged from 0.3 mg/L at monitoring point MP7s to 5.39 mg/L in upgradient well MW153. Background DO concentrations in the shallow portion of the surficial aquifer measured in upgradient or crossgradient wells MW130, MW151, MW150, MW149, MW153 ranged from 3.2 to 5.4 mg/L and averaged 4.5 mg/L. Although shallow DO concentrations within the TCE plume area are generally lower than background concentrations, only at source area well MW154 and downgradient monitoring point MP7s were the measured DO concentrations below 0.5 mg/L in August 1996. The lack of true anaerobic conditions throughout the majority of the TCE plume probably limits the occurrence of reductive dehalogenation.

DO concentrations in the deeper portion of the surficial aquifer, measured in monitoring wells/points MP1d, MP2d, MP3d, TAD-4, MW128, MW155, MW135, and MW138 ranged from 0.2 to 2.4 mg/L and averaged 1.1 mg/L. Deeper DO concentrations were low regardless of the CAH concentration, indicating that deeper zones are naturally lower in DO.

4.4.6.2 Nitrate/Nitrite

After DO has been depleted in the microbiological treatment zone, nitrate may be used as an electron acceptor for anaerobic biodegradation of organic carbon via denitrification. Nitrate concentrations below background in areas with high organic carbon concentrations and low DO are indicative of denitrification. The oxidation of organic carbon via the process of denitrification (using nitrate as an electron acceptor) yields a relatively large amount of free energy to microbial populations, and therefore is energetically favorable (preferred) compared to use of CAHs as electron acceptors. If nitrate concentrations exceed 1 mg/L, then anaerobic microorganisms may



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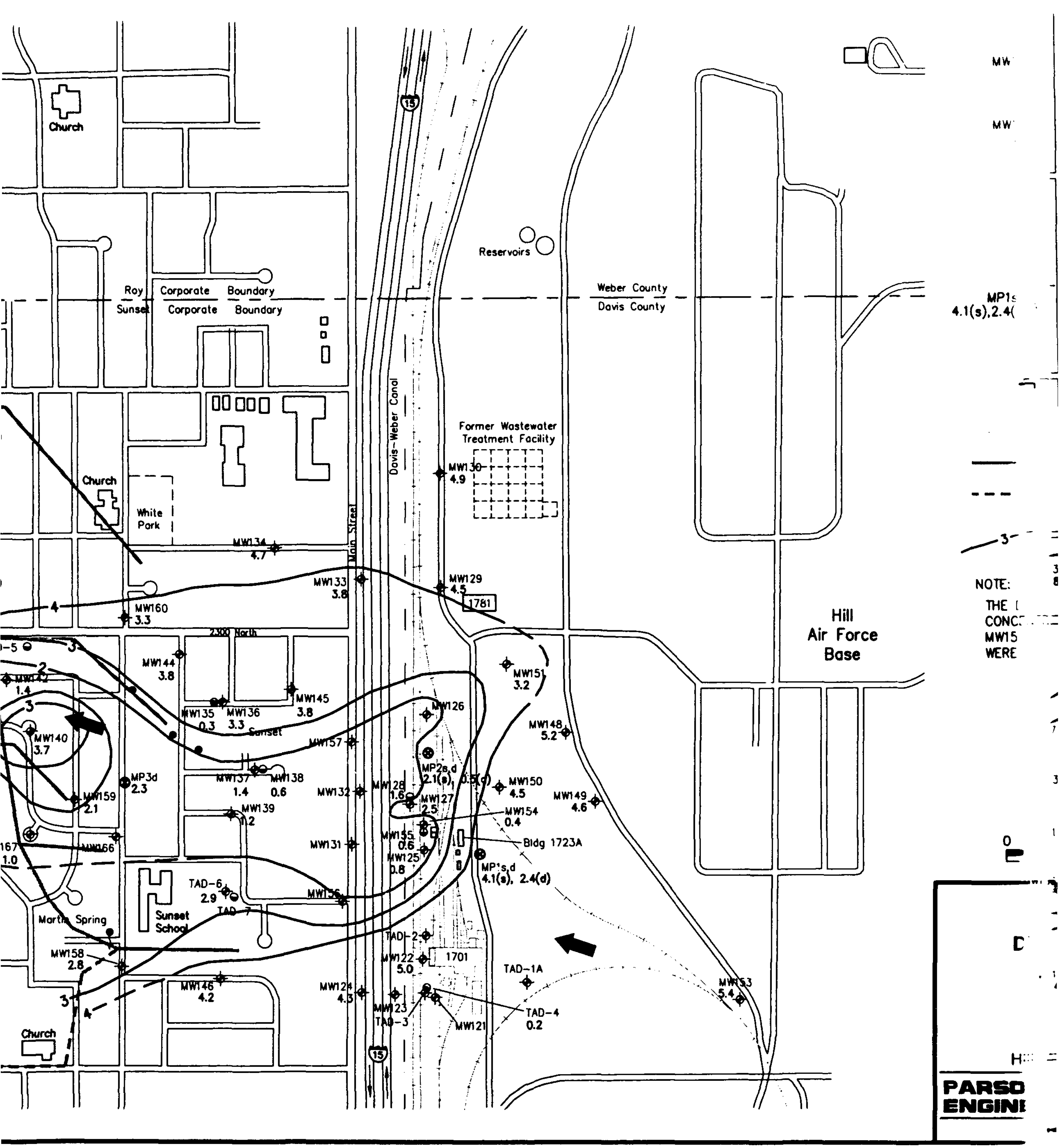
Church
15
Reservoirs
Roy Corporate Boundary
Sunset Corporate Boundary
Weber County
Davis County
Davis-Weber Canal
Former Wastewater Treatment Facility
MW130
4.9
Church
White Park
Main Street
MW134
4.7
MW133
3.8
MW129
4.5
1781
4
MW160
3.3
2300 North
-5
3
2
MW142
1.4
MW144
3.8
MW151
3.2
Hill Air Force Base
MW145
3.8
MW135
0.3
MW136
3.3
Sunset
MW126
MW140
3.7
MW148
5.2
MW157
MP2s,d
2.1(s), 0.5(d)
MP3d
2.3
MW137
1.4
MW138
0.6
MW132
MW128
1.6
MW127
2.5
MW150
4.5
MW149
4.6
MW159
2.1
MW139
1.2
MW154
0.4
MW131
MW155
0.6
Bldg 1723A
167
1.0
MW166
MW125
0.8
MP1s,d
4.1(s), 2.4(d)
TAD-6
2.9
MW156
TAD-7
Sunset School
North Spring
TAD-2
MW158
2.8
MW122
5.0
1701
TAD-1A
MW146
4.2
MW124
4.3
MW123
TAD-3
MW121
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0.2
MW153
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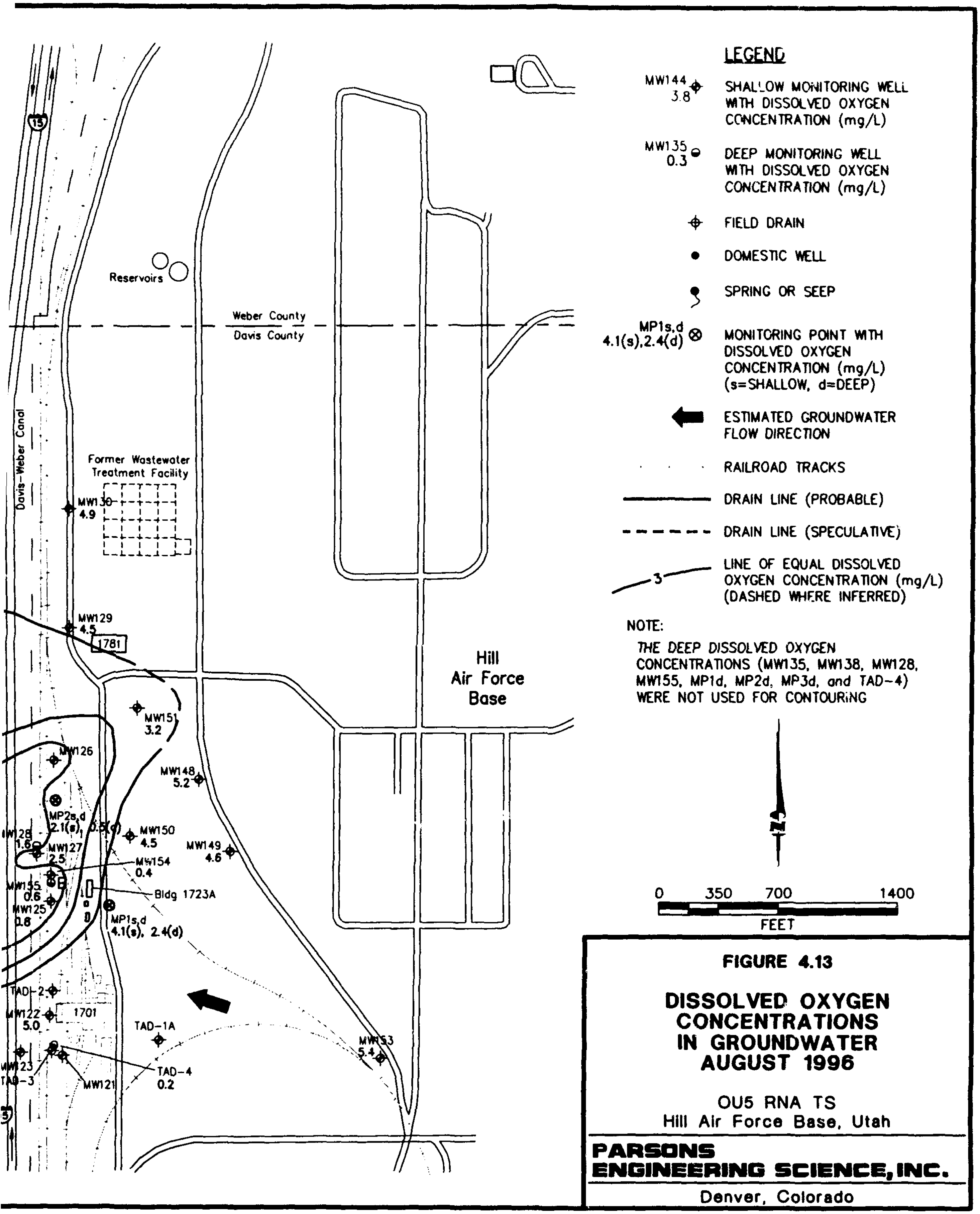

NOTE:

THE DEEP DISSOLVED OXYGEN CONCENTRATIONS (MW135, MW138, MW128, MW155, MP1d, MP2d, MP3d, and TAD-4) WERE NOT USED FOR CONTOURING

FIGURE 4.13

DISSOLVED OXYGEN CONCENTRATIONS IN GROUNDWATER AUGUST 1996

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preferentially use nitrate instead of CAHs to produce energy for their use (Wiedemeier *et al.*, 1996c).

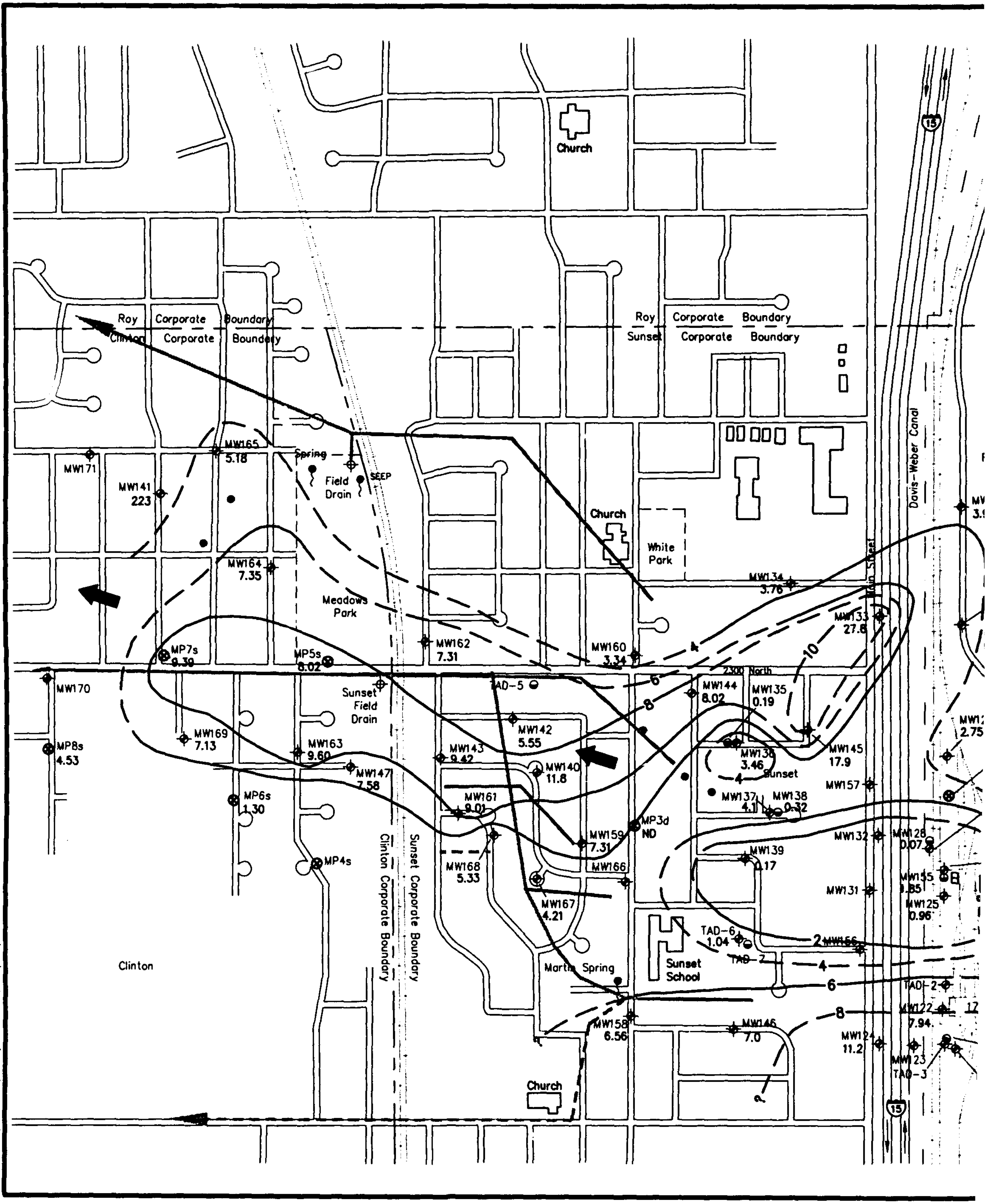
Concentrations of nitrate + nitrite [as nitrogen (N)] were measured at monitoring wells and points during the August 1996 sampling event. These concentrations are summarized in Table 4.3 and displayed on Figure 4.14. Substantially elevated nitrate/nitrite concentrations (as N) were detected in wells MW133 (27.8 mg/L) and MW145 (17.9 mg/L). Well MW133 also had an anomalously high chloride concentration, suggesting the presence of an anion source such as a leaking sewer line near Main Street. The elongate plume of elevated nitrate/nitrite concentrations that appears to extend to the west beneath Sunset and Clinton from the vicinity of MW133 may largely result from a localized, anthropogenic nitrogen source (e.g., sewer line leak) near Main Street.

An area of depleted nitrate/nitrite (as N) concentrations is apparent in the vicinity of the primary TCE source area (former leachfield adjacent to Building 1723A), indicating that denitrification is occurring. Nitrate/nitrite concentrations in shallow groundwater in this area ranged from 0.53 mg/L (well MW154) to 0.96 mg/L (well MW125). Nitrate/nitrite concentrations detected in groundwater from downgradient wells MW139 and TAD-6 also were low (0.17 mg/L and 1.04 mg/L, respectively), suggesting thatthe area of depleted nitrate/nitrite concentrations extends to near Sunset School approximately 1,500 feet west of the Hill AFB boundary. The low nitrate/nitrite concentrations should not impede the progress of reductive dehalogenation in the source area and for a short distance downgradient. However, nitrate concentrations in the central to downgradient portions of the TCE plume are sufficiently elevated that reductive transformation of TCE may be inhibited.

Nitrate/nitrite concentrations in deeper portions of the surficial aquifer are relatively low, ranging from not detected to 2.46 mg/L and averaging 0.7 mg/L (wells/points MW135, MW138, MW128, MW155, MP1d, MP2d, MP3d, and TAD-4). Therefore, reductive dehalogenation of TCE in deeper groundwater may not be inhibited by preferential use of nitrate as an electron acceptor.

4.4.6.3 Ferrous Iron

Although relatively little is known about the anaerobic metabolic pathways involving the reduction of ferric iron (Fe^{3+}), this process has been shown to be a major metabolic pathway for some microorganisms (Lovley and Phillips, 1988; Chapelle, 1993). The reduction of ferric iron results in the formation of ferrous iron (Fe^{2+}). Elevated concentrations of ferrous iron often are found in anaerobic groundwater systems. These concentrations once were attributed to the spontaneous and reversible reduction of ferric oxyhydroxides, which are thermodynamically unstable in the presence of organic compounds such as BTEX, trimethylbenzene (TMB), and naphthalene. However, recent evidence suggests that the reduction of ferric iron cannot proceed at all without microbial mediation (Lovley and Phillips, 1988; Lovley *et al.*, 1991; Chapelle, 1993). None of the common organic compounds found in low-temperature, neutral, reducing groundwater could reduce ferric oxyhydroxides to ferrous iron under sterile laboratory conditions (Lovley *et al.*, 1991). This means that the reduction of ferric iron requires mediation by microorganisms with the appropriate enzymatic capabilities.



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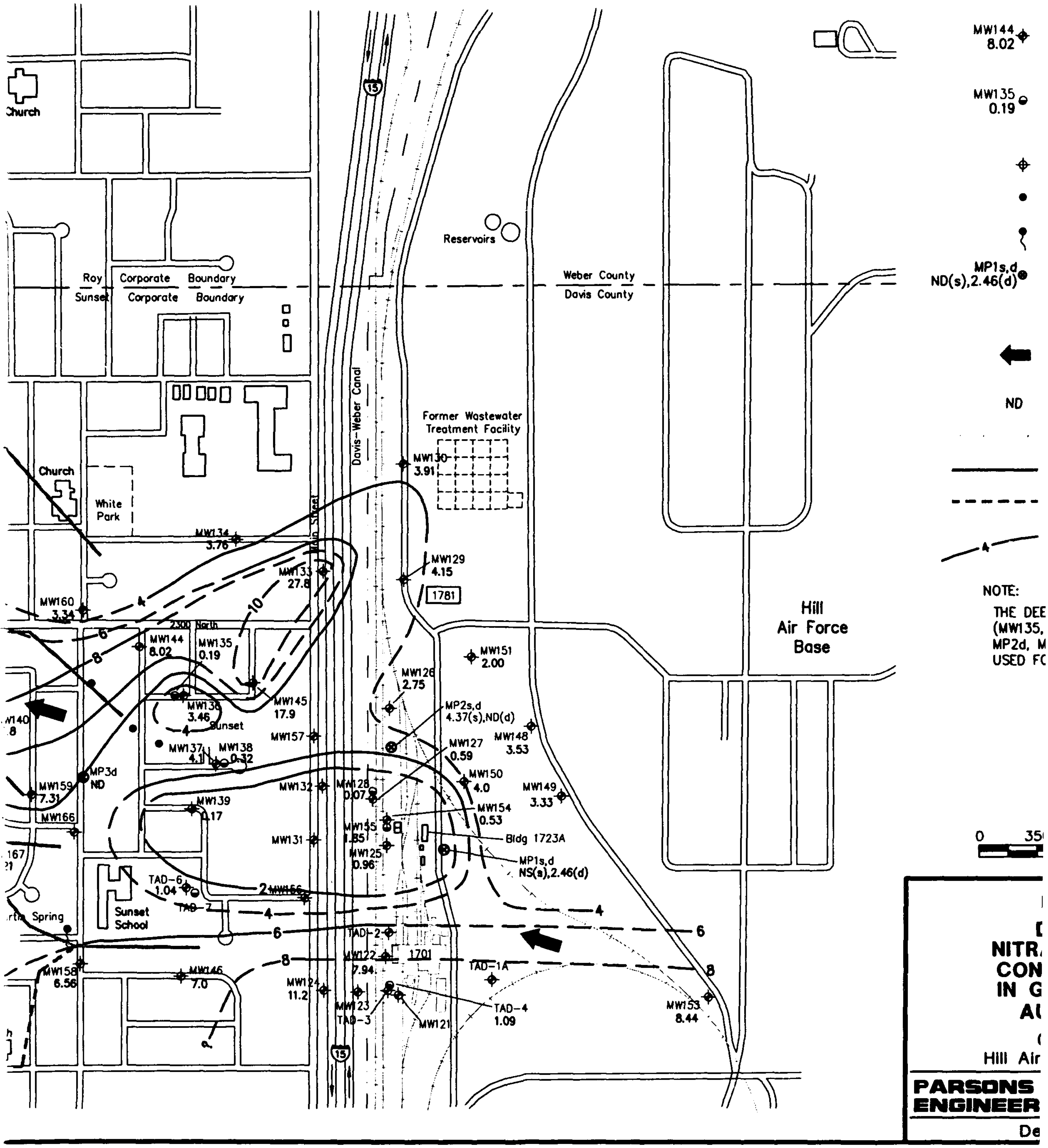
Church
Reservoirs
Roy Corporate Boundary
Sunset Corporate Boundary
Weber County
Davis County
Davis-Weber Canal
Main Street
Former Wastewater Treatment Facility
Church
White Park
2300 North
Sunset
Sunset School
Spring
Hill Air Force Base
1781
1701
Bldg 1723A
15
MW130 3.91
MW134 3.76
MW133 27.8
MW129 4.15
MW160 3.34
MW144 8.02
MW135 0.19
MW145 17.9
MW151 2.00
MW126 2.75
MW136 3.46
MP2s,d 4.37(s),ND(d)
MW140 .8
MW157
MW148 3.53
MW137 4.1
MW138 0.32
MW127 0.59
MP3d ND
MW159 7.31
MW132
MW128 0.07
MW150 4.0
MW149 3.33
MW139 0.17
MW166
MW154 0.53
MW155 1.85
MW131
MW125 0.96
MP1s,d NS(s),2.46(d)
167
21
TAD-6 1.04
MW156
TAD-7
TAD-2
MW122 7.94
TAD-1A
MW158 6.56
MW146 7.0
MW124 11.2
MW123
TAD-3
MW121
TAD-4 1.09
MW153 8.44
2
4
6
8
10
MW144 8.02
MW135 0.19
MP1s,d ND(s),2.46(d)
ND
4
NOTE:
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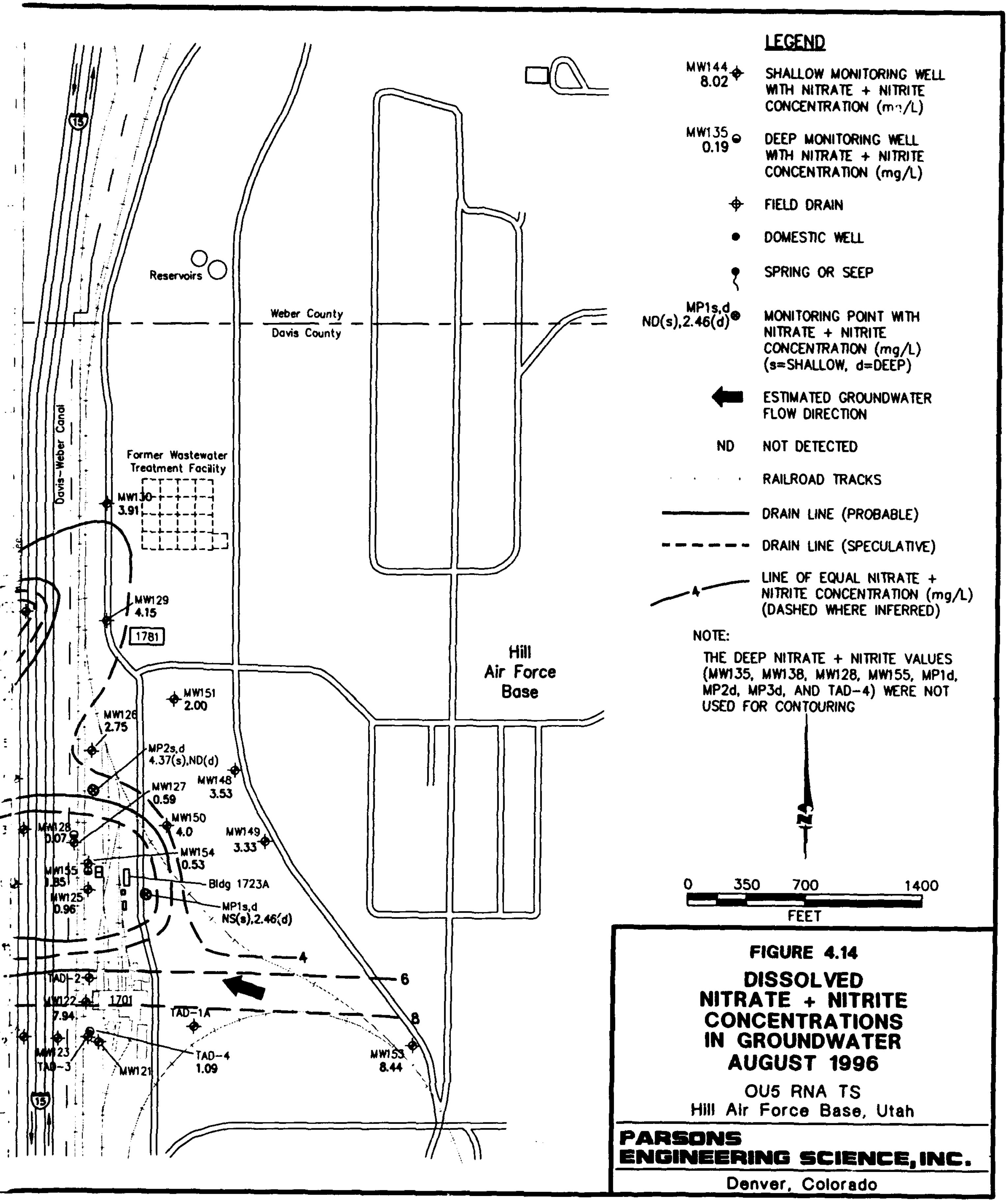

NOTE:

THE DEEP NITRATE + NITRITE VALUES (MW135, MW138, MW128, MW155, MP1d, MP2d, MP3d, AND TAD-4) WERE NOT USED FOR CONTOURING

FIGURE 4.14

DISSOLVED NITRATE + NITRITE CONCENTRATIONS IN GROUNDWATER AUGUST 1996

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Ferrous iron concentrations were measured at selected groundwater monitoring wells and monitoring points in August 1996. These concentrations are summarized in Table 4.3 and displayed on Figure 4.15. Dechlorination of PCE and TCE to DCE is possible under mildly reducing conditions such as nitrate or ferric iron reduction, but the transformations from DCE to VC or from VC to ethene requires the more strongly reducing conditions of methanogenesis. Therefore, the presence of redox conditions that are favorable to the occurrence of iron reduction suggests that reductive dehalogenation of the more highly-chlorinated CAHs (e.g., PCE and TCE) is possible.

Ferrous iron was detected in only three of the wells screened in the shallow portion of the surficial aquifer, including upgradient well MW153 (0.3 mg/L) and downgradient monitoring points MP7s (0.1 mg/L) and MP8s (0.2 mg/L). The paucity of ferrous iron detections indicates that microbial biodegradation via iron reduction is not an important process in the shallow water-bearing zone. Conversely, ferrous iron was detected in five of the seven monitoring wells/points screened deeper in the surficial aquifer (Figure 4.15). Therefore, redox conditions deeper in the surficial aquifer appear to be more favorable to the occurrence of reductive dehalogenation.

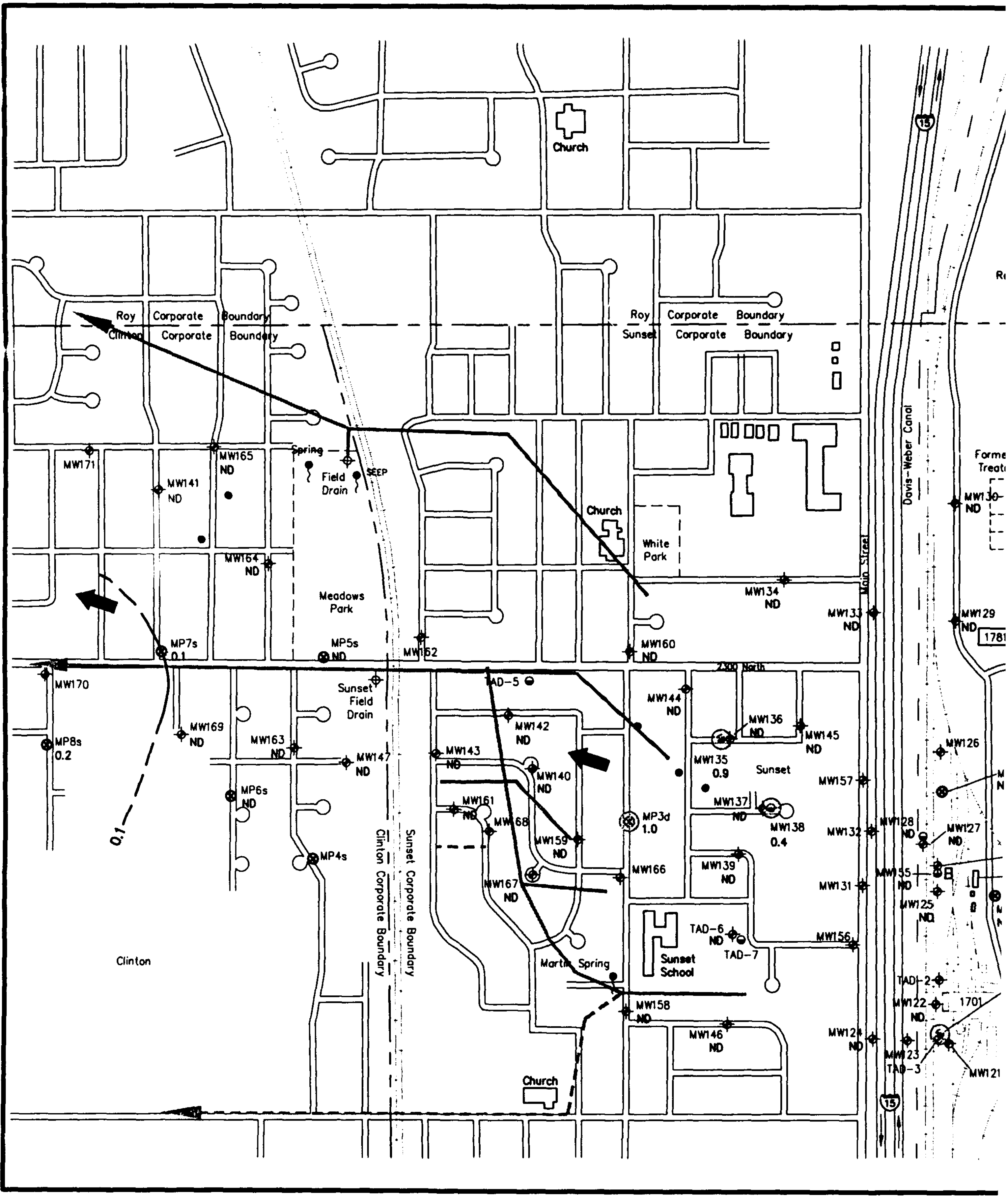
4.4.6.4 Sulfate

Sulfate also may be used as an electron acceptor during microbial degradation of fuel-hydrocarbons under anaerobic conditions (Grbic-Galic, 1990). This redox reaction is commonly called sulfate reduction. Sulfate is reduced to sulfide during the oxidation of natural or anthropogenic organic carbon. Wiedemeier *et al.*, (1996c) report that sulfate may compete with CAHs as an electron acceptor (sulfate may be preferentially used by microorganisms instead of CAHs) if sulfate concentrations exceed 20 mg/L. To investigate the potential for sulfate reduction at OU5, total sulfate concentrations were measured at groundwater monitoring wells and monitoring points during the August 1996 sampling event. Sampling results are summarized in Table 4.3.

Sulfate concentrations in shallow groundwater at the site ranged from 14.6 mg/L to 95.7 mg/L Shallow background sulfate concentrations measured in five upgradient to crossgradient wells (MW130, MW151, MW150, MW149, and MW153) ranged from 17.7 mg/L to 35.9 mg/L and averaged 28.2 mg/L. These data indicate that sulfate concentrations at the site are sufficiently high that use of CAHs as electron acceptors may be inhibited due to preferential use of sulfate.

4.4.6.5 Methane and Carbon Dioxide in Groundwater

Although reductive dehalogenation may occur under nitrate- and sulfate-reducing conditions (Vogel *et al.*, 1987; Chapelle, 1996), the most rapid biodegradation rates, affecting the widest range of CAHs, occurs under methanogenic conditions (Bouwer, 1994). Methane and carbon dioxide concentrations were measured in groundwater samples collected in August 1996 to assess whether methanogenic conditions are present in OU5 groundwater. Table 4.3 lists methane concentrations, and Figure 4.16 shows the distribution of methane in shallow site groundwater. The presence of methane within and downgradient from the TCE source area indicates that conditions have been sufficiently reducing (at least within a very localized area) that petroleum hydrocarbons and native organic matter were being used to support methanogenesis. The presence of strongly reducing (methanogenic) conditions was not indicated by the



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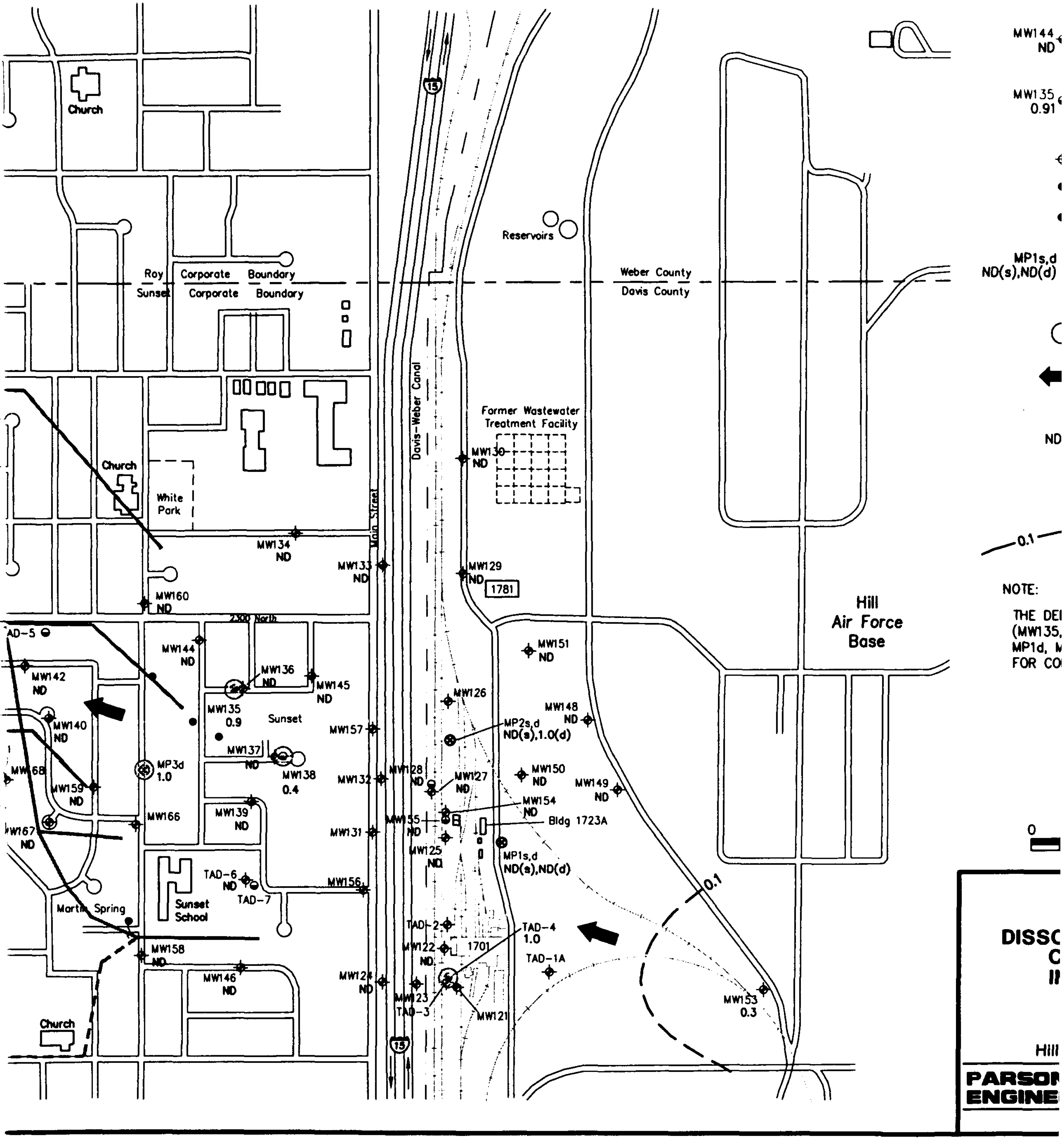
Church
Reservoirs
Roy Corporate Boundary
Sunset Corporate Boundary
Weber County
Davis County
Davis-Weber Canal
Main Street
Former Wastewater Treatment Facility
Church
White Park
2300 North
1781
Hill Air Force Base
Sunset
Sunset School
Martin Spring
Church
Bldg 1723A
1701
15
15
MW130 ND
MW134 ND
MW133 ND
MW129 ND
MW160 ND
AD-5
MW144 ND
MW136 ND
MW145 ND
MW142 ND
MW151 ND
MW126
MW148 ND
MW135 0.9
MW140 ND
MW157
MP2s,d ND(s),1.0(d)
MW137 ND
MW138 0.4
MW168
MP3d 1.0
MW159 ND
MW132
MW128 ND
MW127 ND
MW150 ND
MW149 ND
MW154 ND
MW166
MW139 ND
MW155 ND
MW131
MW167 ND
MW125 ND
MP1s,d ND(s),ND(d)
TAD-6 ND
TAD-7
MW156
0.1
TAD-2
TAD-4 1.0
MW122 ND
TAD-1A
MW158 ND
MW146 ND
MW124 ND
MW123
TAD-3
MW121
MW153 0.3
MW144 ND
MW135 0.91
MP1s,d ND(s),ND(d)
ND
0.1
NOTE:
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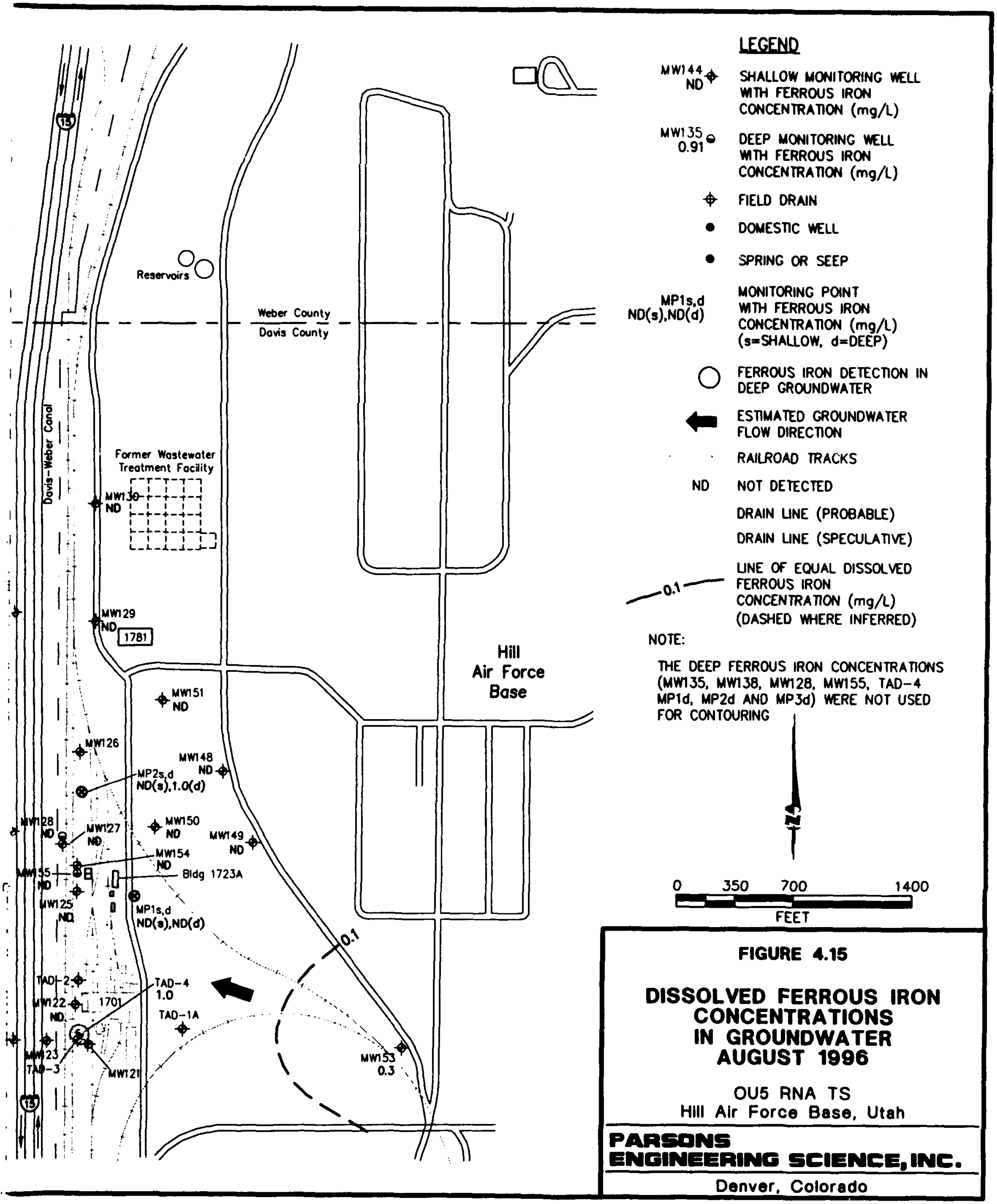

FIGURE 4.15

DISSOLVED FERROUS IRON CONCENTRATIONS IN GROUNDWATER AUGUST 1996

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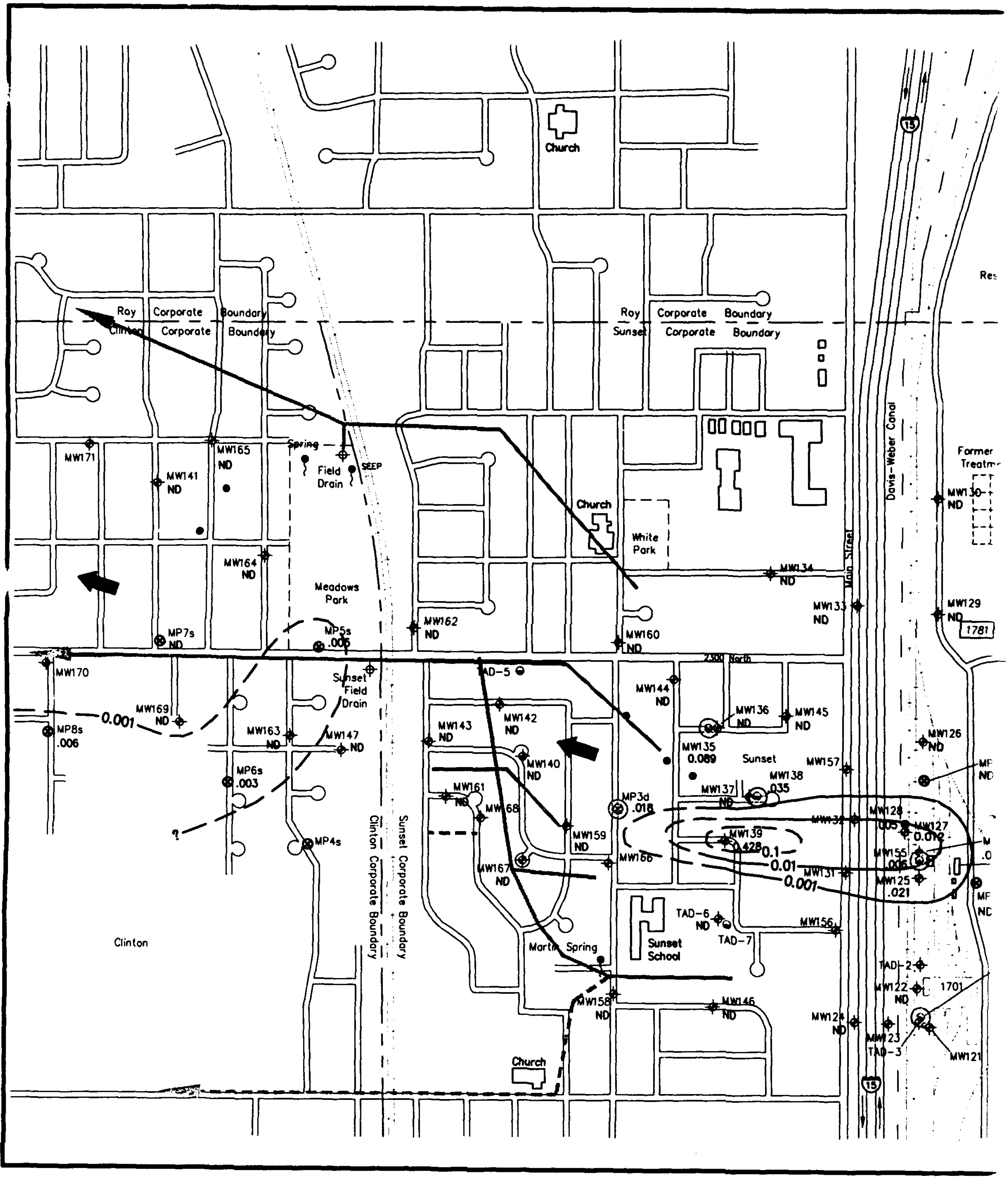

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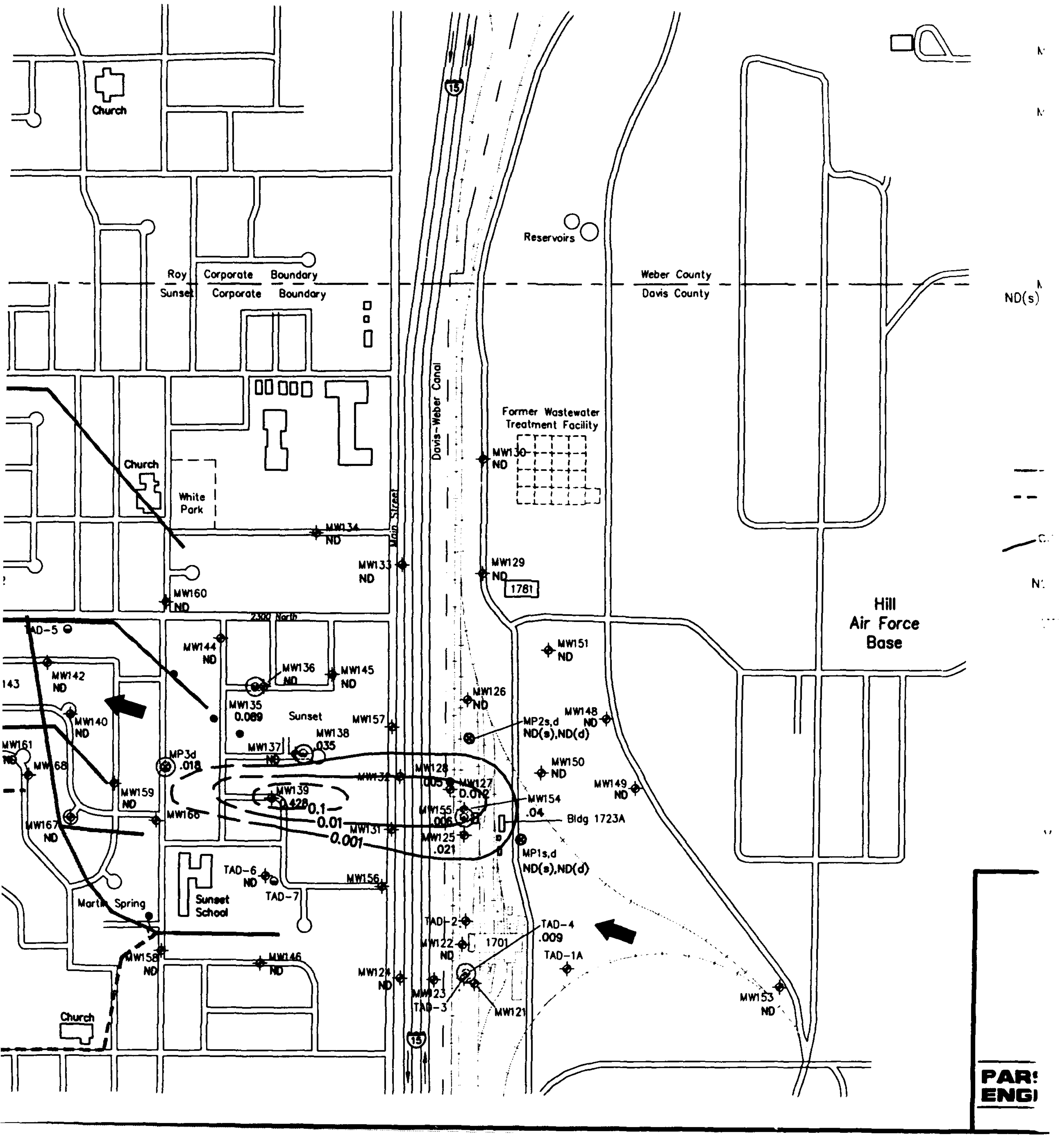
Church
15
Reservoirs
Roy Corporate Boundary
Sunset Corporate Boundary
Weber County
Davis County
ND(s)
Davis-Weber Canal
Former Wastewater Treatment Facility
MW130 ND
Church
White Park
MW134 ND
Main Street
MW133 ND
MW129 ND
1781
MW160 ND
2300 North
Hill Air Force Base
TAD-5
MW144 ND
MW151 ND
MW142 ND
143
MW136 ND
MW145 ND
MW126 ND
MW140 ND
MW135 0.089
Sunset
MW157
MP2s,d ND(s),ND(d)
MW148 ND
MW161 ND
MW138 .035
MW137 ND
MP3d .018
MW168
MW150 ND
MW132
MW128 .005
MW127 0.012
MW149 ND
MW159 ND
MW139 .428
0.1
MW154 .04
MW166
MW155 .006
0.01
Bldg 1723A
MW167 ND
MW131
0.001
MW125 .021
MP1s,d ND(s),ND(d)
TAD-6 ND
TAD-7
MW156
Sunset School
Martin Spring
TAD-2
TAD-4 .009
MW122 ND
1701
TAD-1A
MW158 ND
MW146 ND
MW124 ND
MW123
TAD-3
MW121
MW153 ND
Church
15
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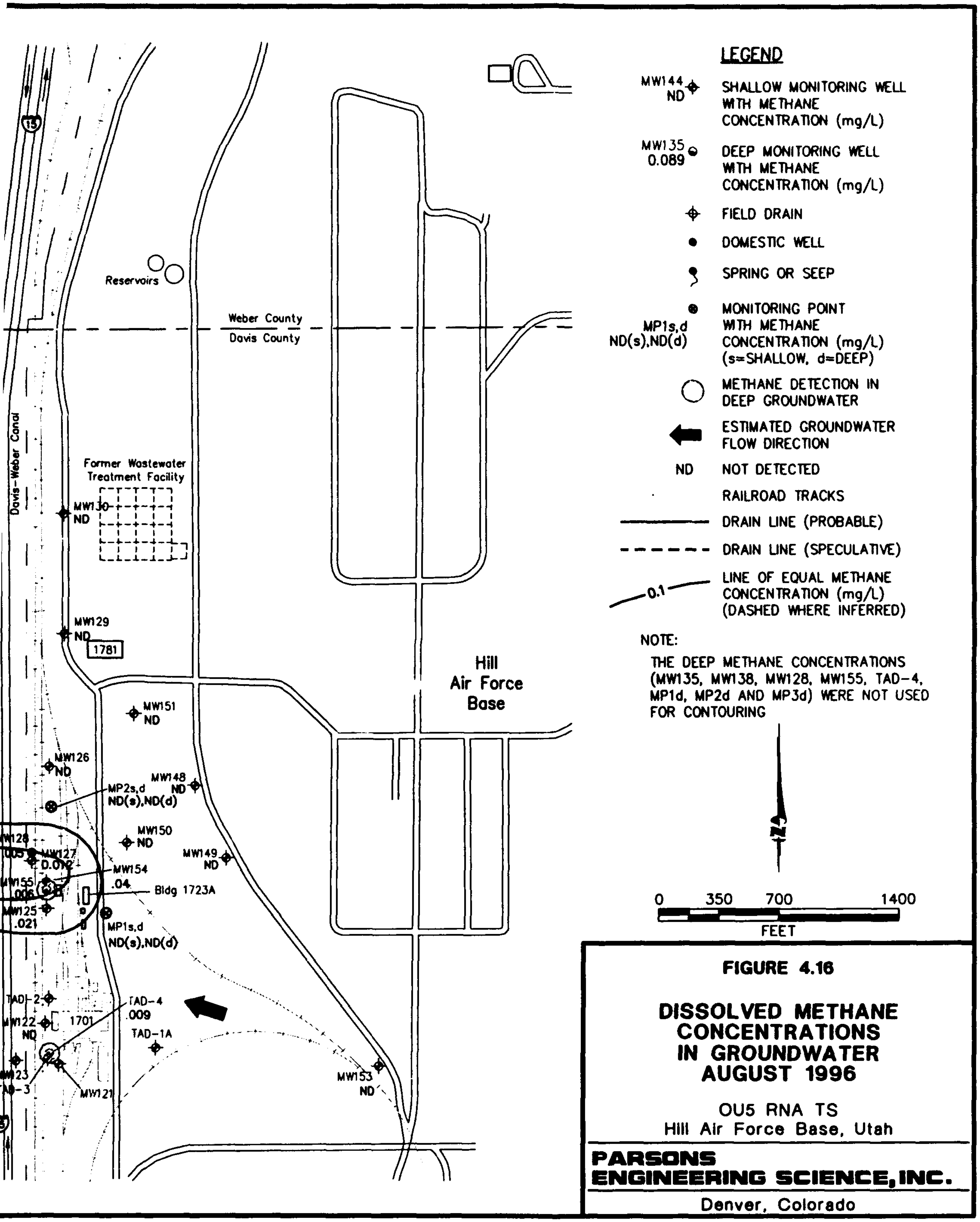

FIGURE 4.16

DISSOLVED METHANE CONCENTRATIONS IN GROUNDWATER AUGUST 1996

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ORP or H_2 data presented in Section 4.4.4. However, according to Vroblesky and Chapelle (1994), terminal electron-accepting processes can vary both spatially and temporally, with shifts taking place in as little as 10 days. The inference that methanogenesis has occurred indicates that conditions in the plume area have been highly reducing, and therefore favorable for reductive dehalogenation of CAHs. Methanogenic conditions may result from the presence of residual petroleum hydrocarbons in soils leaching into the groundwater and acting as an electron donor to drive redox reactions.

Background carbon dioxide concentrations measured in August 1996 ranged from 35 mg/L to 184 mg/L and averaged 97 mg/L on the basis of data from upgradient to cross-gradient monitoring wells/points MW130, MW151, MW150, MW149, and MW153 (Table 4.3). The carbon dioxide concentration detected in groundwater from source area well MW127 was relatively low (40 mg/L), indicating a current lack of methanogenic activity (methanogenesis produces more carbon dioxide than it uses). Carbon dioxide concentrations in other, nearby, source area wells (MW154 and MW125) were within the range of background concentrations.

4.4.6.6 Volatile Fatty Acids and Phenols

Fatty acids are synthesized by microorganisms to be used in the production of lipids necessary for incorporation into various membranes. A portion of these fatty acids are volatile. Volatile fatty acids (VFAs) are produced when the bacterial cell has obtained the required energy from metabolism of a carbon source (i.e., BTEX, CAHs, or naturally occurring organic carbon). After VFAs are secreted from the bacterial cell, they volatilize fairly rapidly; therefore detection of VFAs in groundwater is a strong indication of recent metabolic activity and possibly biodegradation of BTEX or CAHs. The standard method of VFA analysis performed by USEPA researchers is a gas chromatography/mass spectrometry method in which groundwater samples are compared to a standard mixture containing 58 phenols, aromatic acids, and aliphatic acids.

Samples for VFA analysis were collected from three wells at OU5: shallow wells MW127 and MW137, and deep well MW138. Each of these wells contained elevated TCE concentrations. Analysis results are presented in Table 4.6. Collectively, 30 of the 58 compounds in the standard were detected in these samples, indicating that oxidation of organic matter is occurring. However, 24 of the 30 analytes were detected at very low concentrations (below the calibration limit of 5 µg/L), indicating that the oxidation processes producing the acids are not prolific.

4.4.6.7 Ammonia

The presence of ammonia in groundwater can result from either nitrate reduction (facilitated by microbes) or fixing of atmospheric nitrogen (also a microbial process). Because nitrate appears to be widespread in groundwater within the surficial aquifer (Figure 4.14), and because fixation of atmospheric nitrogen only occurs under reducing conditions [ORP less than -500mV (Stumm and Morgan, 1981)], ammonia production via nitrate reduction is probably more common that by fixation of atmospheric nitrogen. In either case, the presence of ammonia in groundwater is a strong indication of microbial activity.

TABLE 4.6
CONCENTRATIONS OF PHENOLS, ALIPHATIC ACIDS, AND AROMATIC ACIDS IN GROUNDWATER
AUGUST 1996
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Compound	MW-138	MW-137	MW-127
	(concentrations in µg/L) [a]		
propanoic acid	15	14	<5
butyric acid	5	<5	5
hexanoic acid	6	<5	6
octanoic acid	12	<5	<5
benzoic acid	6	7	9
decanoic acid	7	<5	ND [b]
2-methylpropanoic acid	<5	<5	<5
trimethylacetic acid	<5	<5	<5
2-methybutyric acid	<5	<5	<5
3-methybutyric acid	<5	<5	<5
3,3-dimethylbutyric acid	<5	<5	<5
pentanoic acid	<5	<5	<5
2,3-dimethylbutyric acid	<5	<5	<5
2-ethylbutyric acid	<5	<5	<5
2-methylpentanoic acid	<5	<5	<5
3-methylpentanoic acid	<5	<5	<5
4-methylpentanoic acid	<5	<5	<5
2-methylhexanoic acid	<5	<5	<5
phenol	<5	ND	ND
cyclopentanecarboxylic acid	ND	<5	<5
5-methyhexanoic acid	ND	<5	<5
2-ethylhexanoic acid	<5	<5	<5
heptanoic acid	ND	ND	<5
1-cyclopentene-1-carboxylic acid	ND	<5	ND
cyclopentaneacetic acid	ND	<5	ND
3-cyclohexene-1-carboxylic acid	<5	ND	<5
1-cyclohexene-1-carboxylic acid	ND	<5	<5
o-methylbenzoic acid	ND	<5	ND
2,6-dimethybenzoic acid	ND	<5	ND
p-methylbenzoic acid	ND	<5	ND

a/ µg/L = micrograms per liter.
b/ ND = not detected.

Ammonia concentrations measured in groundwater samples collected in August 1996 are summarized in Table 4.3. Ammonia was detected in 7 of the 52 samples analyzed, 4 of which came from the deeper monitoring wells/points MP2d, TAD-4, MW138, and MP3d. As described in Section 4.4.6.2, nitrate/nitrite concentrations detected in deeper wells and points at OU5 were relatively low. This observation, in conjunction with the presence of ammonia, indicates that nitrate reduction is occurring at least locally in the deeper portions of the surficial aquifer. The scarcity of ammonia detections in shallow groundwater (in 3 of 45 samples) suggests that microbial activity connected with nitrate reduction is extremely limited. The general lack of microbial activity indicated by the ammonia data further supports the observation that microbial biodegradation of CAHs is very limited in OU5 groundwater.

4.4.7 Additional Geochemical Indicators

Other geochemical data collected for this evaluation can be used to further interpret and support the contaminant, electron donor, electron acceptor, and byproduct data previously discussed. These parameters provide additional qualitative indications of which processes may be operating at the site.

4.4.7.1 Alkalinity

Total alkalinity [as calcium carbonate ($CaCO_3$)] was measured in groundwater samples collected in August 1996 (Table 4.3). Alkalinity is a measure of the ability of groundwater to buffer changes in pH caused by the addition of biologically generated acids. Total alkalinity at the site varied from 70 mg/L to >500 mg/L. This range of alkalinity is sufficient to buffer potential changes in pH caused by biologically mediated reactions and suggests that aerobic and/or anaerobic biodegradation processes should not cause detrimental shifts in pH.

4.4.7.2 pH

pH was measured for groundwater samples collected from groundwater monitoring points and monitoring wells in August 1996 (Table 4.3). The pH of a solution is the negative logarithm of the hydrogen ion concentration [H^+]. With the exception of well TAD-4, groundwater pH measured at the site ranged from 6.8 to 7.9 standard units, which is within the optimal range for most microbial populations that degrade organic matter. Groundwater from TAD-4 had a pH of 5.8 standard units. The limited and relatively neutral range of pHs also indicates that microbial reactions have a minimal effect on groundwater pH, likely due to a combination of the moderately high alkalinity of site groundwater and the limited nature of microbial reactions that are occurring. The pH values measured in deeper samples are similar to the values measured at shallower depths.

4.4.7.3 Temperature

Groundwater temperature was measured at groundwater monitoring points and monitoring wells in August 1996 (Table 4.3). Temperature affects the types and growth rates of bacteria that can be supported in the groundwater environment, with higher temperatures generally resulting in higher growth rates. Temperatures in the surficial aquifer varied from 14 degrees Celsius (°C) to 24°C, with 44 of the 52 measurements ranging from 14°C to 20°C. Wiedemeier *et al.* (1996c) report that biochemical processes are accelerated at groundwater temperatures greater than 20°C. The temperature data summarized above indicate that this is not the case at OU5.

4.5 APPROXIMATION OF BIODEGRADATION RATES

Estimation of biodegradation rate constants is necessary to accurately simulate the fate and transport of contaminants dissolved in groundwater. Several methodologies, including first- and second-order approximations, may be used to estimate the rate of biodegradation of chlorinated compounds when they are being used to oxidize other organic compounds. Use of the first-order approximation can be appropriate to estimate biodegradation rates for chlorinated compounds where the rate of biodegradation is assumed to be controlled solely by the concentration of the contaminant. However, the use of a first-order approximation may not be appropriate when more than one substrate is limiting microbial degradation rates or when microbial mass is increasing or decreasing. In such cases, a second- or higher-order approximation may provide a better estimate of biodegradation rates. The preferable method of contaminant biodegradation rate-constant determination is by use of field data.

Buscheck and Alcantar (1995) derive a relationship that allows calculation of first-order biodegradation rate constants for steady-state plumes. This method involves coupling the regression of contaminant concentration (plotted on a logarithmic scale) versus distance downgradient (plotted on a linear scale) to an analytical solution for one-dimensional, steady-state, contaminant transport that includes advection, dispersion, sorption, and biodegradation (Bear, 1979). For an expanding plume, this first-order approximation can be viewed as an upper bound on the biodegradation rate. Use of this method results in an overestimation of the rate of biodegradation because a typical expanding plume exhibits decreasing source area concentrations, increasing downgradient concentrations, or both. Over time, these changes result in a decreasing slope on a log-linear plot, and consequently a decreasing biodegradation rate. In addition, decay rates computed using this method include decay related to processes other than reductive dechlorination, such as aerobic degradation of DCE and abiotic reactions.

Another method for estimating dehalogenation rates of CAHs is described by Moutoux *et al.* (1996). This method can be used to estimate the theoretical contaminant concentration resulting from biodegradation alone for every point along a flow path on the basis of the measured contaminant concentration at the point of plume origin and the contaminant/tracer ratios between consecutive points along the flow path. This series of points can then be used to estimate a first-order rate of biodegradation. The carbon core of the CAH compounds, which is subject to the same non-destructive attenuation mechanisms that act on the larger chlorinated molecule, but is unaffected by biologically mediated reductive dechlorination, is used as the tracer. This method provides a total dechlorination rate for all dechlorination steps. All rates (including the rapid TCE to DCE rate and the slow VC to ethene rate) are averaged in the Moutoux *et al.* (1996) method. Because abiotic reactions and reactions that involve CAHs in the role of an electron donor are not included in this rate, the rate should be considered to be a lower bound on the destructive attenuation rate.

Although a first-order rate assumption may provide a reasonable approximation of how CAH compounds are degrading in groundwater systems, this approach may not provide the best approximation of how CAH compounds are dechlorinated in the presence of an electron donor such as BTEX. These reactions may be more appropriately approximated by a second-order rate expression. This approach was not used for the OU5 plume due to the lack of BTEX in the groundwater.

The two first-order methods described above were used to estimate first-order biodegradation rate constants for CAHs at OU5. Because concentrations of the primary parent solvent (TCE) are dominant, the rates are substantially equivalent to TCE decay rates. The decay rate calculations are summarized in Appendix D. As described in Section 4.3.1, the relatively rapid decrease in TCE concentrations measured between wells MW159 (227 µg/L) and MW143 (90 µg/L) may be caused by discharge of CAH-contaminated groundwater to a drain line that is inferred to be located between these wells. As a result, decay rates calculated using the decrease in CAH concentrations between these two wells may be inaccurate. Decay constants were thus computed for two distinct segments of the CAH plume. The first segment consisted of the portion of the plume that is upgradient from the inferred drain line (between source area well MW154 and downgradient well MW159). The second segment consisted of the portion of the plume that is downgradient from the inferred drain line (between well MW143 and monitoring point MP7). The decay rates computed for these plume segments are summarized in Table 4.7, and additional details are provided in Appendix D.

The rates computed using the method of Buscheck & Alcantar (1995) are approximately one to three orders of magnitude higher than the rates derived for reductive dechlorination using the method of Moutoux (1996). As described above, the Buscheck and Alcantar method can be viewed as an upper bound on the biodegradation rate, and the lower reductive dechlorination rates are probably more representative of the OU5 CAH plume given the limited evidence that reductive dehalogenation is occurring. The computed reductive dechlorination rates ranged from 1×10^{-7} day^{-1} in the central portion of the plume to 2×10^{-5} day^{-1} near the source area. The average reductive dechlorination rate for the entire plume is probably within this range. The reductive dechlorination rate of 1×10^{-6} day^{-1}, derived for the flowpath MW127-MW138- MW159, may be the most representative rate for the upgradient segment of the plume, because it was derived using data points spaced along a relatively long flowpath.

4.6 SUMMARY

The dissolved CAH plume appears to have migrated approximately 5,000 feet west of the source area at the Tooele Rail Shop. The CAH mass that discharges to the surface at springs or seeps is insignificant relative to the mass that is migrating in the groundwater. However, some discharge of dissolved CAHs to a north/south-trending drain line may be occurring.

Several lines of chemical and geochemical evidence indicate that, although dissolved CAHs at OU5 are undergoing biologically facilitated reductive dehalogenation, the occurrence of this process is limited and localized. As a result, the parent CAH (TCE) still comprises the majority of the contamination present in groundwater. The dissolved CAH plume at OU5 exhibits characteristics of mixed behavior, with type 2

TABLE 4.7
SUMMARY OF CAH DECAY RATES
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Plume Segment	Analysis Method	Selected Flow Path	Date of Sampling Data	Decay Rate (day^{-1})
Upgradient	B&A[a/]	MW138-MW159	Spring 1996	2.6×10^{-5}
Upgradient	B&A	MW138-MW159	August 1996	1.3×10^{-5}
Upgradient	B&A	MW127-MW138-MW159	March 1995	3.2×10^{-4}
Upgradient	B&A	MW154-MW132-MW138-MW159	October 1995	2.8×10^{-4}
Upgradient	Reduc. Dechlor[b/]	MW138-MW159	August 1996	1×10^{-7}
Upgradient	Reduc. Dechlor	MW127-MW138-MW159	March 1995	1×10^{-6}
Upgradient	Reduc. Dechlor	MW154-MW132-MW138-MW159	October 1995	[c/]
Upgradient	Reduc. Dechlor	MW154-MW132	October 1995	2×10^{-5}
Downgradient	B&A	MW143-MW163	Spring 1996	3.5×10^{-4}
Downgradient	B&A	MW143-MW163	August 1996	2.9×10^{-4}
Downgradient	B&A	MW143-MW163-MP7	August 1996	5.3×10^{-4}
Downgradient	Reduc. Dechlor	MW143-MW163	Spring 1996	[c/]
Downgradient	Reduc. Dechlor	MW143-MW163-MP7	August 1996	[c/]

a/ B&A = Method of Buscheck and Alcantar (1995) for steady-state plumes.

b/ Reduc. Dechlor. = Method of Moutoux et al. (1996), which gives decay rate attributable to reductive dechlorination.

c/ Corrected CAH concentrations increased with distance along flow path; reductive dechlorination rate not calculated.

behavior evidenced in and immediately downgradient of the source area, and type 3 behavior evidenced throughout the remainder of the plume. The presence of methane in groundwater near the source area suggests that prior releases of at least small amounts of petroleum hydrocarbons in the source area near Building 1723A may have stimulated additional microbial activity and made the groundwater system reducing enough to allow more rapid reductive dehalogenation of CAHs (localized Type 1 behavior). The evidence supporting the limited occurrence of TCE biodegradation is summarized below:

- The presence of *cis*-1,2-DCE is a direct indication that TCE is being reductively dehalogenated, but the low magnitude of daughter product concentrations relative to TCE indicate that reductive transformation of TCE is very limited;
- The presence of elevated chloride concentrations (above background levels) is very localized, indicating that reductive dehalogenation reactions are not prevalent enough in many portions of the plume to significantly influence chloride concentrations;
- ORP and dissolved H_2 data indicate that the groundwater is sufficiently reducing to support the occurrence of reductive dehalogenation, but redox conditions are not optimal for this process;
- Dissolved TOC concentrations are not sufficient to sustainably drive dehalogenation reactions;
- The lack of true anaerobic conditions throughout the majority of the TCE plume probably limits the occurrence of reductive dehalogenation, which is an anaerobic process;.
- Nitrate and sulfate concentrations within much of the plume area are sufficiently high that use of CAHs as electron acceptors may be inhibited due to preferential use of these anions as alternate electron acceptors;
- The evidence that methanogenic conditions existed near the source area indicates that conditions favorable for reductive dehalogenation of CAHs were at least locally present; however, methane was infrequently detected and, where present, occurred at low concentrations, indicating that the occurrence of methanogenesis was spatially and temporally very limited; and
- The scarcity of ammonia and VFAs in groundwater further supports the observation that microbial biodegradation of CAHs is very limited in OU5 groundwater.

Wiedemeier *et al.* (1996c) present a worksheet to allow an initial assessment of the prominence of natural attenuation at a site. The worksheet, including the point values determined for OU5, are included as Table 4.8.

The interpretation of points awarded during the screening process outlined in Table 4.8 is shown in Table 4.9. The score for OU5 computed using Table 4.8 is 11.5, indicating that evidence for biodegradation of chlorinated organics is present, but limited.

As discussed in Section 4.5, rates of CAH biodegradation estimated from data collected for this investigation range from 5.3×10^{-4} day^{-1} to 1×10^{-7} day^{-1}. An average decay rate that is intermediate between these bounding values (e.g., in the 10^{-6} day^{-1} range) may be most representative of the overall OU5 CAH plume.

TABLE 4.8
ANALYTICAL PARAMETERS AND WEIGHTING FOR PRELIMINARY SCREENING
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Analysis	Concentration in Most Contaminated Zone	Interpretation	Value	OU5 Score
Oxygen	<0.5 mg/L	Tolerated, suppresses the reductive pathway at higher concentrations	3	3
	>1 mg/L	VC may be oxidized aerobically	-3	--
Nitrate	<1 mg/L	At higher concentrations may compete with reductive pathway	2	2
Iron II	>1 mg/L	Reductive pathway possible	3	0
Sulfate	<20 mg/L	At higher concentrations may compete with reductive pathway	2	0
Sulfide	>1 mg/L	Reductive pathway possible	3	--
Methane	<0.5 mg/L	VC oxidizes	0	0
	>0.5 mg/L	Ultimate reductive daughter product, VC Accumulates	3	0
Oxidation Reduction Potential (ORP)	<50 millivolts (mV)	Reductive pathway possible	1	1
	<-100mV	Reductive pathway likely	2	0
pH	5 < pH < 9	Optimal range for reductive pathway	0	0
	5 > pH >9	Outside optimal range for reductive pathway	-2	0
TOC	> 20 mg/L	Carbon and energy source; drives dechlorination; can be natural or anthropogenic	2	0
Temperature	> 20°C	At T >20°C biochemical process is accelerated	1	0
Carbon Dioxide	>2x background	Ultimate oxidative daughter product	1	0.5[b/]
Alkalinity	>2x background	Results from interaction of carbon dioxide with aquifer minerals	1	0
Chloride	>2x background	Daughter product of organic chlorine	2	1[c/]
Hydrogen	>1 nM/L	Reductive pathway possible, VC may accumulate	3	0
	<1 nM/L	VC oxidized	0	0
Volatile Fatty Acids	> 0.1 mg/L	Intermediates resulting from biodegradation of aromatic compounds; carbon and energy source	2	0

TABLE 4.8 (Continued)
ANALYTICAL PARAMETERS AND WEIGHTING FOR PRELIMINARY SCREENING
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Analysis	Concentration in Most Contaminated Zone	Interpretation	Value	OU5 Score
BTEX	> 0.1 mg/L	Carbon and energy source; drives dechlorination	2	0
PCE		Material released	0	0
TCE		Material released	0	0
		Daughter product of PCE	2[d]	0
1,2-DCE		Material released	0	0
		Daughter product of TCE.	2[d]	2
		If *cis* is greater than 80% of total DCE it is likely a daughter product of TCE		
VC		Material released	0	0
		Daughter product of DCE	2[d]	0
Ethene/Ethane	>0.01mg/L	Daughter product of VC/ethene	2	0
	>0.1 mg/L		3	0
Chloroethane		Daughter product of VC under reducing conditions	2	0
1,1,1-Trichloroethane		Material released	0	0
1,2-Dichlorobenzene		Material released	0	0
1,3-Dichlorobenzene		Material released	0	0
1,4-Dichlorobenzene		Material released	0	0
Chlorobenzene		Material released or daughter product of dichlorobenzene	2[d]	0
1,1-DCE		Daughter product of TCE or chemical reaction of 1,1,1-TCA	2[d]	2

a/ Partial points awarded because the occurrence of ORPs along the plume flowpath that are less than 100 mV is limited to one well (MW138), indicating that conditions favorable to reductive dehalogenation are very localized.

b/ Partial points awarded because elevated carbon dioxide concentrations were detected, but are not widespread.

c/ Partial points awarded because the chloride concentration in well MW137, while greater than 2X the average background chloride concentration, is not greater than the maximum background chloride concentration.

d/ Points awarded only if it can be shown that the compound is a daughter product (i.e., not a constituent of the parent compound).

TABLE 4.9
INTERPRETATION OF POINTS AWARDED DURING NATURAL ATTENUATION SCREENING
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Score	Interpretation
0 to 5	Inadequate evidence for biodegradation of chlorinated organics
6 to 14	Limited evidence for biodegradation of chlorinated organics
15 to 20	Adequate evidence for biodegradation of chlorinated organics
>20	Strong evidence for biodegradation of chlorinated organics

SECTION 5

GROUNDWATER FLOW AND CONTAMINANT TRANSPORT MODEL

5.1 GENERAL OVERVIEW AND MODEL DESCRIPTION

In order to help predict the future migration and fate of CAHs dissolved in groundwater at Hill AFB OU5, groundwater flow and the fate and transport of dissolved TCE in the surficial aquifer was modeled. The primary TCE plume emanating from the Building 1723A area as well as the TCE detection west of Building 1781 at well MW129 were included in the model. As described in Section 4.3.2, a significantly elevated PCE concentration (253 µg/L) was detected in well MW141, located in Clinton west of Meadows Park. The detected TCE concentrations in this well and nearby well MW165 were 5.1 µg/L and 8.9 µg/L, respectively. These CAH detections were not modeled because they have not been linked to a Hill AFB source, and may be sourced off-Base.

The modeling effort had three primary objectives: 1) predict the future extent and concentrations of the dissolved contaminant plume by modeling the combined effects of advection, dispersion, sorption, and biodegradation; 2) assess the potential for downgradient receptors to be exposed to contaminants at concentrations above regulatory levels of concern; and 3) if applicable, provide technical support for the natural attenuation remedial option at post-modeling regulatory negotiations. The model was developed using site-specific data and reasonable assumptions about governing physical and chemical processes. This analysis is not intended to represent a baseline assessment of potential risks posed by site contamination.

The model codes MODFLOW (McDonald and Harbaugh, 1988) and MT3D® (Zheng, 1990) were used to estimate the potential for dissolved TCE migration and degradation by naturally occurring mechanisms operating at the site. MODFLOW was used to generate a groundwater flow model for the site, and the flow field from this model was incorporated into the transport solution computed by MT3D®. The pre- and post-processors contained in Visual MODFLOW® (Waterloo Hydrogeologic Software, 1995) were used to facilitate model development and analysis/presentation of model results. The MT3D® code incorporates advection, dispersion, sorption, and biodegradation to simulate contaminant plume migration and degradation. MT3D® uses solution routines based on the method of characteristics (MOC) solute transport model [e.g., as developed by Konikow and Bredehoeft (1978) for the USGS two-dimensional (2D) MOC model code]. The model was modified by Zheng (1990) to allow three-dimensional (3D) solutions, and to allow use of a modified MOC method that reduces numerical dispersion. Biodegradation of dissolved and sorbed contaminants can be simulated through the use of a first-order decay constant.

Ideally, a code for simulating degradation of CAHs would track parent compounds and daughter products and allow specification of varying retardation coefficients and decay rates for each compound. However, such a model is not yet available, although Battelle National Laboratories is in the process of developing such a code by modifying MT3D®.

5.2 CONCEPTUAL MODEL DESIGN AND ASSUMPTIONS

Prior to developing a groundwater model, it is important to determine if sufficient data are available to provide a reasonable estimate of aquifer conditions. In addition, it is important to ensure that any limiting assumptions can be justified.

On the basis of the data presented in Section 3, the surficial aquifer at OU5 was conceptualized and modeled as a shallow, heterogeneous, unconfined aquifer. Hydrogeologic profiles of the site (Figures 3.6 and 3.7) indicate that the surficial aquifer is comprised primarily of fine- to medium-grained, silty sand interbedded with alternating layers of coarser sand and fine gravel with thin seams of silt and clay. Depth to groundwater ranges from 15 to 40 feet bgs in the Tooele Rail Shop area, to less than 10 feet bgs beneath Sunset and Clinton. The groundwater surface elevation contour map prepared using August 1996 groundwater elevation data (Figure 3.8) indicates that the groundwater flow direction beneath OU5 is generally to the west and northwest. The surficial aquifer is bounded on the bottom by silt/clay zones at depths ranging from 15 feet to more than 50 feet bgs. An intermediate, silty, clayey zone that splits the surficial aquifer into shallow and deep portions, also is present. However, contaminant distribution data indicate that this intermediate zone does not completely block vertical migration of groundwater and contaminants between the shallow and deep portions. The TCE plume emanating from the Tooele Rail Shop migrates primarily through the upper portion of the surfical aquifer, but is also present in the deep portion of the surficial aquifer in eastern Sunset.

Because of the localization of the TCE plume in the surficial aquifer; the predominantly horizontal groundwater flow and contaminant migration direction throughout the site; and the lack of discrete, laterally continuous, well-defined layers that are hydraulically distinct, a 2D simulation was determined to be appropriate. Groundwater elevation data collected in August 1996 and presented on Figure 3.8 were used to calibrate the flow model. Hydraulic gradients and groundwater flow directions inferred from the August 1996 data are similar to those presented in the RI report (Radian, 1995). Therefore, it was assumed that the August 1996 water levels are reasonably representative of steady-state conditions. In addition, it was assumed that recharge to the surfical aquifer from precipitation and lawn irrigation was not significant enough to include in the model.

During the development and calibration of the contaminant fate and transport model, it was assumed that TCE was first introduced into groundwater beneath the Rail Shop in 1949, which is when TCE reportedly began to be used at the Rail Shop. The rate of TCE introduction into the surficial water-bearing zone was assumed to be constant until

1964, when the use of TCE at the Rail Shop reportedly ceased. Therefore, from 1964 to 1996, the source strength was decreased to simulate depletion of the source due to the effects of leaching, volatilization, and decay. The source of the TCE detected north of the Rail Shop in well MW129 is not known. For modeling purposes, it was assumed that TCE was introduced into the surficial aquifer at this location in 1988. Additional details regarding the locations of the source cells and how the source terms were varied during the calibration and predictive periods (1964 to 1996 and 1997 to 2097, respectively) are presented in Sections 5.3.3.1 and 5.4.2.1.

The most important assumption made when using the MT3D® code is that dispersion, sorption, and biodegradation are major factors controlling contaminant fate and transport at the site. According to data presented in Section 4, detectable concentrations of organic carbon are present within the fluvial-deltaic deposits through which the TCE plume is migrating, indicating that some sorption of organic contaminants is occurring. Sorption is simulated in the model using a coefficient of retardation. Available data also suggest that limited biodegradation of TCE is occurring locally within the plume; biodegradation of TCE was simulated using a first-order decay constant. Dispersivity is a characteristic of the porous medium and is a measure of the longitudinal and lateral spreading of the contaminant caused by local heterogeneities that cause deviations from the average linear migration velocity. The magnitude of dispersivity is generally believed to be scale-dependent; the longer the plume flowpath the higher the dispersivity. Given the considerable length of the TCE plume flowpath (nearly 1 mile) and the documented presence of subsurface heterogeneities (Section 3), it is reasonable to assume that dispersivity is an important parameter influencing solute transport at OU5. Selection of values for these parameters is discussed in Section 5.3 and 5.4.

Because of the small surface area of the groundwater flow system exposed to soil gas, volatilization of many VOCs, including chlorinated solvents, from groundwater is a relatively slow process that, in the interest of being conservative, generally can be neglected when modeling CAH fate and transport. For example, Chiang et al. (1989) demonstrated that less than 5 percent of the mass of dissolved BTEX is lost to volatilization in the saturated groundwater environment. Moreover, Rivett (1995) observed that for plumes more than about 1 meter below the air/water interface, only low, if any, solvent concentrations will be detectable in soil gas due to the downward groundwater velocity in the vicinity of the water table. This suggests that for portions of plumes more than 1 meter below the water table, very little, if any, mass will be lost to volatilization. In addition, vapor transfer across the capillary fringe can be very slow (McCarthy and Johnson, 1993), further limiting mass transfer rates. In summary, the impact of volatilization on dissolved CAH reduction can generally be neglected, except possibly in the case of vinyl chloride, which has a high Henry's Law constant and is therefore very susceptible to volatilization.

5.3 INITIAL MODEL SETUP

Where possible, the initial setup for this model was based on site-specific data. Where site-specific data were not available (e.g., effective porosity), reasonable assumptions were made on the basis of widely accepted literature values for materials similar to those found in the shallow aquifer. The following sections describe the basic model setup. Those model parameters that were varied during model calibration are also discussed in Section 5.4.

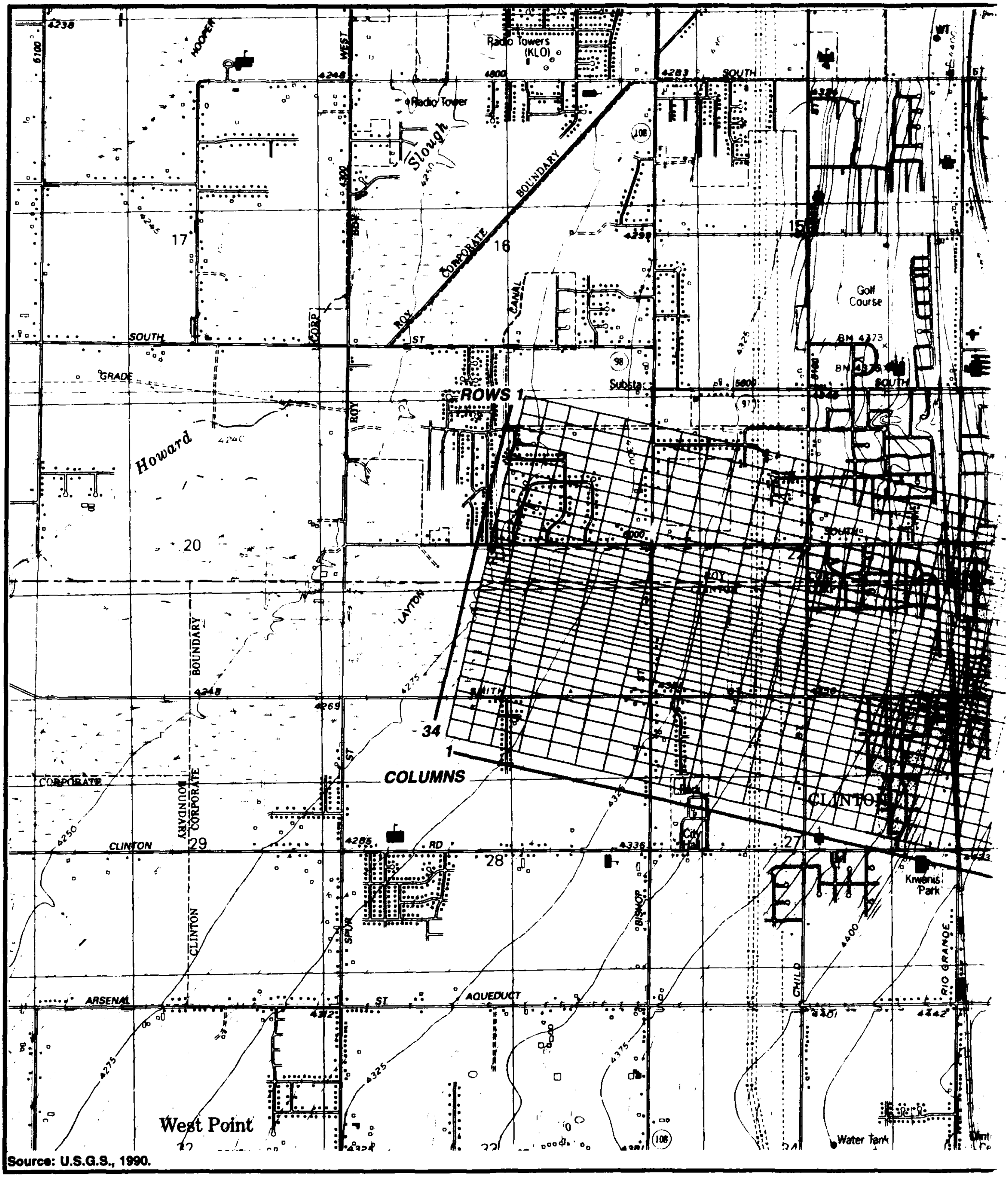
5.3.1 Grid Design

The model domain for OU5 is represented using 1 layer, with a 34- by 66-cell horizontal grid. The long axis of the model grid, which is depicted on Figure 5.1, is oriented approximately parallel to the groundwater flow and plume migration direction observed at OU5. The model grid covers an area of 100,800,000 square feet, or approximately 2,314 acres. The orientation of the grid assumes that the groundwater flow direction west of the TCE plume is also to the west-northwest; this is a reasonable assumption given that groundwater probably migrates toward Howard Slough and the adjacent wetland areas. Relatively small grid cells (100- by 100-feet) were used in the contaminant source area to allow more accurate simulation of the source; the cell size was gradually increased with distance from the source area, with the largest cell measuring 500 feet in the east-west direction and 300 feet in the north-south direction. The grid thickness in the OU5 area varies from 30 feet in the Tooele Rail Shop area to 20 feet near the downgradient toe of the TCE plume in order to simulate the thinning, believed to occur near MW159, of the surficial aquifer and the observed TCE plume (Figure 4.6). The western boundary of the grid coincides with the presence of wetlands near Howard Slough that may represent groundwater discharge areas (Figure 3.1). As described in Section 6, these wetland areas are being drained and developed, and therefore are no longer as laterally extensive as portrayed on Figure 3.1.

5.3.2 Groundwater Flow Model

5.3.2.1 Boundary Conditions

In defining the model domain, the area of interest must be separated from the surrounding system. Boundary conditions describe the interaction between the system being modeled and its surroundings or, for transport models, the loading of contaminant mass into the system. Boundary conditions are used to include the effects of the system outside the area being modeled with the system being modeled, while at the same time allowing the isolation of the desired model domain from the larger system. In effect, the boundaries of the model tell the area immediately inside the boundaries what to expect from the outside world. The solution of any differential equation requires specification of the conditions at the periphery of the system. Model boundaries are thus mathematical statements that specify the dependent variable (head or contaminant concentration) or the flux (derivative of the head or contaminant concentration with respect to time) at the model grid boundaries.



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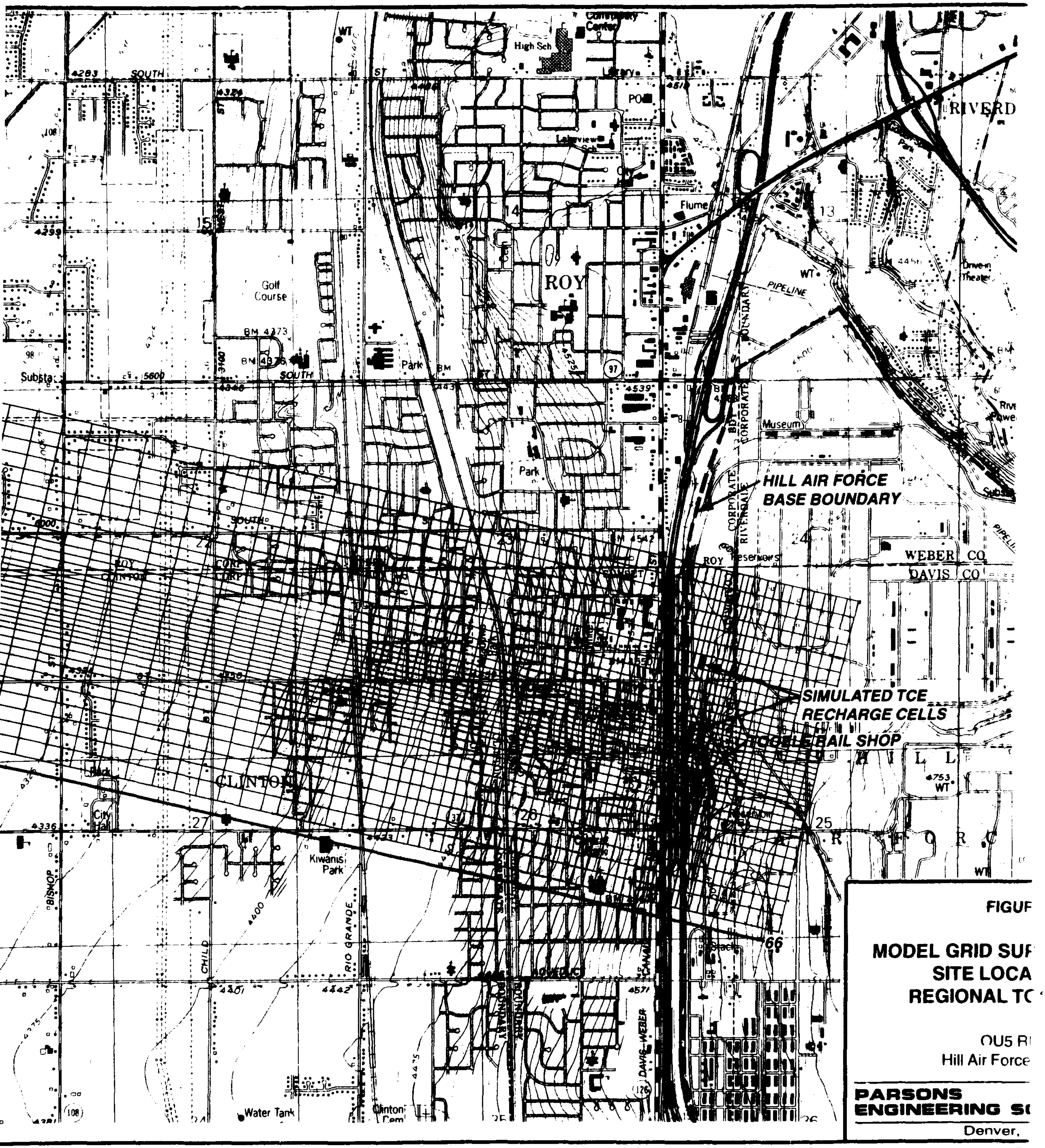

FIGUF

MODEL GRID SUF
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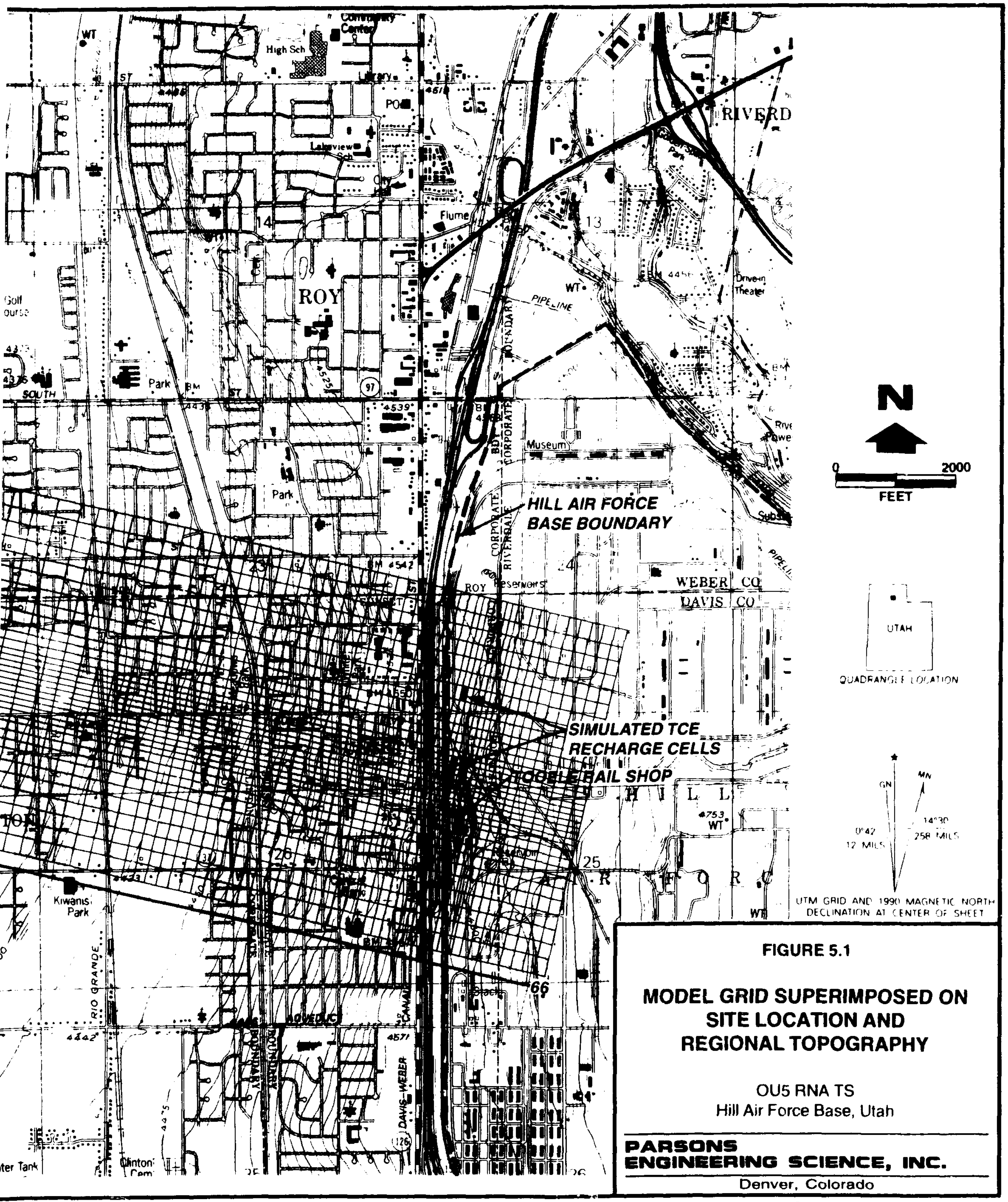


FIGURE 5.1

MODEL GRID SUPERIMPOSED ON SITE LOCATION AND REGIONAL TOPOGRAPHY

OU5 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Three types of boundary conditions generally are utilized to describe groundwater flow and solute transport. Boundary conditions are referred to as type one (Dirichlet), type two (Neumann), and type three (Cauchy). Table 5.1 summarizes boundary conditions for groundwater flow and solute transport.

TABLE 5.1
COMMON DESIGNATIONS FOR SEVERAL IMPORTANT BOUNDARY CONDITIONS[a]
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Boundary Condition	Boundary Type	Formal Name	General Mathematical Description	
			Groundwater Flow	**Contaminant Transport**
Specified-Head or Specified-Concentration	Type One	Dirichlet	$H = f(x,y,z,t)$	$C = f(x,y,z,t)$
Specified Flux	Type Two	Neumann	$\frac{\partial H}{\partial n} = f(x,y,z,t)$	$\frac{\partial C}{\partial n} = f(x,y,z,t)$
Head-Dependent or Concentration-Dependent Flux	Type Three (mixed-boundary condition)	Cauchy	$\frac{\partial H}{\partial n} + cH = f(x,y,z,t)$	$\frac{\partial C}{\partial n} + cC = f(x,y,z,t)$

[a] Modified from Franke *et al.* (1987).

In flow models, boundary conditions are ideally used to specify actual hydrogeologic boundaries to the system, such as streams, lakes, confining units, groundwater divides, or any geologic or anthropogenic feature that may bound a system. Also, the boundaries may be defined as areas where properties (e.g., flux) are known and can be defined. When using a numerical flow model, hydrologic boundaries such as constant-head features (e.g., lakes, etc.) or constant-flux features should, when possible, coincide with the perimeter of the model. In areas that lack obvious hydrologic boundaries, constant-head or constant-flux boundaries can be specified at the numerical model perimeter as long as the perimeter is far enough removed from the contaminant plume that transport calculations will not be affected.

Specified-head boundaries for the model were set at the upgradient (eastern) and downgradient (western) model boundaries. These boundaries were selected to simulate the westerly groundwater flow observed in the study area. By projecting heads from the groundwater flow maps, the hydraulic head west of the Rail Shop along the eastern model boundary was estimated to be approximately 4,609 to 4,619 feet above msl. These specified-head cells were placed far enough upgradient from the TCE plume to avoid potential boundary interferences. The head at the downgradient model boundary was estimated to be 4,280 feet above msl. This constant-head value was derived by assuming that, given the presence of wetland areas, the groundwater elevation at the model boundary equaled the ground surface elevation.

Along the northern and southern boundaries of the model grid, a no-flow (specified-flux) boundary was assumed to be present in the areas where groundwater flow was interpreted to be parallel to the grid boundary. The flux through these boundaries was assumed to be zero because flow is generally parallel to these boundaries. The base or lower boundary of the model also was assumed to be no-flow, and was set at a depth of 20 to 30 feet below the water table based on the depth of the bounding silt/clay unit. The upper model boundary was defined by the simulated groundwater table surface.

5.3.2.2 Aquifer Properties

Effective Porosity. Effective porosity is the volume of interconnected pore space in an aquifer. For fine sand aquifers, effective porosity may range from 1 to 46 percent (Spitz and Moreno, 1996). For the surficial aquifer at OU5 (comprised primarily of silty sand) the effective porosity was assumed to have an intermediate value of 20 percent.

Specific Yield/Specific Storage. The specific yield of an unconfined aquifer is defined as the volume of water that a unit volume of aquifer releases from storage under a unit decline in hydraulic head, and is equivalent to effective porosity (Spitz and Moreno, 1996). Therefore, specific yield was assumed to be 20 percent of the total aquifer volume. Specific storage is the term for confined aquifers where the volume of water that the aquifer yields due to a unit decline in hydraulic head is a function of water and formation matrix compressibility. This term is significantly less than specific yield, and for the model input was assumed to be 0.02 percent.

Hydraulic Conductivity. Field data from 37 slug tests indicate that hydraulic conductivities for the surficial aquifer range from 0.07 to 225 ft/day with a geometric mean of 2.3 ft/day (Section 3.4.1). Initial hydraulic conductivity values used in the groundwater flow model ranged from 0.64 to 12.8 ft/day, corresponding to a range of hydraulic conductivities within an order of magnitude of the geometric mean of the hydraulic conductivities measured in the field.

5.3.2.3 Recharge and Evapotranspiration

Mean annual precipitation at Hill AFB is approximately 18 inches per year, while potential evaporation is approximately 45 inches per year (Section 3.1). Because of this arid environment, it was assumed that any precipitation or irrigation would be taken up in evaporation, evapotranspiration, or soil vapor. With a depth to groundwater generally in excess of 5 feet bgs and a predominance of pavement or manicured lawns as opposed to phreatophyte vegetation, it was also assumed that evapotranspiration had a negligible impact on groundwater in the study area. Therefore, recharge and evapotranspiration were assumed to be zero throughout most of the model domain. As described in Sections 5.3.3.1 and 5.4.2.1, recharge was simulated in the TCE source area to facilitate addition of TCE to source area groundwater over time. In reality, percolation of water from the gravel leachfield (Section 1.2) probably did recharge the groundwater system in this area.

5.3.3 Contaminant Transport Model

5.3.3.1 TCE Source

The contaminant transport model simulates the migration and fate of TCE because, as stated in Section 4.3.1, TCE is the most prevalent CAH in extent and concentration. In addition, TCE was the only Hill AFB-related CAH detected in study area groundwater at concentrations exceeding its USEPA (1996) MCL of 5 µg/L in August 1996. As described in Section 4.3.2, the elevated PCE detection at well MW141 has not been linked to a Hill AFB source.

Transport models use boundary conditions to specify contaminant sources such as NAPL bodies, dissolved mass entering through recharge, injection wells, surface water bodies, and leaking structures. Sources such as NAPL bodies may be represented as specified-concentration boundaries (limited by solubility constraints or observed maximum concentrations) or as specified-flux boundaries (for which the chemical loading rate must be known or estimated). However, in most cases, only the effects of the source are measured, not the source characteristics (Spitz and Moreno, 1996). The source must therefore be represented as a "black box" that produces appropriate contaminant concentrations or fluxes at selected points in the model. The source may be misrepresented under such a scenario, but there is often little choice in the matter. Estimating contaminant flux into groundwater from NAPL or dissolved mass entering through recharge is difficult and is dependent upon several parameters, most of which cannot be measured (Feenstra and Guiguer, 1996; Abriola, 1996).

TCE is assumed to enter groundwater in the study area through contact between groundwater and residual NAPL below the water table and/or migration of recharge through soil containing residual NAPL above the water table. Partitioning of CAHs from these sources into groundwater was simulated using contaminant specified-flux boundaries. Seven model grid cells located near Building 1723A and one cell near Building 1781 were designated as TCE source cells (Figure 5.1).

Rather than using various calculations to attempt to estimate CAH partitioning from NAPL into groundwater, the "black box" source approach was used. Experience modeling contaminated sites as part of the AFCEE Natural Attenuation Initiative has suggested that this is the best method for reproducing observed plumes.

5.3.3.2 Dispersivity

Longitudinal dispersivity was originally estimated to range from 360 feet [calculated using the method of Pickens and Grisak (1981)] to 596 feet (calculated using the method of Neuman, 1990). Published data summarized in Spitz and Moreno (1996) suggest that, as a rule of thumb, longitudinal dispersivity is about one-tenth the travel distance of the plume (from the source to the downgradient toe), which is equivalent to approximately 450 feet at OU5. For the initial model setup, the lower bound of 360 feet was selected as a conservative estimate to minimize dispersion-related contaminant losses. Transverse dispersivity was estimated as one-tenth (0.1) of the longitudinal dispersivity value (Domenico and Schwartz, 1990).

5.3.3.3 Sorption/Retardation

Retardation of TCE relative to the advective velocity of the groundwater occurs when TCE molecules are sorbed to organic carbon, silt, or clay in the aquifer matrix. Based on measured TOC concentrations near the water table at seven locations, an assumed bulk density of 1.65 grams per cubic centimeter (g/cc) (typical for sediments of this type), and a conservative value of the soil sorption coefficient (K_{oc}) for TCE of 87 liters per kilogram (L/kg) (as listed in Wiedemeier *et al.*, 1996), the coefficient of retardation for TCE was calculated (Table 5.2 and Appendix D). Retardation values ranged from 1.19 to 3.08. The lower the assumed coefficient of retardation, the faster the TCE plume will migrate downgradient. The average calculated TCE retardation coefficient of 1.57 was used in the model setup.

5.3.3.4 Biodegradation

As discussed in Section 4.5, first-order biodegradation rates of 1×10^{-7} day^{-1} to 5.3×10^{-4} day^{-1} were estimated for CAHs using site-specific data. These rates were used to define a range of possible values for model input. An initial, intermediate, value of 3×10^{-6} day^{-1} was defined for the model domain based on the reductive dechlorination rates calculated for the upgradient segment of the TCE plume (Section 4.5). Also as noted in Section 4.5, reductive dehalogenation of CAHs may be best represented using a second-order rate, but most common transport codes (including MT3D®) can incorporate only a first-order rate. Second-order rates may provide the best approximation of CAH dechlorination in the presence of fuel hydrocarbons; however, the absence of fuel hydrocarbons at OU5 indicates that use of a first-order decay rate is appropriate.

5.4 MODEL CALIBRATION

Model calibration is an important component in the development of any numerical groundwater model. Calibration of the flow model demonstrates that the model is capable of matching hydraulic conditions observed at the site; calibration of the contaminant transport model superimposed upon the calibrated flow model helps demonstrate that contaminant loading and transport conditions are being appropriately simulated. Model input and output are included in Appendix E.

5.4.1 Groundwater Flow Model

Groundwater elevation data collected in August 1996 from 48 monitoring wells were used to compare measured and simulated heads for calibration purposes. Some paired monitoring wells screened in deeper aquifer intervals exhibited lower potentiometric

TABLE 5.2
CALCULATION OF RETARDATION COEFFICIENTS
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Compound	K_{oc} (L/kg[a])	Maximum Fraction Organic Carbon[b]	Minimum Fraction Organic Carbon[b]	Average Fraction Organic Carbon[b]	Distribution Coefficient K_d (L/kg)			Bulk Density (kg/L)[d]	Effective Porosity[d]	Coefficient of Retardation		
					Maximum[c1]	Minimum[c2]	Average[c3]			Maximum	Minimum	Average
TCE	87	0.0029	0.00026	0.00079	0.252	0.023	0.069	1.65	0.20	3.08	1.19	1.57

NOTES:

[a] From technical protocol (Wiedemeier *et al.*, 1996)

[b] From laboratory analyses of site soil samples

[c1] K_d = Maximum Fraction Organic Carbon x K_{oc}

[c2] K_d = Minimum Fraction Organic Carbon x K_{oc}

[c3] K_d = Average Fraction Organic Carbon x K_{oc}

[d] Estimated Value.

elevations, and therefore, water level data from these wells were not used in the comparison of measured and simulated heads.

The numerical flow model presented herein was calibrated by altering hydraulic conductivity, source area recharge rates, and specified-head elevations in a trial-and-error fashion until simulated heads approximated observed field values within a prescribed accuracy. Hydraulic conductivity is an important aquifer characteristic that represents the ability of the water-bearing strata to transmit groundwater. An accurate estimate of hydraulic conductivity is important to help quantify advective groundwater flow velocities and to define the flushing potential of the aquifer. As a result, models used to estimate contaminant transport are particularly sensitive to variations in hydraulic conductivity. Lower values of hydraulic conductivity result in a slower-moving plume with a relatively small areal extent. Higher values of hydraulic conductivity result in a faster-moving plume that is spread over a larger area.

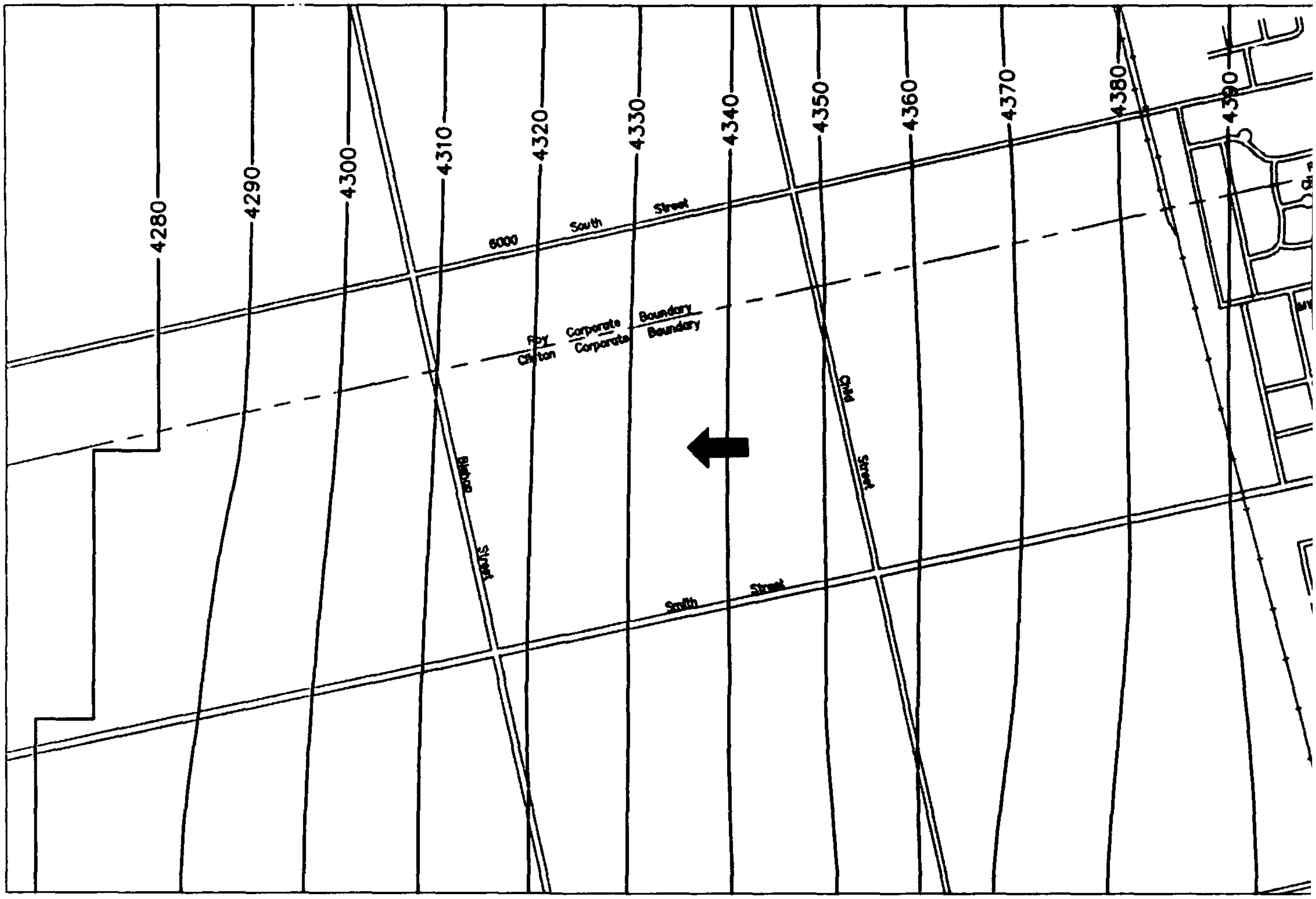
Geologic data and water level measurements were used in conjunction with the hydraulic conductivity values derived from slug tests to estimate an initial uniform hydraulic conductivity for the saturated zone across the entire model domain. As stated in Section 5.3.2.2, the initial hydraulic conductivity values used in the model ranged from 0.064 to 12.8 ft/day. To better match heads in the model to observed values, the initial hydraulic conductivity values were varied according to changes in aquifer thickness to maintain a uniform transmissivity (the product of hydraulic conductivity and aquifer thickness). The hydraulic conductivity was then progressively varied in blocks and rows until the simulated water levels for cells corresponding to the selected well locations closely matched the observed water levels.

Figure 5.2 shows the calibrated water table. Final calibrated model hydraulic conductivities ranged between 0.24 and 4.72 ft/day, with an average of 2.0 ft/day. Most model grid cells were assigned a hydraulic conductivity between 0.80 and 4.72 ft/day.

Simulated advective velocities were variable, but generally ranged from 0.17 ft/day to 0.35 ft/day (62 to 128 ft/yr) throughout the study area. These velocities compare favorably with the velocity range of 0.03 to 0.3 ft/day (11 to 110 ft/yr) estimated prior to the start of the modeling using available hydraulic conductivity and hydraulic gradient data (see Section 3.4.2).

The root mean squared (RMS) error is commonly used to express the average difference between simulated and measured heads. RMS error is the average of the squared differences between measured and simulated heads, and can be expressed as:

$$\mathrm{RMS} = \left[\frac{1}{n} \sum_{i=1}^{n} \left(h_m - h_s \right)_i^2 \right]^{0.5}$$



LEGEND

MW137 ⊕ SHALLOW MONITORING WELL

MW138 ● DEEP MONITORING WELL

MP7s ⊗ (s,d) MONITORING POINT SHALLOW/DEEP

⊕ FIELD DRAIN

● DOMESTIC WELL

SPRING OR SEEP

—4290— LINE OF EQUAL SIMULATED GROUNDWATER ELEVATION (feet msl) CONTOUR INTERVAL = 10 FEET

⬅ DIRECTION OF GROUNDWATER FLOW

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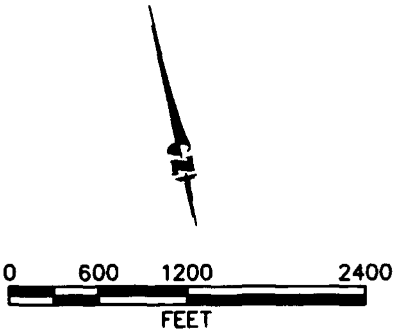

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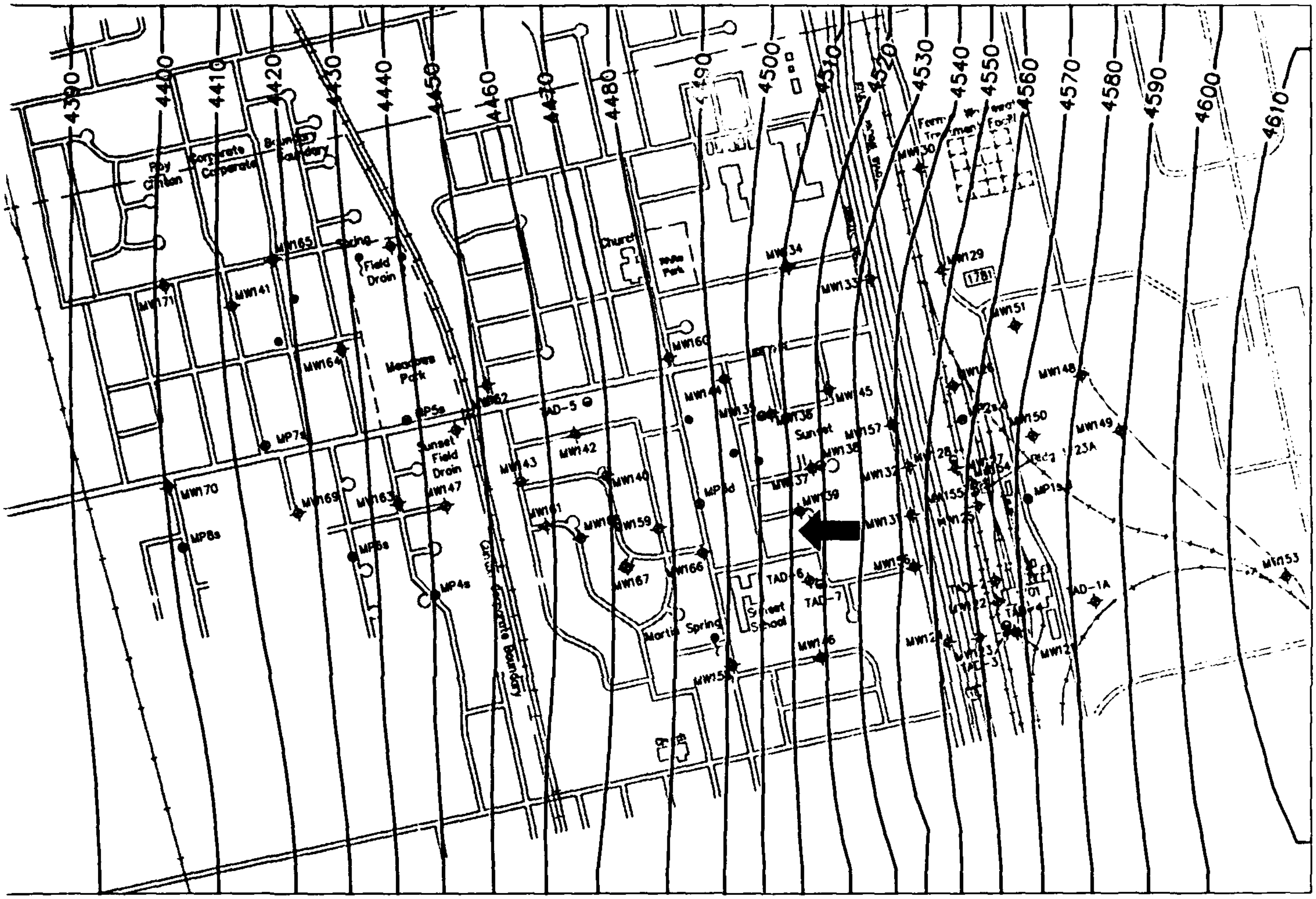

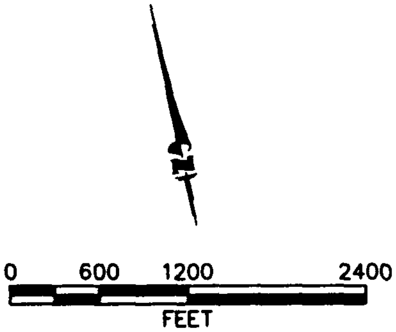

FIGURE 5.2

CALIBRATED GROUNDWATER SURFACE

OU5 RNA TS
Hill Air Force Base, Utah

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Denver, Colorado

where: n = the number of points where heads are being compared,

h_m = measured head value, and

h_s = simulated head value.

The RMS error between observed and calibrated values, as calculated by Visual Modflow in the 48 comparison points is 4.8 percent. RMS error calculations are summarized in Appendix D.

In solving the groundwater flow equation, Visual MODFLOW establishes the water table surface and calculates an overall hydraulic balance that accounts for the numericaldifference between flux into and out of the system. The hydraulic mass balance for the calibrated model was adequate to accomplish the objectives of this modeling effort, with 99.99 percent of the water flux into and out of the system being numerically accounted for (i.e., a 0.01-percent error).

5.4.2 TCE Plume Calibration

After calibration of the flow model, the numerical solute transport model was calibrated by altering contaminant transport parameters and contaminant source term concentrations in a trial-and-error fashion until the simulated extent and magnitude of the TCE plume approximated observed field values. The transport parameters varied during the plume calibration were the aquifer dispersivity, the TCE decay rate constant, and the distribution coefficient governing the retardation of TCE. Because the original estimates for the parameters resulted in a calculated TCE plume that did not reasonably reproduce the observed plume, these parameters generally were varied with the intent of limiting plume migration to the observed extent measured in 1996.

The dissolved TCE concentrations obtained from March 1996 laboratory analytical results for each monitoring well (Radian, 1997) were used to calibrate the contaminant transport model. These data were selected because they were generally higher in magnitude than the data obtained for this TS in August 1996. Therefore, the more conservative set of analytical data were used to calibrate the model. August 1996 analytical data were used for the monitoring points installed during the TS field program. The March 1996 TCE concentrations and TCE plume map are contained in Appendix A. For comparison, Table 4.2 presents dissolved TCE concentration data for August 1996, and Figure 4.5 shows the distribution of dissolved TCE in August 1996. The concentrations and shapes of the plumes depicted in these figures are the result of transport under the influence of advection, dispersion, sorption, and biodegradation.

5.4.2.1 TCE Source Term

For the primary TCE plume sourced at the Tooele Rail Shop near Building 1723A, TCE dissolution into groundwater was assumed to begin in 1949, when use of TCE was first reported at the Rail Shop. Loading was assumed to remain constant until 1964, when use of TCE at the Rail Shop reportedly ceased. Between 1964 and 1996 the source strength was decreased linearly at a rate of 3 percent per year to simulate the gradual weathering and depletion of the source. However, the rapid decrease in source area concentrations from 1993 to 1996, measured in well MW127 (Figure 4.9), could not be fully duplicated in the model. The inability to accurately simulate the measured decrease in TCE concentrations in source area well MW127 may be due to spatial variation in decay rates that could not be simulated by the model, or because decay rates in the source area may be second order as opposed to first order as simulated by the model.

As described in Section 5.3.3.1, the partitioning of TCE from residual NAPL into the groundwater beneath the Rail Shop was simulated by adding recharge containing TCE to seven cells in the model grid. The locations of the simulated recharge cells are shown on Figure 5.1. The cell locations were selected on the basis of the known location of the former drain line and gravel leach bed that constitute the primary TCE source (Figure 1.3). The recharge area was extended to the south to account for drain line leaks and to the north to allow for adequate simulation of the plume width within and downgradient from the source area. The injected TCE concentrations were uniformly distributed among the source cells, although the recharge rate was doubled for the center cell to simulate both the measured TCE concentration in source area well MW127 and measured concentrations along the plume axis downgradient from the source area. The location of the grid cell containing the highest recharge rate corresponds to the location of the former leachfield. The recharge rate for each source cell was set at 4 inches per year, with the center cell set at 8 inches per year. These values are low enough that the flow calibration and water balance were not affected.

As described in Section 5.2, the location and history of the source responsible for the TCE detected near Building 1781, north of the Rail Shop, is not known. The introduction of TCE into the groundwater in this area was simulated by adding recharge containing TCE to one model grid cell starting in 1988. The source strength was gradually increased to a maximum concentration in 1996 to simulate the TCE concentration measured in well MW129 in 1996. The recharge rate in the source cell was 3 inches per year.

5.4.2.2 Dispersivity

As described in Section 5.3.3.2, longitudinal dispersivity for the modeled area was originally estimated to be 360 feet, and the transverse dispersivity value was estimated to be one-tenth (0.1) of the longitudinal dispersivity value (Domenico and Schwartz, 1990). However, because the 1996 site plume was relatively wide, the ratio of transverse to longitudinal dispersivity was increased to 0.3. During plume calibration, the longitudinal dispersivity was reduced to 240 feet to better simulate the observed TCE plume. This is the value used to produce the calibrated plume depicted in Figure 5.3. Decreasing the dispersivity below this value caused the model to underpredict TCE concentrations at downgradient monitoring well MW163 to an unreasonable degree. Use of a dispersivity value that is lower than those estimated using empirical relationships presented in the literature (see Section 5.3.3.2) is conservative, because dispersion-related contaminant losses around the fringes of the plume are reduced.

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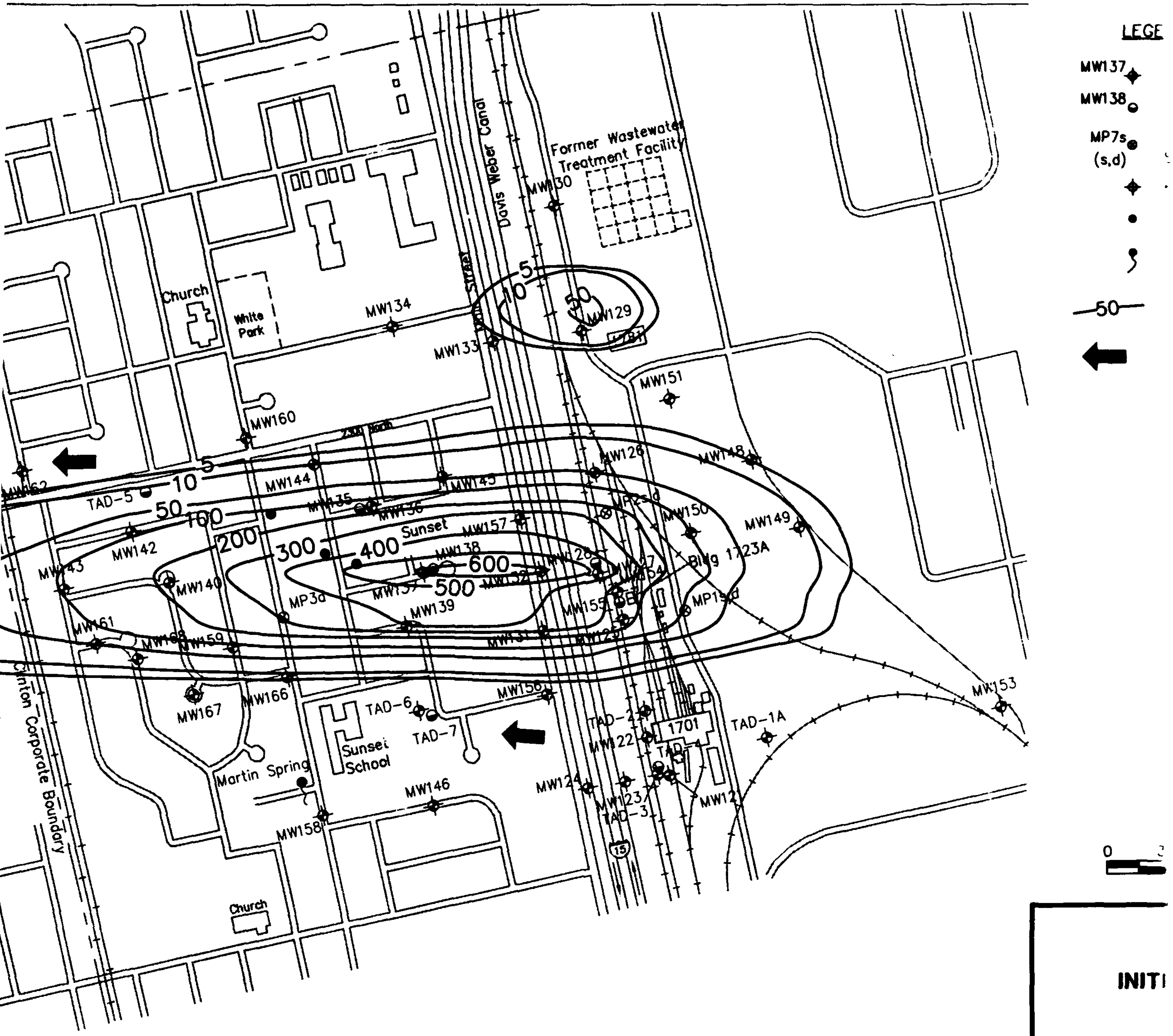

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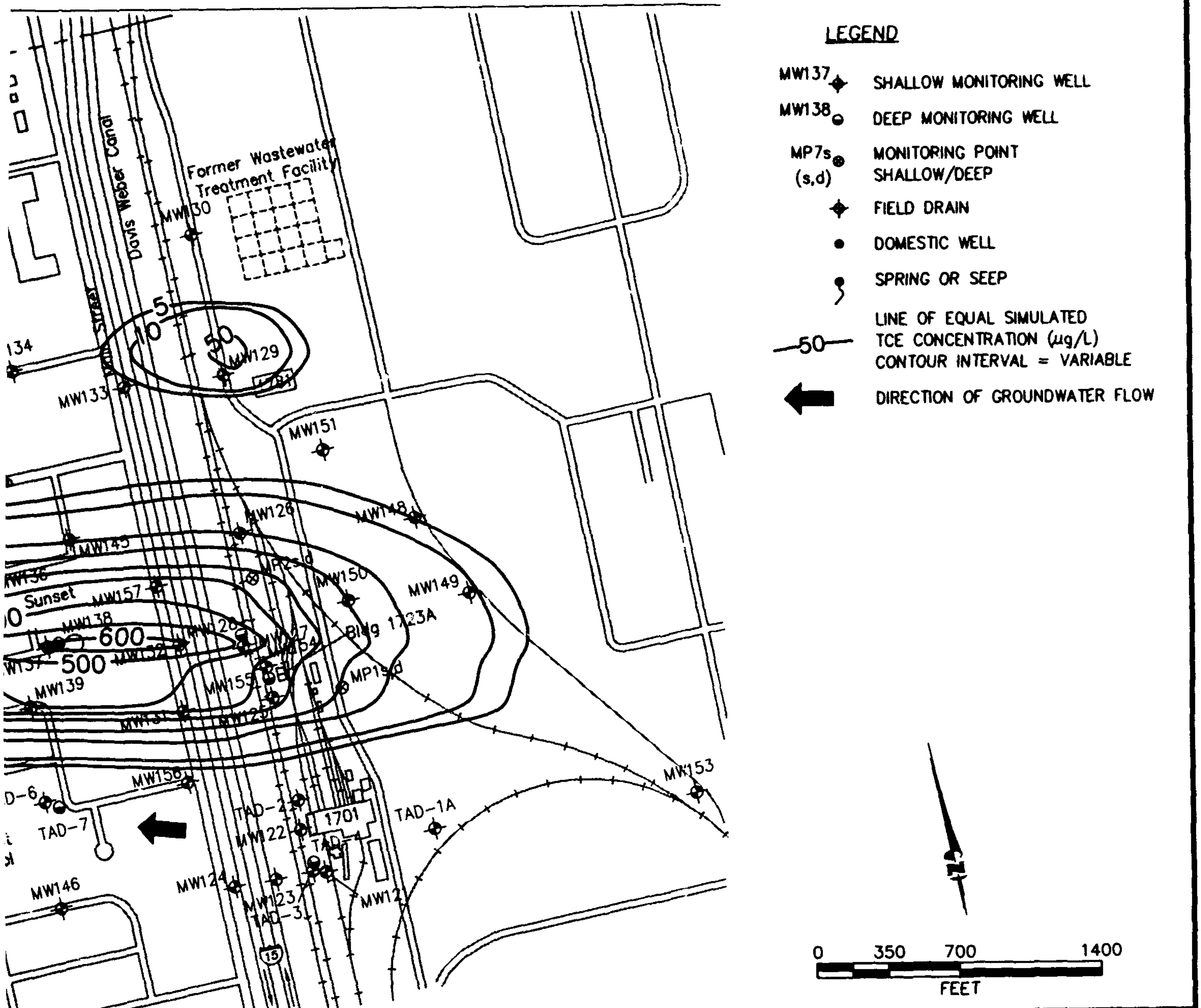

FIGURE 5.3

INITIAL CALIBRATED TCE PLUME

OU5 RNA TS
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5.4.2.3 Anaerobic Decay Rate Constant

As discussed in Section 5.3.5, the TCE decay rate constant was initially estimated to range from 1 x 10^{-7} day^{-1} to 5.3 x 10^{-4} day^{-1}. This parameter was varied during plume calibration, and the calibrated model used a value of 6 x 10^{-6} day^{-1}, which corresponds to a TCE half-life of 316 years. Use of this value yielded a good match between simulated and measured TCE concentrations. However, the value is reasonablyconservative because it is near the low end of the range of potential decay rates computed for the site. As described in Section 4.5, the low decay rates (representative of reductive dehalogenation rates) are believed to be most representative of actual conditions throughout the majority of OU5; however, in isolated areas (e.g. the source area) biodegradation rates may be somewhat higher.

5.4.2.4 Coefficient of Retardation

During plume calibration the initial retardation coefficient of 1.57 was varied, but no significant improvement in model calibration was realized. Therefore, the value of 1.57 was retained in the calibrated model. Raising or lowering the retardation coefficient would have caused the simulated TCE concentrations at the downgradient plume boundary to under- or overestimate measured concentrations, respectively.

5.4.2.5 Comparison of Measured and Simulated TCE Plumes

The calibrated TCE plume calculated by the model (Figure 5.3) is similar, but not identical, to the observed 1996 TCE plumes (Appendix A, Figure 4.5). The model reasonably simulates measured TCE concentrations in the Rail Shop source area, along the axis of the primary TCE plume downgradient from the source area, and at the downgradient plume toe in eastern Clinton. One primary difference between the simulated and measured plumes emanating from the Rail Shop is that the measured TCE plume appears to abruptly shift to the north in Sunset, west of well MW159 (Figure 4.5). This shift may be caused by the presence of a north/south-trending subsurface drain line that is believed to be present in that area. The impact of the drain line could not be accurately represented by the numerical model; therefore, the northward shift was not simulated.

A second primary difference between the measured and simulated plumes is that the measured plume appears to widen west of Main Street. The inferred width of the plume between the 5-µg/L isopleths at Main Street in August 1996 is 860 feet, compared to 1,130 feet farther to the west between wells MW160 and MW166 (Figure 4.5). Similar trends have been observed during other sampling events, including the March 1996 event used for model calibration purposes. The increase in width may be due to one or more factors, including stratigraphic controls, preferential (northward) migration of TCE along utility corridor(s) beneath or adjacent to Main Street, or temporal variations in groundwater flow directions. The increased width of the plume west of Main Street was simulated by lengthening the line of source cells, as described in Section 5.4.2.1. However, the simulated plume does not exhibit the variations in width with distance from the source area that are apparent in the observed plumes.

5.5 SENSITIVITY ANALYSIS

The purpose of a sensitivity analysis is to determine the effect of varying model input parameters on model output. The sensitivity analysis was conducted by varying hydraulic conductivity, the coefficient of retardation, the first-order decay rate, dispersivity, and the TCE injection rate.

To perform the sensitivity analyses, the calibrated model was adjusted by systematically changing the aforementioned parameters individually, and then comparing the new simulations to the results of the calibrated model. The models were run for a 47-year period, just as the calibrated model was, so that the independent effect of each variable could be assessed. Ten sensitivity runs of the calibrated model were made, with the following variations:

1. Hydraulic conductivity uniformly increased by a factor of 5;
2. Hydraulic conductivity uniformly decreased by a factor of 5;
3. Coefficient of retardation increased from 1.57 to 3.08;
4. Coefficient of retardation decreased from 1.57 to 1.19;
5. First-order decay rate increased from 6×10^{-6} day^{-1} to 3×10^{-4} day^{-1};
6. First-order decay rate decreased from 6×10^{-6} day^{-1} to 2×10^{-6} day^{-1};
7. Dispersivity increased from 240 feet to 480 feet;
8. Dispersivity decreased from 240 feet to 120 feet;
9. TCE recharge flux rate increased by a factor of 2; and
10. TCE recharge flux rate decreased by a factor of 2.

Simulated TCE concentrations at several wells located along the approximate axis of the TCE plume for each of the above-described sensitivity analysis model runs are listed in Table 5.3. Comparison of these simulated concentrations to the calibrated and measured (March 1996) concentrations indicates how the parameter changes affect the model results. Figures depicting the sensitivity analysis results are presented in Appendix D. As described in the following paragraphs, the parameter modifications listed above generally resulted in substantial changes in the resulting TCE plumes, with the dispersivity modifications having the least effect.

5.5.1 Sensitivity to Variations in Hydraulic Conductivity

The effects of varying hydraulic conductivity are shown in Table 5.3 and Appendix D. Uniformly increasing the hydraulic conductivity by a factor of five increased the longitudinal dispersion of the plume such that the plume extended to the downgradient boundary of the model grid, approximately 9,300 feet west of the toe of the calibrated

TABLE 5.3
MODEL SENSITIVITY ANALYSIS RESULTS
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HILL AIR FORCE BASE, UTAH

Monitoring Well	Model Grid Cell Location (row,column)	Measured TCE Concentration March 1996 (μg/L)	Simulated TCE Concentrations (μg/L)[a]										
			Initial Calibrated Model (μg/L)	KX5 (feet per day)	K/5 (feet per day)	R = 3.08	R = 1.19	Decay = 3E-4 (day^{-1})	Decay = 2E-6 (day^{-1})	DI = 480 (feet)	DI = 120 (feet)	Recharge Concentration Doubled	Recharge Concentration Halved
MW-127	17, 50	597	510	57	1574	512	480	134	523	476	485	1019	255
MW-132	17, 48	484	606	65	1428	560	579	127	623	522	640	1212	303
MW-138	17, 44	643	636	84	287	368	678	76	658	511	750	1273	318
MW-159	21, 38	253	96	62	<1	7	179	5	100	85	102	191	48
MW-143	18, 34	98	116	115	<1	3	269	5	122	141	87	233	58
MW-163	20, 29	33	24	128	<1	<1	97		25	46	10	48	12
MP7	16, 25	4 (8/96)	5	46	<1	<1	26		5	14	1	9	2

Note: K = hydraulic conductivity, R = retardation coefficient, Decay = first-order decay rate, DI = longitudinal dispersivity.

[a] μg/L = micrograms per liter.

plume. The simulated TCE concentration in the vicinity of source area monitoring well MW127 decreased below the measured (March 1996) and calibrated concentrations by one order of magnitude (simulated concentration of 57 μg/L versus field-measured and calibrated concentrations of 597 μg/L and 510 μg/L, respectively). Conversely, the simulated TCE concentration in the vicinity of downgradient monitoring well MW163 increased to 128 μg/L, compared to measured (March 1996) and calibrated concentrations of 33 μg/L and 24 μg/L, respectively.

In contrast, decreasing the hydraulic conductivity by a factor of five slowed overall plume migration, and caused the TCE mass to be concentrated within a smaller area. As a result, the simulated length of the TCE plume was less than half the length of the measured and calibrated plumes. The simulated TCE concentration at source area monitoring well MW127 increased to 1,574 μg/L, compared to the calibrated concentration of 510 μg/L. The simulated plume did not extend to downgradient monitoring well MW163, whereas the TCE concentration at this well in the calibrated model was 24 μg/L. Overall, the model appears to be very sensitive to hydraulic conductivity variation within a reasonable range.

5.5.2 Sensitivity to Variations in the Coefficient of Retardation

The effects of varying the coefficient of retardation are shown in Table 5.3 and Appendix D. Uniformly increasing the coefficient of retardation from 1.57 to 3.08 (the maximum retardation coefficient calculated for the site on the basis of site-specific soil TOC data, see Table 5.2) decreased the longitudinal dispersal of the plume such that the simulated plume length was only about two-thirds the length of the calibrated plume. The simulated TCE concentration in the vicinity of source area monitoring well MW127 (512 μg/L) was nearly identical to the calibrated concentration 510 μg/L; however, the toe of the simulated plume was located near well MW143, which had measured (March 1996) and simulated concentrations of 98 μg/L and 116 μg/L, respectively.

In contrast, decreasing the coefficient of retardation from 1.57 to 1.19 (the minimum value computed using site-specific TOC data, see Table 5.2) increased overall plume migration. The downgradient toe of the simulated plume was approximately 1,400 feet farther west than the calibrated plume toe. As a result, the simulated TCE concentration in downgradient well MW163 increased to 97 μg/L from the measured and calibrated concentrations of 33 μg/L and 24 μg/L, respectively. Because the available TCE mass was spread over a larger area, the simulated TCE concentration in source area well MW127 (480 μg/L) decreased slightly compared to the calibrated concentration of 510 μg/L. Overall, the model appears to be moderately sensitive to variation of the retardation coefficient within a reasonable range.

5.5.3 Sensitivity to Variations in the Decay Rate Constant

The effects of varying the first order TCE decay rate are shown in Table 5.3 and Appendix D. Increasing this parameter from 6 x 10^{-6} day^{-1} (the value used in the calibrated model) to 3 x 10^{-4} day^{-1} (representative of upper bound values computed for the site, see Section 4.5) results in more rapid degradation of dissolved TCE. The resulting TCE plume is correspondingly short (approximately one-half the length of the calibrated plume), and simulated TCE concentrations at downgradient wells MW143 (5 µg/L) and MW163 (0.7 µg/L) are 96 to 97 percent lower than calibrated values for these wells (116 µg/L and 24 µg/L, respectively). The simulated TCE concentration at source area well MW127 (134 µg/L) is 74 to 78 percent lower than the measured (March 1996) and calibrated values of 597 µg/L and 510 µg/L, respectively.

Conversely, decreasing the decay rate to 2 x 10^{-6} day^{-1} (representative of lower bound values calculated for the site, see Section 4.5) decreases the rate of degradation, resulting in an overall increase in simulated source area and downgradient TCE concentrations to levels that are above measured and calibrated concentrations. However, because the magnitude of the decay rate change was relatively low (both the calibrated and revised values were in the 10^{-6} range), the effects on the model results were not substantial. For example, the length and width of the simulated plume were nearly identical to that of the calibrated plume, and the simulated TCE concentration at source area monitoring well MW127 was 523 µg/L, compared to measured and calibrated concentrations of 597 and 510 µg/L, respectively. Simulated TCE concentrations in wells downgradient from the source area (e.g., MW143 and MW163) also were similar to the calibrated and measured values, indicating that small changes in the decay rate do not significantly affect the model results. However, as indicated in the previous paragraph, the model is more sensitive to order-of-magnitude changes in the decay rate, particularly as the rate is increased and biodegradation becomes a significant attenuation mechanism.

5.5.4 Sensitivity to Variations in Dispersivity

The effects of varying dispersivity are presented in Table 5.3 and Appendix D. Both longitudinal and transverse dispersivity were varied for this analysis, as the ratio of the two values (3.3 to 1) remained constant. Increasing the dispersivity from 240 feet to 480 feet caused the simulated plume to extend approximately 1,000 feet farther in both the upgradient and downgradient directions than the calibrated plume did. The dispersal of the TCE mass over a larger area caused an overall reduction in TCE concentrations in the vicinity of the source area and within the central portion of the plume in eastern Sunset. For example, the simulated TCE concentrations in source area well MW127 and downgradient well MW138 were 476 and 511 µg/L, respectively, compared to calibrated concentrations of 510 and 636 µg/L. The extension of the plume in the downgradient direction caused the simulated concentrations near the toe of the plume to increase over calibrated and measured (March 1996) concentrations (e.g., see data for well MW163 in Table 5.3).

Decreasing the dispersivity from 240 feet to 120 feet generally had the opposite effect, producing a shorter plume with slightly higher concentrations in the upgradient to central portions of the plume. The simulated TCE concentration at source area well MW127 (485 µg/L) was slightly lower than the calibrated concentration of 510 µg/L; however, simulated concentrations at wells MW132, MW138, and MW159 were higher than the calibrated concentrations. Simulated concentrations near the toe of the plume (monitoring wells/points MW143, MW163, and MP7) were lower than the calibrated concentrations because the simulated plume was shorter than the calibrated plume. Overall, the sensitivity of the model to dispersivity changes of this magnitude appears to be in the low to moderate range.

5.5.5 Sensitivity to Variations in Injected TCE Concentrations

The results of increasing and decreasing the TCE concentrations injected into the aquifer in the source area by a factor of two are shown in Table 5.3 and Appendix D. The dimensions of the plume that resulted from increasing the injected concentrations by a factor of two are similar to the calibrated plume because the parameters governing the migration of the plume were unchanged. However, the simulated TCE concentrations throughout the length of the plume were approximately double the calibrated concentrations.

Decreasing the injected TCE concentrations by a factor of two had the opposite affect, resulting in simulated concentrations throughout the plume that were approximately one-half the calibrated concentrations. Again, however, the simulated plume length and width did not differ substantially from those of the calibrated plume.

5.5.6 Summary of Sensitivity Analysis Results

The results of the sensitivity analysis suggest that the calibrated model depicted on Figure 5.3 is generally reasonable. Varying the model parameters within the prescribed ranges generally caused the extent and magnitude of the dissolved TCE plume to differ noticeably from measured conditions. Varying the hydraulic conductivity within a reasonable range caused substantial changes in both the lateral extent of the plume and the magnitude of simulated TCE concentrations. The effects on the plume extent and magnitude of varying the retardation coefficient within a reasonable range and of increasing the first-order TCE decay rate to a value representative of those computed using the method of Buscheck and Alcantar (1995) also were significant, although less substantial than with the hydraulic conductivity.

The overall sensitivity of the model to variations of the longitudinal and lateral dispersivity within a reasonable range appears to be relatively low. Variation of this parameter has the greatest effect on the downgradient and upgradient extents of the 5-μg/L and 10-μg/L TCE isopleths. Increasing the dispersivity causes low concentrations of TCE to be dispersed farther downgradient and upgradient, while decreasing this parameter caused more contaminant mass to remain in the plume core, thereby "tightening up" the eastern and western portions of the plume. Increasing and decreasing the TCE injection concentrations in the source area does not significantly affect the areal extent of the plume, but the magnitudes of simulated concentrations within the plume are directly proportional to the magnitudes of the injected concentrations.

The simulated plumes resulting from increasing and decreasing the dispersivity values indicated that the model calibration could be improved in the area upgradient from the Rail Shop by varying the dispersivity in that area. The calibrated model plume depicted on Figure 5.3 extends throughout a broad area east of the Rail Shop, whereas the observed plumes measured in March and August 1996 appear to extend only upgradient toward well MW148 (Figure 4.5 and Appendix A). To better simulate the observed upgradient extent of dissolved TCE and improve the accuracy of model predictions, the longitudinal dispersivity throughout most of the upgradient plume area was decreased to 60 feet, and the dispersivity within a northeast/southwest-trending band between wells MW127 and MW148 was increased to 480 feet (approximately one-tenth the distance between the source area and the downgradient plume toe). These changes enabled the model to better simulate the lobate shape of the plume in the upgradient area. The final calibrated model that incorporates these changes and was used for predictive purposes is shown on Figure 5.4. In reality, the source of the TCE detected in well MW148 is not known, and may be located in the former Base housing area (Radian, 1995). The final calibrated TCE concentrations along the axis of the plume are: MW127 (492 μg/L), MW132 (609 μg/L), MW138 (670 μg/L), MW159 (105 μg/L), MW143 (128 μg/L), MW163 (26 μg/L), and MP-7 (5 μg/L). The results of predictive simulations are contained in Section 6.

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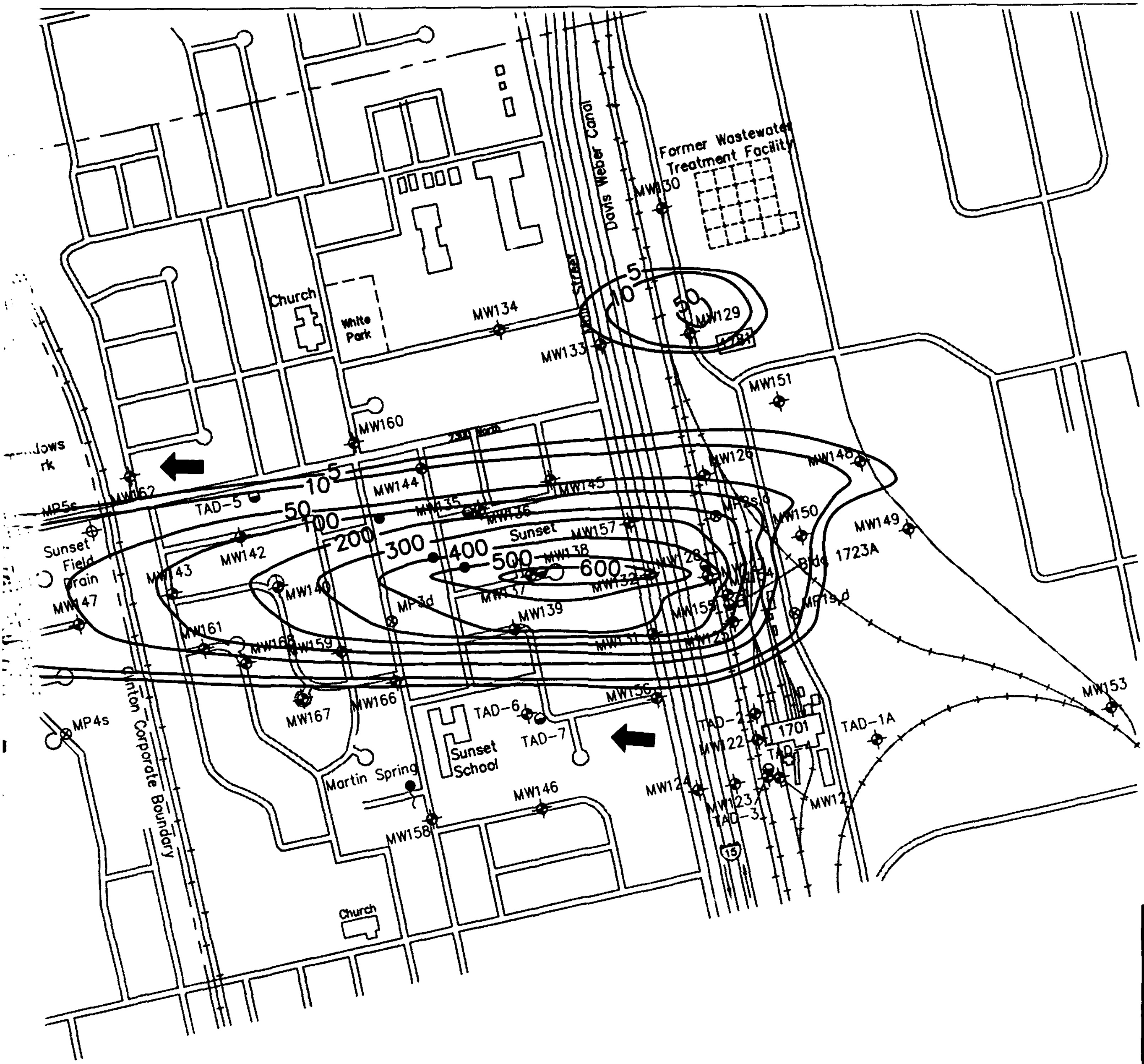
Former Wastewater Treatment Facility
Davis Weber Canal
Main Street
MW130
5
10
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MW129
1701
MW133
MW134
Church
White Park
MW151
MW160
2300 North
...dows ...rk
MW162
MP5s
TAD-5
5
10
50
100
200
300
400
500
600
MW144
MW145
MW135
MW136
MW126
MW148
MP8s,d
MW150
MW149
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MW128
MW137
MW132
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Sunset Field Drain
MW142
MW143
MW140
MP3d
MW139
MW155
MP15,d
MW147
MW161
MW168
MW159
MW131
MW125
Clinton Corporate Boundary
MW167
MW166
TAD-6
TAD-7
MW156
MW153
MP4s
Sunset School
Martin Spring
TAD-2
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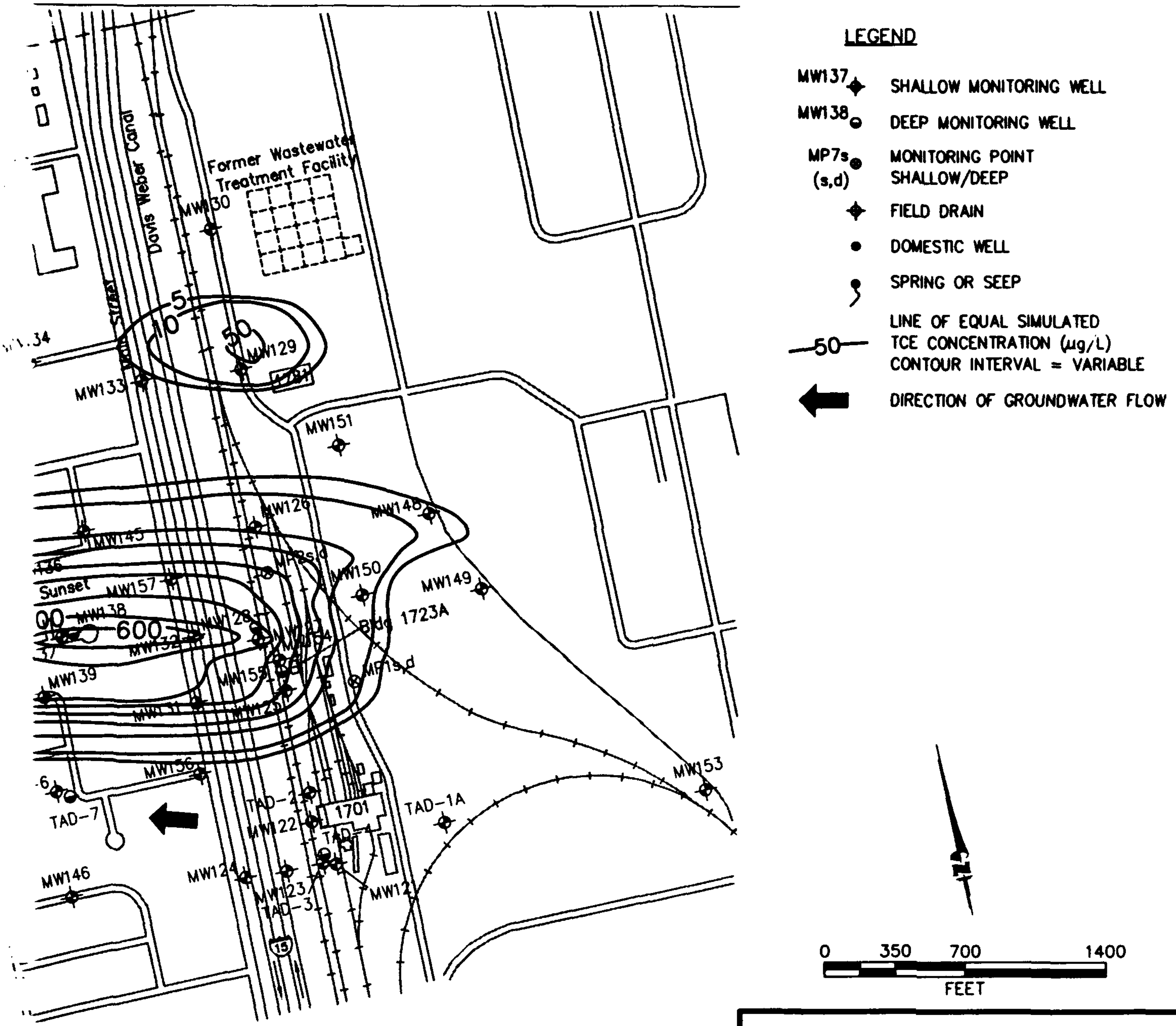


FIGURE 5.4

FINAL CALIBRATED TCE PLUME

OU5 RNA TS
Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

SECTION 6

ANALYSIS OF REMEDIAL ALTERNATIVES

This section presents the predicted impact of planned and probable engineered remedial actions on dissolved TCE in the surficial water-bearing zone at OU5. The intent of this evaluation is to assist the Base in developing final remedial strategies for the site.

6.1 SUMMARY OF PLANNED AND PROBABLE REMEDIAL ACTIONS

Typically, multiple remedial alternatives would be developed and compared in this section in terms of effectiveness, technical and administrative implementability, and cost. This discussion would address factors influencing alternatives development, including the objectives of the RNA demonstration program, contaminant properties, site geology and hydrogeology, potential exposure pathways, and remediation goals. However, a feasibility study (FS) that evaluates multiple remedial technologies has already been performed for OU5 (Radian, 1996c), and is currently in regulatory review. In addition, the following interim remedial actions (IRAs) either have been implemented or are scheduled for implementation:

- A 400-foot-long air sparging curtain has been installed across the TCE plume along the east side of Main Street in the city of Sunset. This curtain, which has been designed to reduce TCE concentrations in groundwater migrating through the curtain to 5 µg/L, began operating in April 1997. The Base projects that the sparging curtain will operate for approximately 15 years.

- A local groundwater extraction and treatment system consisting of five extraction wells will be installed in a vacant lot adjacent to the cul-de-sac at the east end of 2125 North in eastern Sunset, near well pair MW137/MW138. This system is scheduled to become operational in November 1997, and is projected to operate for approximately 5 years. The total extraction rate is projected to be approximately 12 to 15 gallons per minute (gpm), and extracted water will be treated with granular activated carbon (GAC) and discharged into the sanitary or storm sewer. The objective of this system is to remediate a "hot spot" containing relatively elevated dissolved TCE concentrations (Figure 4.5).

In addition, the following remedial actions have been designed conceptually and may be implemented in the future:

- Installation of an 800-foot-long groundwater extraction trench along 300 West (the north/south street where well MW159 is located) in Sunset. If installed, the trench would probably be operational by late 1999 and operate for approximately

15 years. The total projected groundwater extraction rate for the trench is 15 to 20 gpm, and extracted groundwater would be discharged directly into the sanitary sewer.

- Installation of a local groundwater extraction system west of well MW129 and north of the primary TCE plume sourced near Building 1723A. Extraction wells would be installed in a north-south line along the railroad tracks. This extraction system is currently "on hold" while the feasibility of a no-action scenario for this contamination is explored.

Because a remedial action plan for OU5 groundwater that incorporates engineered remedial actions has already been developed, RNA will not be evaluated as a potential remedial alternative by itself. Instead, the primary focus of the remainder of this section will be to assess how the various elements of the plan will affect the identified TCE contamination in groundwater. The impacts of two remedial alternatives have been simulated using the numerical model described in Section 5. These alternatives include:

- RNA combined with LTM, institutional controls, air sparging along Main Street, and localized pump and treat near well pair MW137/138; and
- RNA, LTM, institutional controls, air sparging along Main Street, localized pump and treat near well pair MW137/138, groundwater extraction along 300 West, and groundwater extraction west of well MW129.

The remedial objective for OU5 consists of reducing dissolved TCE concentrations to or below 5 µg/L, which is the Utah groundwater standard for this compound [Utah Department of Environmental Quality (DEQ), 1995] (Wheeler, 1997). TCE is the only compound that historically has exceeded its groundwater quality standard. Because an awareness of current and potential future land uses and exposure pathways is essential to evaluating the significance of any future plume expansion and the adequacy of the planned and probable remedial actions, these topics are discussed in the following subsections.

6.2 POTENTIAL EXPOSURE PATHWAYS

A pathways analysis identifies the human and ecological receptors that could potentially come into contact with site-related contamination and the pathways through which these receptors might be exposed. To have a completed exposure pathway, there must be a source of contamination, a potential mechanism(s) of release, a pathway of transport to an exposure point, an exposure point, and a receptor. If any of these elements do not exist, the exposure pathway is considered incomplete, and receptors will not come into contact with site-related contamination. Evaluation of the potential long-term effectiveness of any remedial technology or remedial alternative as part of this demonstration project includes determining if the approach will be sufficient and adequate to minimize pathway completion.

Assumptions about current and future land uses at a site form the basis for identifying potential receptors, potential exposure pathways, reasonable exposure scenarios, and appropriate remediation goals. USEPA (1991) advises that the land use associated with the highest (most conservative) potential level of exposure and risk that can reasonably be expected to occur should be used to guide the identification of potential exposure pathways and to determine the level to which the site must be remediated.

The on-Base portion of OU5 is located along the western boundary of Hill AFB in the northern half of the Base. The current land use in the on-Base portion of the site, which includes the source area, is industrial (the Tooele Rail Shop). The nearest off-Base development consists of commercial development bordering Main Street in the city of Sunset. The area west of Main Street to the downgradient toe of the plume, in the cities of Sunset and Clinton, is primarily residential. West of the downgradient toe of the CAH plume, the land use is mixed residential, agricultural, and cattle rangeland.

Howard Slough lies still further to the west (Figure 3.1). Much of the wetland area near Howard Slough has been drained and is being developed for residential, agricultural, and/or ranching use. Patches of wetland are, however, still present. Drainage ditches have been constructed, presumably to lower the water table and facilitate development; these ditches probably intercept the water table at least seasonally and are potential groundwater discharge areas. Therefore, the area near Howard Slough still represents a potential discharge area for the CAH plume based on currently available information.

As described in Section 3.4.1, groundwater from the shallow aquifer at Hill AFB is not extracted for beneficial use, and there are no private wells located on Base. Water used at the Base is supplied by deep (>600-foot-bgs) wells, occasionally supplemented by water purchased from the Weber Basin Water Conservancy District during summer months (Radian, 1995; SAIC, 1989). The cities of Sunset and Clinton also obtain potable water from deep wells screened in the Delta aquifer. although some residents have shallow wells or use springs to irrigate gardens. The Martin spring, located immediately west of the Sunset Elementary School (Figure 4.16), is used to fill a swimming pool.

Under reasonable current land use assumptions, potential receptors of groundwater-related contamination include onsite worker populations, residents and workers in the portions of Sunset and Clinton impacted by the CAH plume, surface water biota in the marshy area west of the plume, and ingestors of agricultural products impacted by the contamination. On-Base workers could be exposed to site-related contamination in phreatic soils or shallow groundwater during construction-related excavations (the shallowest depth to groundwater in the vicinity of the Tooele Rail Shop in August 1996 was approximately 15 feet bgs), or via inhalation of volatilized contaminants. Off-base residents could be exposed to site-related contamination via the following pathways:

- Inhalation of volatilized contaminants;
- Direct dermal contact with or ingestion of groundwater seeping into basements or discharging to the surface in shallow wells or springs;
- Ingestion of fruits and vegetables irrigated with contaminated groundwater; and

- Ingestion of meat and dairy products affected by uptake of contaminants from groundwater.

Assumptions about hypothetical future land uses also must be made to ensure that the remedial technology or alternative considered for shallow groundwater at the site is adequate and sufficient to provide long-term protection. Except for the possibility that current agricultural land could revert to residential use as a result of further residential development in Clinton, the future use of the Tooele Rail Shop and off-Base areas are projected to be unchanged from the current uses described above. Therefore, potential future receptors and exposure pathways are the same as those listed in the preceding paragraph, provided that shallow groundwater use is not expanded in the future to meet additional residential or commercial/industrial water supply needs. Incorporation of RNA into the remedial plan for OU5 will require that the source area be maintained as industrial property and that restrictions on shallow groundwater use be enforced in areas downgradient from the site until natural attenuation, in combination with engineered remediation, reduces contaminants to concentrations that meet regulatory standards. As plume remediation technologies such as air sparging and groundwater extraction and treatment are implemented, they will have some impact on the short- and long-term land use options and will require some level of institutional control and worker protection during remediation.

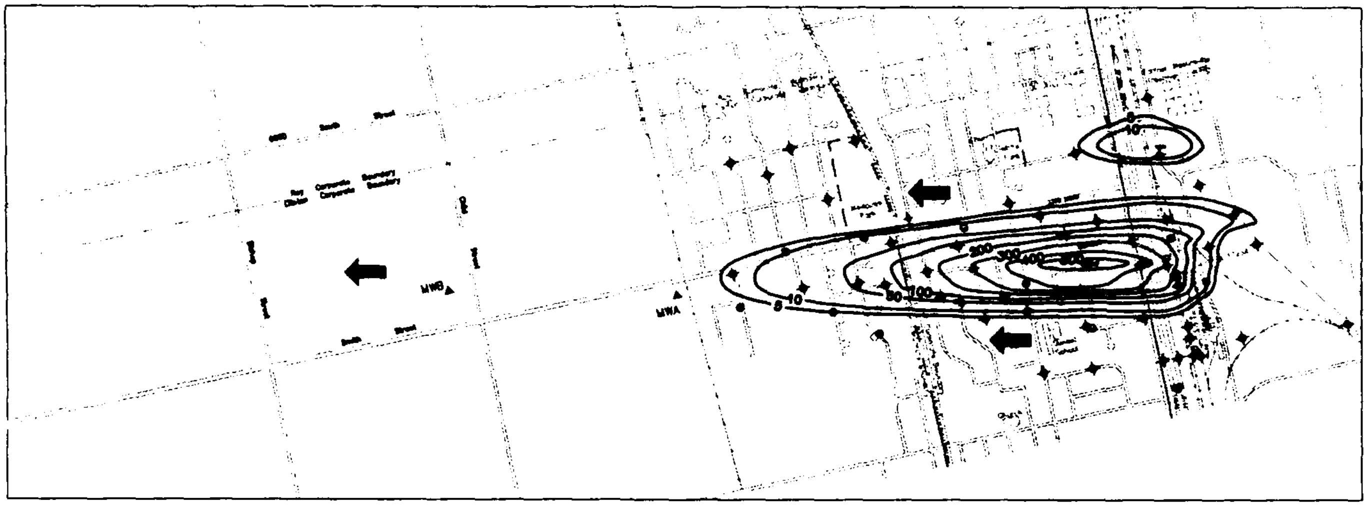
In summary, available data suggest that exposure pathways involving shallow groundwater exist that potentially could be completed under current and projected future conditions. Due to the high degree of development (particularly residential development) in and downgradient from the plume area, the application of institutional controls to prevent commercial/industrial and residential use of groundwater in the surficial aquifer is likely to be a necessary component of any groundwater remediation strategy for this site. The required duration of these institutional controls may vary depending on the effectiveness of the selected remedial technology at reducing contaminant mass and concentration in the groundwater.

6.3 EVALUATION OF REMEDIAL ALTERNATIVES

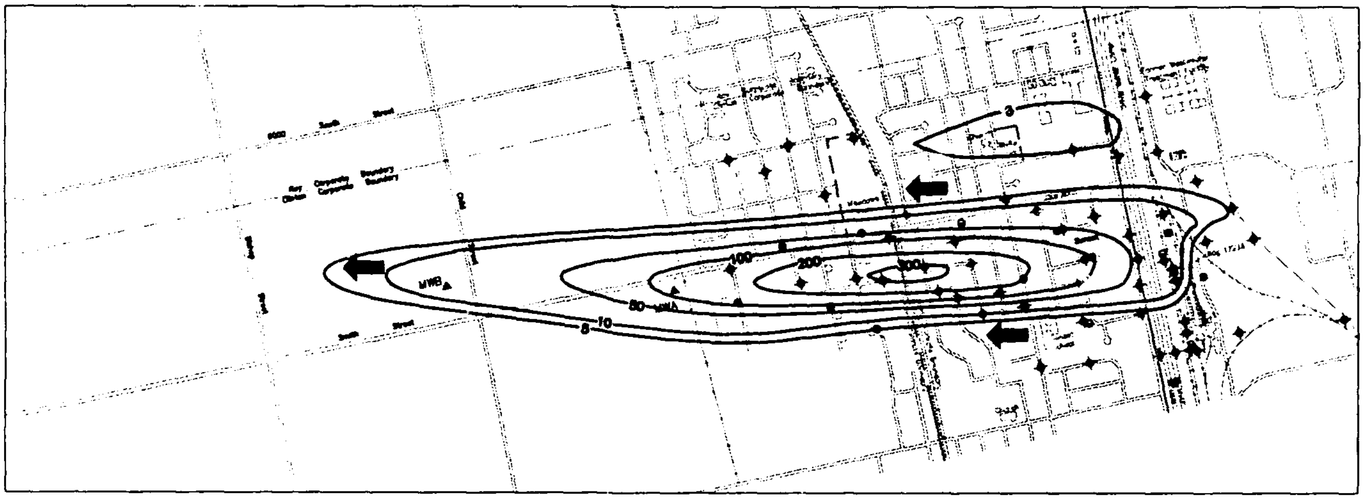
The predicted effectiveness of each of the remedial alternatives presented in Section 6.1 is described in this section using output from numerical model simulations. The implementability and cost of the remedial alternatives have already been considered during the FS performed by Radian (1997c). Therefore, these comparison criteria are not discussed in this report. The simulated plume migration under the influence of RNA alone (no engineered remediation) is shown on Figure 6.1. The results of this model, termed OU5-A, are presented to provide a baseline against which the simulations incorporating engineered remediation can be compared.

6.3.1 Alternative 1-- RNA Combined with LTM, Institutional Controls, Air Sparging Along Main Street, and Groundwater Extraction and Treatment Near Well Pair MW137/MW138

The numerical model developed for OU5 and described in Section 5 was used to simulate the effects of current and planned remedial actions. Specifically, the calibrated model was revised to allow simulation of the following IRAs:



YEAR 2002



YEAR 2047

LEGEND

- ⊕ SHALLOW MONITORING WELL
- ⊖ DEEP MONITORING WELL
- ⊗ MONITORING POINT
- MWA ▲ SIMULATED OBSERVATION WELL
- —50— LINE OF EQUAL SIMULATED TCE CONCENTRATION (μg/L) CONTOUR INTERVAL = VARIABLE
- ⬅ DIRECTION OF GROUNDWATER FLOW

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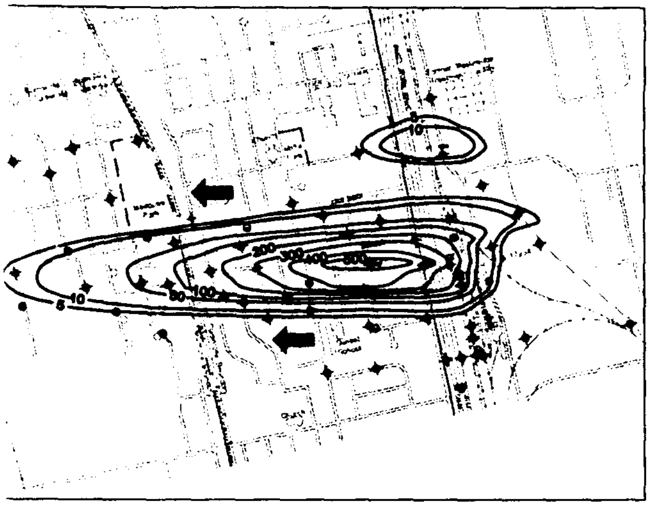

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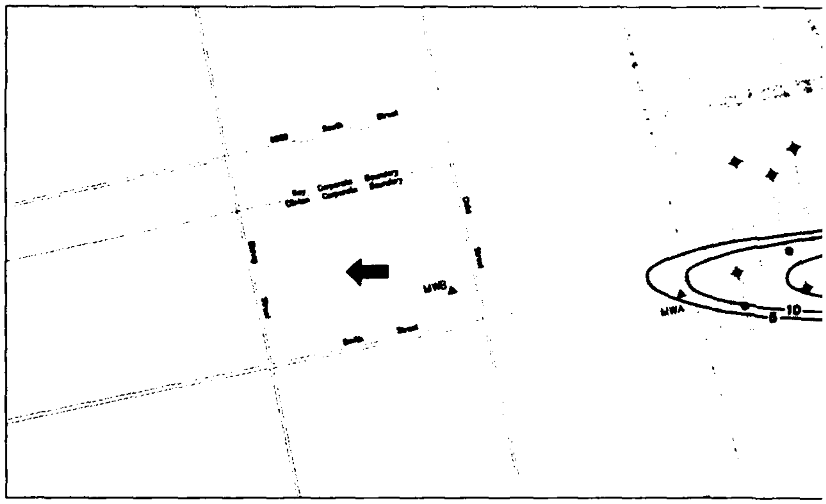

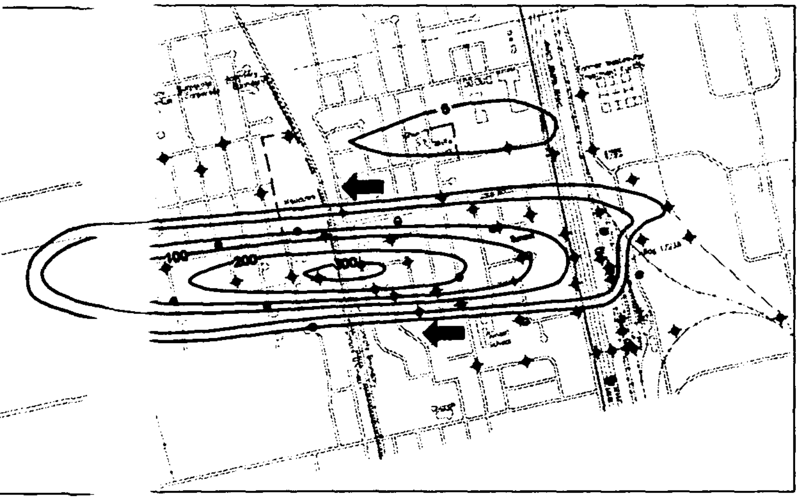

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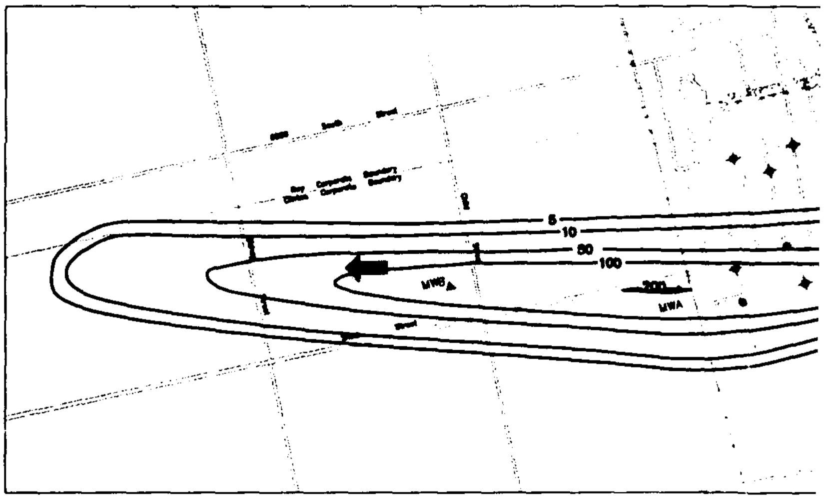

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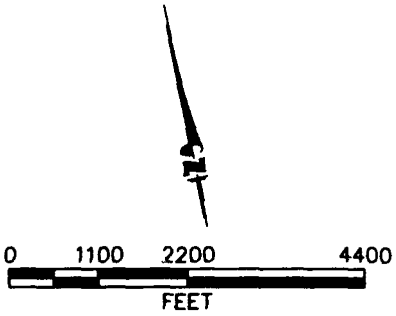
DIRECTION OF GROUNDWATER FLOW



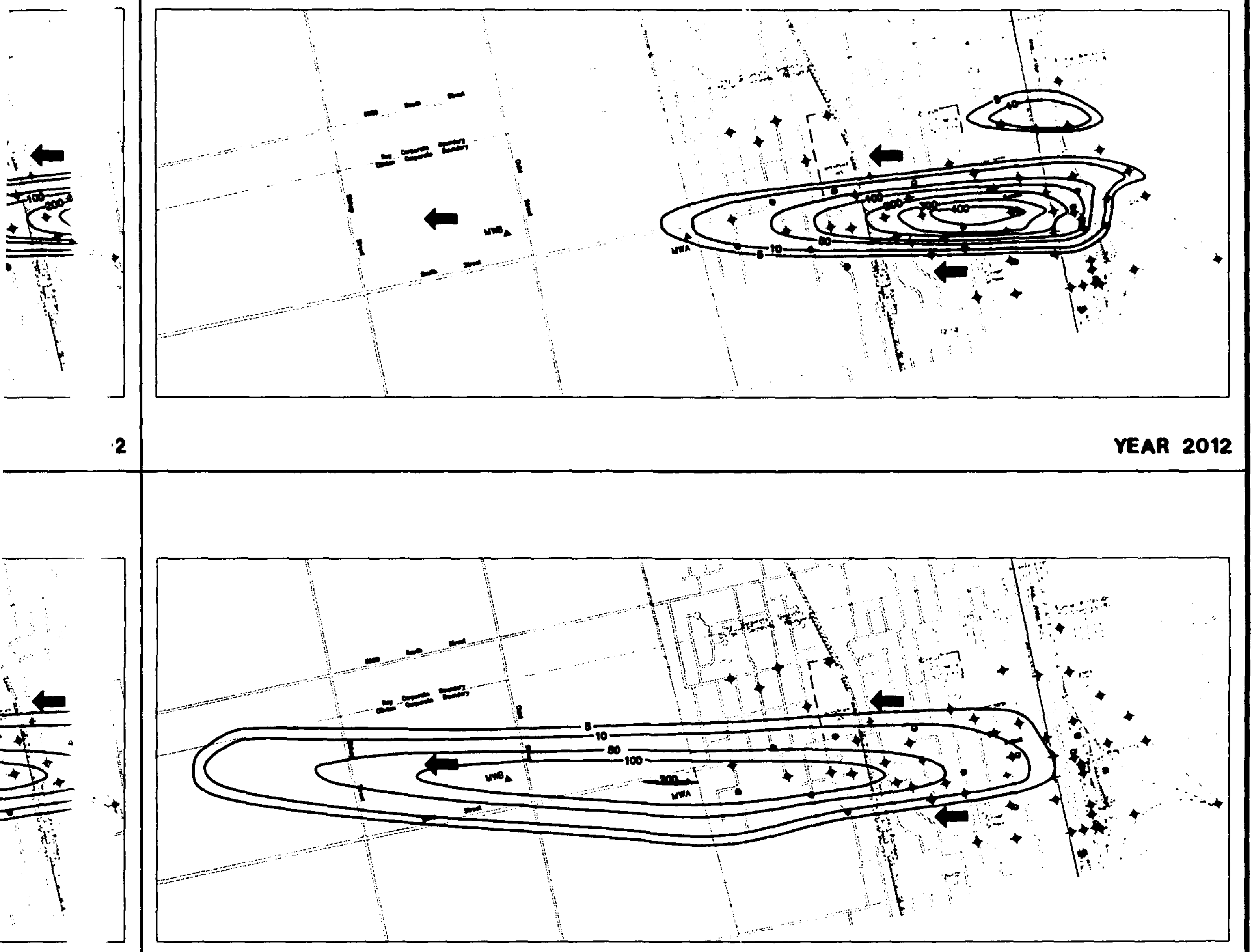


FIGURE 6.1

SIMULATED PLUME MIGRATION MODEL OU5-A

OU5 RNA TS
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Denver, Colorado

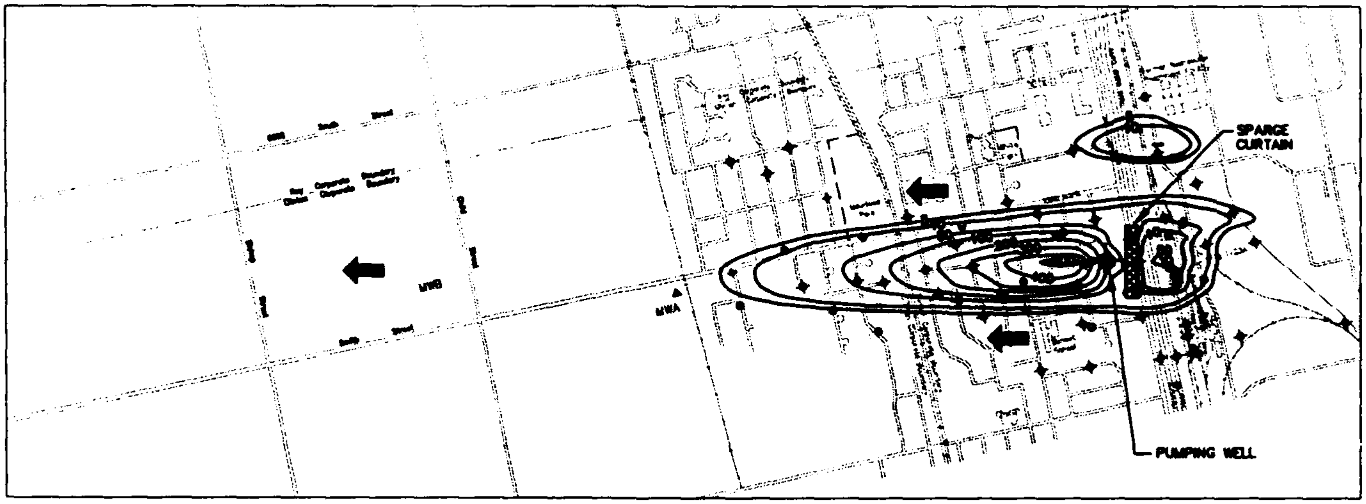
- A 400-foot-long air sparging curtain across the plume core along Main Street in eastern Sunset; and
- A localized groundwater extraction system near well pair MW137/138, approximately 600 feet west of the air sparging curtain.

The sparging curtain was simulated by removing groundwater and contaminant mass from the model grid cells that coincide with the curtain location via evapotranspiration (ET), and simultaneously adding clean water back into the same cells via recharge. The net effect of this sparging curtain simulation was a removal of contaminant mass with no disruption of the groundwater flow system. The distance between the 100-µg/L TCE isopleths at Main Street in March and August 1996 is approximately 350 to 400 feet (Figure 4.5 and Appendix A). Therefore, if the sparging curtain is as effective as planned, it should decrease dissolved TCE concentrations in excess of 50 to 100 µg/L to 5 µg/L or less. Comparison of Figures 4.5 and 5.4 shows that the TCE plume simulated by the calibrated model is wider (in the north/south direction) than the measured plume at Main Street. Therefore, the simulated sparging curtain in the numerical model was lengthened to span the distance between the 100-µg/L isopleths depicted on Figure 5.4 in order to better simulate its effectiveness. The sparging curtain was "turned on" in the model for 15 years, from calendar year 1997 to 2012; simulated TCE concentrations within the sparging curtain during the 15-year operational period were less than 15 µg/L, with average concentrations less than 10 µg/L.

Installation of five groundwater extraction wells in the approximately 100-foot by 100-foot vacant lot east of well pair MW137/138 is planned. The projected per-well pumping rate is approximately 2.5 to 3 gpm. This extraction system was simulated by adding one groundwater extraction well pumping 15 gpm in model grid cell (45,17) (Figure 5.1). The dimensions of this grid cell (100 feet by 150 feet) fully encompass the area within which all five wells will be installed. This simulated extraction system was operated for 5 years, from calendar year 1997 to 2002.

As described in Section 4.4.1, the strength of the TCE source near Building 1723A appears to be declining. To simulate this decrease, the magnitude of the TCE source near Building 1723A was decreased by one-half every 5 years starting in 1996, and was shut off entirely in the model starting in year 2011. Sensitivity analyses indicate that eliminating the source term 10 years earlier or later does not significantly affect the magnitude of dissolved TCE concentrations simulated by the model for the source area over time. The magnitude of the TCE source near Building 1781, north of the primary TCE plume, also was decreased by one-half every 5 years between 1996 and 2021, at which time the source was shut off entirely.

The revised model (referred to as Model OU5-B) was run for a period of 100 years beyond 1997 (to calendar year 2097). Figure 6.2 presents the projected impact of the above-described Alternative 1 remedial actions over time. As shown on the plume map for year 2002, the simulated sparging curtain is preventing TCE concentrations in excess of 50 µg/L from migrating downgradient from the curtain location, and a "shadow" of relatively low TCE concentrations is developing west of the curtain. In addition, maximum dissolved TCE concentrations are being reduced in the immediate



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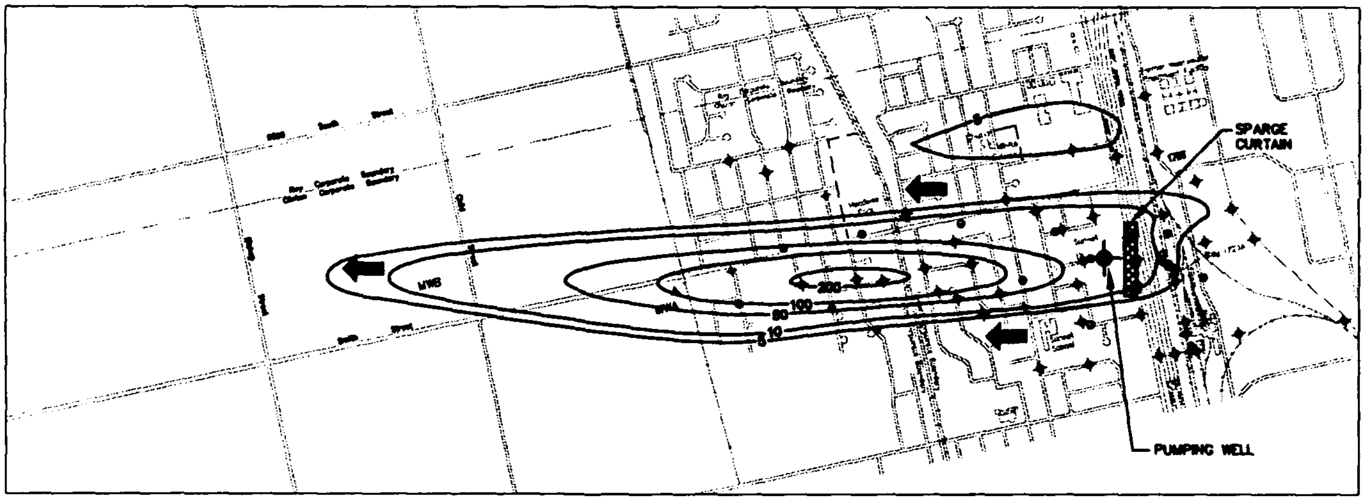

YEAR 2047

LEGEND

✦	SHALLOW MONITORING WELL
●	DEEP MONITORING WELL
⊗	MONITORING POINT
MWA ▲	SIMULATED OBSERVATION WELL
—50—	LINE OF EQUAL SIMULATED TCE CONCENTRATION (μg/L) CONTOUR INTERVAL = VARIABLE
⬅	DIRECTION OF GROUNDWATER FLOW

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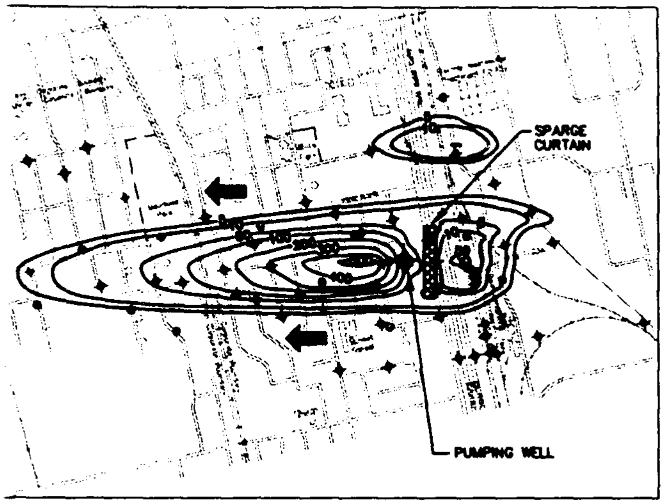

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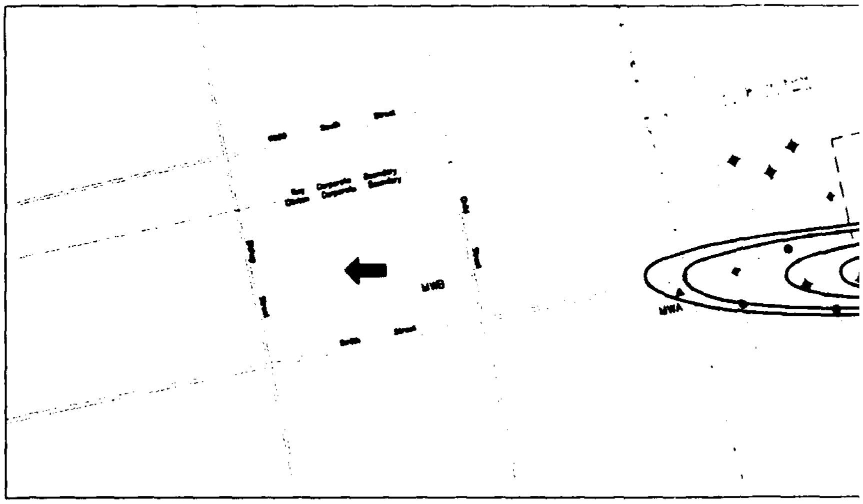

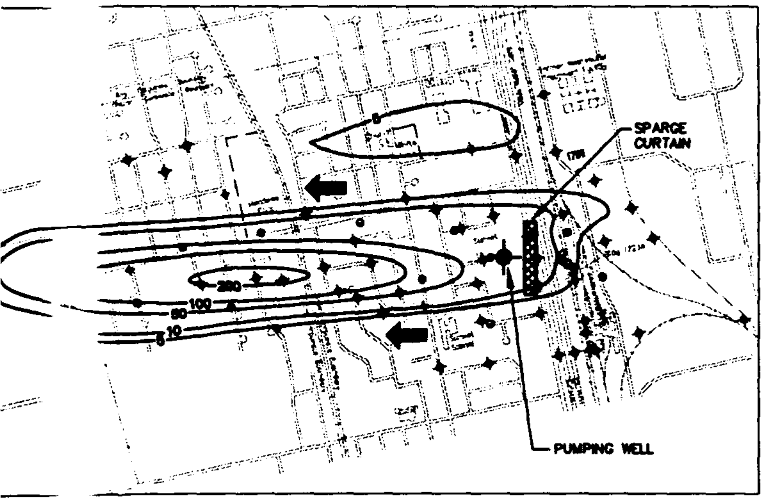

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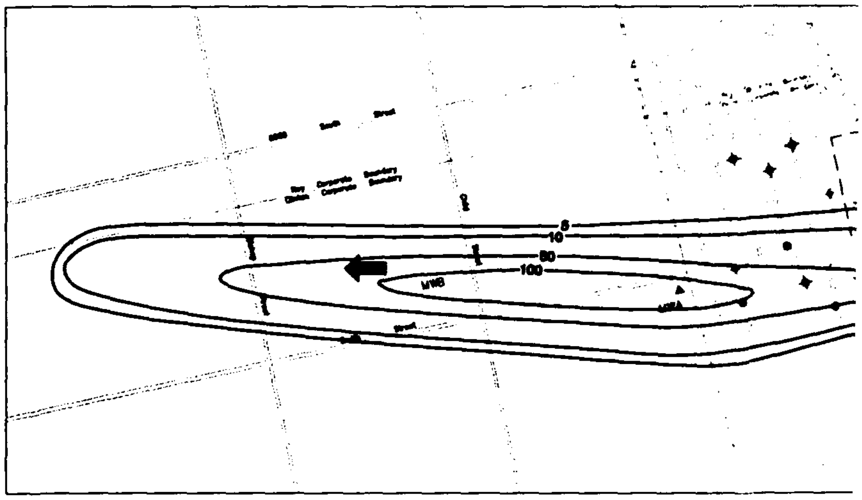

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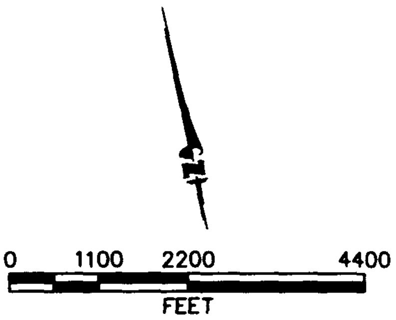

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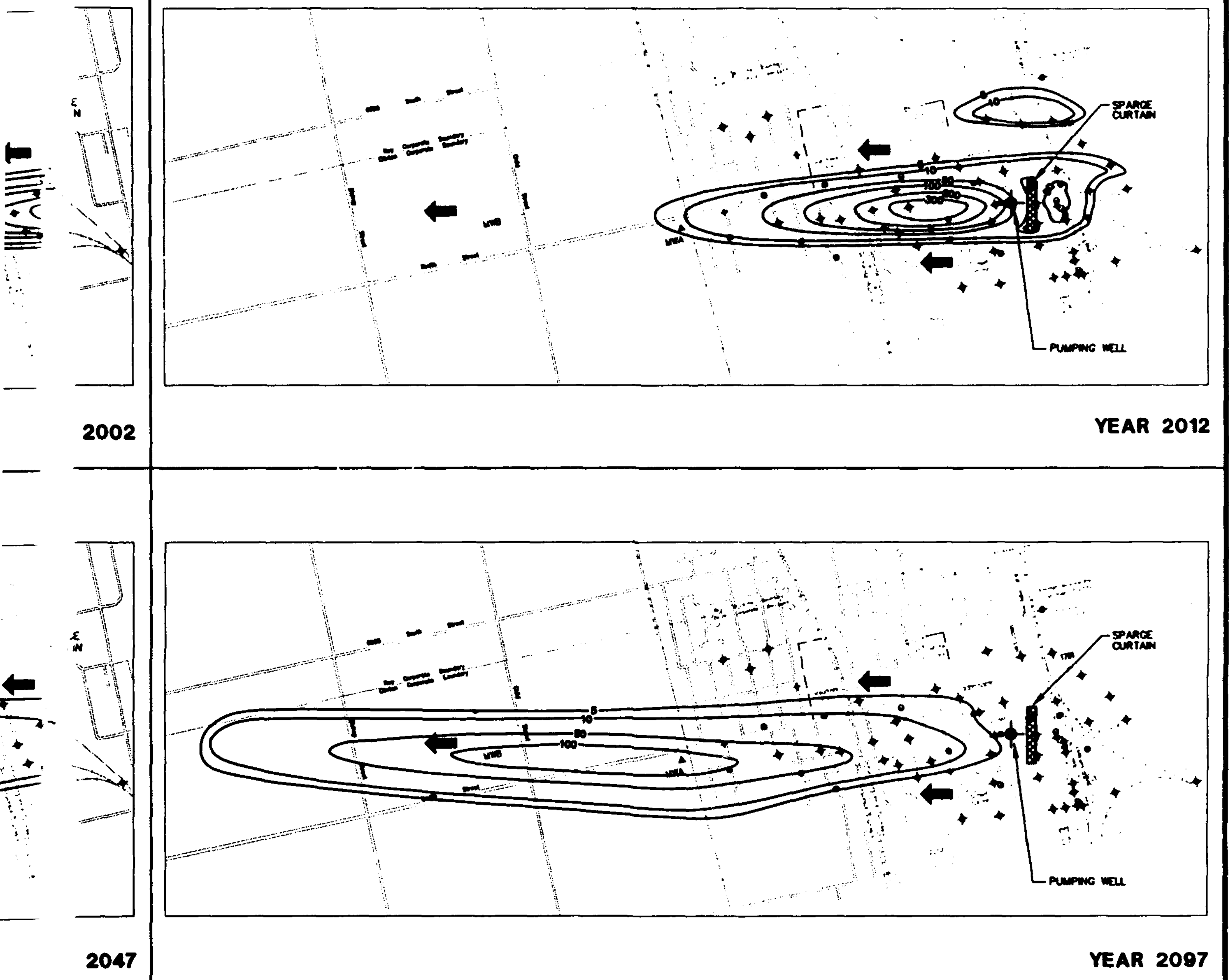

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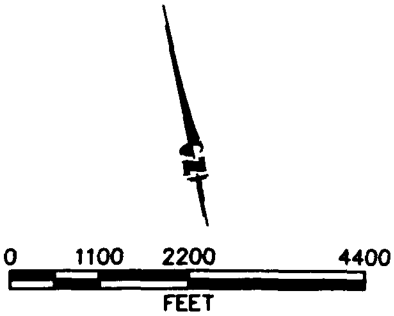

FIGURE 6.2

SIMULATED PLUME MIGRATION MODEL OU5-B

OU5 RNA TS
Hill Air Force Base, Utah

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vicinity of the downgradient groundwater extraction system adjacent to well pair MW137/138. By year 2012, when the sparging curtain is projected to cease operating, the model predicts that the center of mass of the TCE plume will be located in western Sunset. As shown on the plume maps for 2047 and 2097, the model predicts that substantial concentrations of TCE in excess of 5 µg/L will persist throughout the 100-year predictive period, and will continue to migrate downgradient, nearly reaching the downgradient model boundary (approximately 9,500 feet west of the August 1996 plume toe). The simulated migration and persistence of TCE is due largely to the low decay rate and low retardation coefficient used in the model, and the fact that substantial TCE concentrations (in excess of 200 µg/L) already have migrated downgradient from the locations of the simulated remedial systems and will not be affected by these systems.

The model indicates that the dissolved TCE contamination identified in well MW129, north of the main TCE plume, has the potential to migrate off-Base beneath Sunset. In fact, the calibrated model depicted on Figure 5.4 suggests that it may already have migrated off-Base. Given the assumptions regarding the future magnitude and longevity of the TCE source, described above, the model predicts that this plume will be completely dissipated prior to year 2097.

Simulated TCE concentrations at three existing monitoring wells within the primary TCE plume and two observation points downgradient from the primary plume during the 100-year predictive period are shown on Figure 6.3. Well MW127 is located in the source area; MW138, which contained the highest dissolved TCE concentration in both March and August 1996, is located near the simulated plume axis approximately 900 feet west of the source area; and MW163 is located near the downgradient toe of the plume. Observation points A and B are located approximately 1,000 feet and 3,800 feet downgradient from the 1996 plume toe, respectively.

Continued decrease of dissolved TCE concentrations in the source area is predicted as the source is progressively depleted. The model projects that dissolved TCE concentrations at well MW127 will decrease by 90 percent over the next 20 years, and reach the 5 µg/L MCL in approximately 60 years. As described above, the contaminant source incorporated into the numerical model was cut off in year 2011. The simulated persistence of dissolved TCE in the source area following completeremoval of the source may be reasonable as a result of gradual desorption of TCE from the aquifer matrix, underflow of contaminants that were dispersed upgradient from the source area, and potential migration of TCE from an as-yet-unidentified upgradient source that may be causing or contributing to the TCE concentration detected in well MW148. This well contained 17.2 µg/L TCE in August 1996 (Figure 4.5) and 37.9 µg/L TCE in September 1996 (Radian, 1997). It should be noted that the future magnitude of dissolved TCE concentrations in the source area will be dependent on the actual persistence and magnitude of the source over time.

Dissolved TCE concentrations at well MW138 are projected to decrease by more than one-half during the 5 years that the air sparging curtain and adjacent groundwater extraction system are operating concurrently. After the groundwater extraction system ceases to operate in year 2002, the concentration is projected to decrease more slowly. The rate at which TCE concentrations decline is predicted to decrease again after the

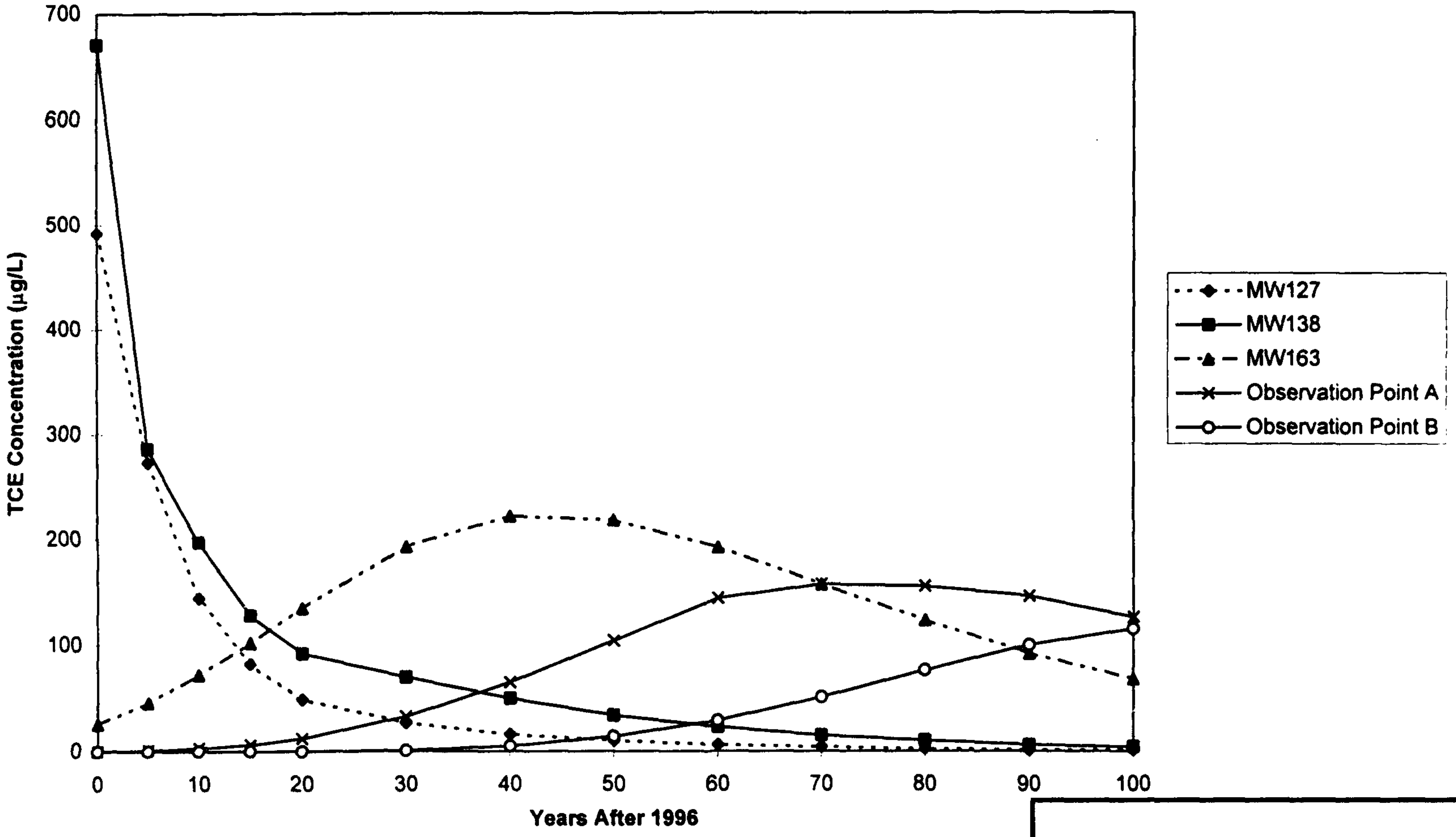

FIGURE 6.3

SIMULATED TCE CONCENTRATIONS
MODEL OU5-B

OU5 RNA TS
Hill Air Force Base, Utah

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air sparging curtain ceases to operate in 2012. The model predicts that the 5-µg/L Utah DEQ standard will be attained at this well approximately 90 years after 1996.

Dissolved TCE concentrations at downgradient well MW163 and downgradient observation points A and B are projected to increase with time as the plume migrates toward the west. The model predicts that the TCE concentration at well MW163 will peak after approximately 40 to 45 years, followed by a slow decrease as the majority of TCE mass migrates beyond this well.

Model OU5-B results for wells MW138, MW163, and Observation Point A are compared on Figure 6.4 to the TCE concentrations that the model predicts would occur at these locations if no engineered remediation were performed (Model OU5-A). Comparison of the concentration-versus-time curves for MW138 indicate that the IRAs simulated by Model OU5-B will substantially reduce the TCE concentration at this location relative to what would be present if no engineered remediation were performed. The model predicts that the impact of the IRAs on TCE concentrations atMW163 and Observation Point A will be evidenced starting in approximately 30 and 60 years, respectively.

6.3.2 Alternative 2 – RNA, LTM, Institutional Controls, Air Sparging along Main Street, Groundwater Extraction and Treatment Near Well Pair MW137/MW138, Groundwater Extraction Along 300 West, and Groundwater Extraction West of Building 1781

Model OU5-B, used to simulate remedial Alternative 1, was revised to simulate the effects of an 800-foot-long groundwater extraction trench across the plume along 300 West and multiple groundwater extraction wells west of Building 1781. The resulting model is referred to as Model OU5-C. The groundwater extraction trench was simulated by installing a line of 10 groundwater/TCE extraction wells in the model grid column corresponding to the location of 300 West. Similar to the air sparging curtain simulation described in Section 6.3.1, the simulated extraction trench was longer than 800 feet (it was extended two model grid cells to the north) to compensate for differences in the width of the calibrated and measured plumes. As a result, the simulated extraction trench extends to between the 10-µg/L and 50-µg/L isopleths both to the south and north, similar to the proposed 800-foot-long trench. The projected extraction rate for this trench is 15 to 20 gpm. Assuming an actual total pumping rate of 20 gpm for an 800-foot-long trench (2.5 gpm per 100 feet of trench), the simulated pumping rate for the simulated 1,000-foot-long trench was 25 gpm. Review of the water budget for the trench area computed by MODFLOW indicates that this pumping rate is more than sufficient to capture all of the groundwater (and dissolved contaminants) migrating through the proposed trench cross-section. The trench was "turned on" in the model in 1998, and operated for 15 years (through 2012).

In addition to the groundwater extraction trench, four simulated groundwater extraction wells, each pumping 2.5 gpm, were added to the model west of Building 1781. These wells are assumed to pump for a period of 5 years, from 1998 to 2003, to capture dissolved contaminants migrating from the Building 1781 area.

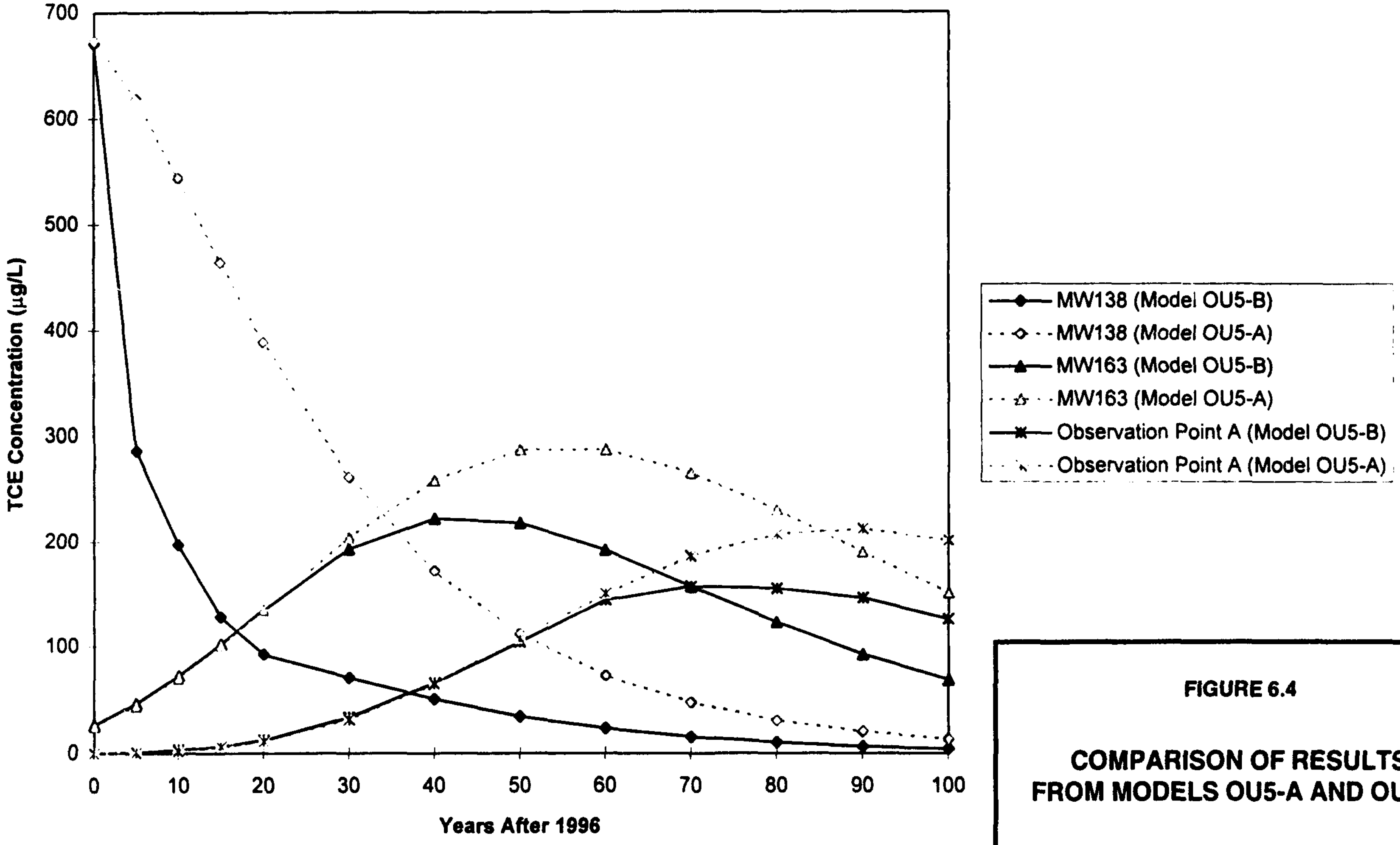

FIGURE 6.4

COMPARISON OF RESULTS FROM MODELS OU5-A AND OU5-B

OU5 RNA TS
Hill [illegible] Force Base, Utah

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Model OU5-C was run for a period of 100 years beyond 1997 (to calendar year 2097). Figure 6.5 presents the projected impact of the above-described remedial actions over time. Similar to Alternative 1 (Figure 6.2), Model OU5-C predicts that substantial concentrations of TCE in excess of 5 µg/L will persist throughout the 100-year predictive period, and will continue to migrate downgradient, nearly reaching the downgradient model boundary (approximately 9,500 feet west of the August 1996 plume toe). As shown on Figure 4.5, dissolved TCE concentrations in excess of 200 µg/L appear to have already migrated past 300 West, which is the planned location of the groundwater extraction trench. Due to the low decay rate simulated in the model, the model predicts that this contamination will continue to persist at elevated concentrations as it migrates toward the west. Maximum concentrations within the simulated plume are, however, reduced relative to those simulated by Model OU5-B due to the effects of the extraction trench.

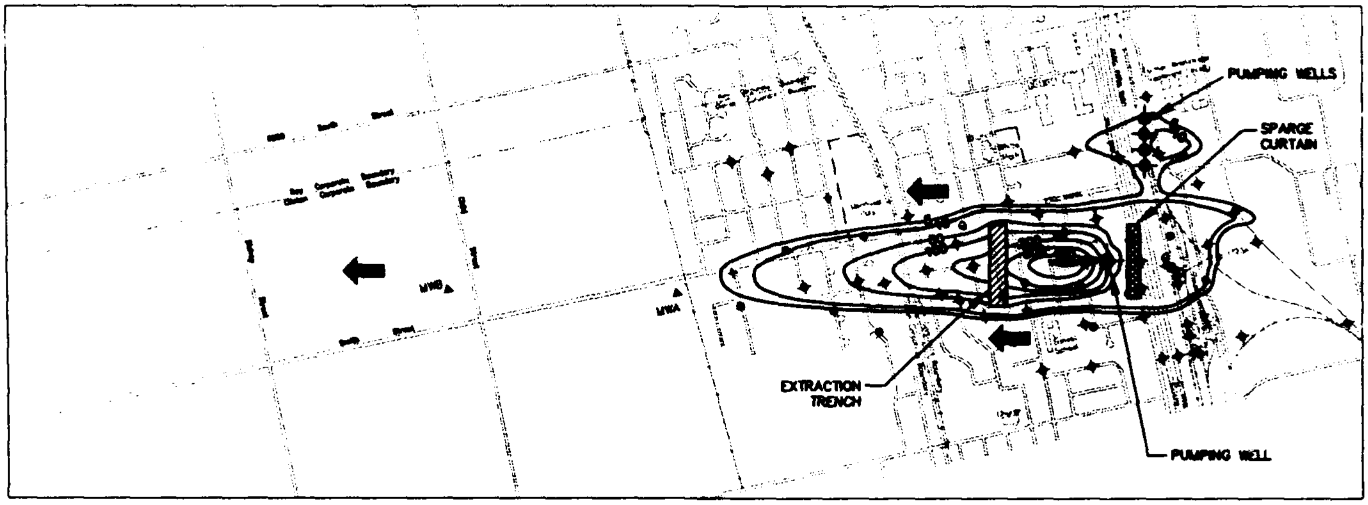
The four simulated groundwater extraction wells west of Building 1781, north of the primary TCE plume, capture the on-Base portion of the dissolved TCE contamination in that area. However, the portion of this plume that the model predicts has already migrated off-Base continues to migrate toward the west beneath Sunset. The 50-year "snapshot" (year 2047) shows the plume detached from the source area and becoming reduced in magnitude and areal extent. At 100 years, this plume has dissipated entirely.

The temporal variation in TCE concentrations at well MW163 and Observation Points A and B, simulated by Model OU5-C, are depicted on Figure 6.6. This figure also shows the results from Model OU5-B for comparison purposes. The maximum dissolved TCE concentrations at all three locations simulated by Model OU5-C are approximately one-half those simulated by Model OU5-B due to the effects of the groundwater extraction trench along 300 West. The TCE concentrations simulated by Model OU5-C for wells MW138 and MW127 are very similar to those depicted forModel OU5-B on Figure 6.4 because they are not influenced by the groundwater extraction trench. Therefore, they were not included on Figure 6.6.

6.4 SUMMARY AND CONCLUSIONS

The effectiveness of two remedial alternatives has been evaluated for the shallow groundwater at OU5. Engineered remedial components of the alternatives evaluated include air sparging and three separate groundwater extraction systems. The predicted effectiveness of RNA at reducing the extent and magnitude of the TCE plume over time was simulated by numerical models.

On the basis of the very limited and localized occurrence of TCE biodegradation thus far observed in OU5 groundwater, and the low TOC content of the aquifer matrix, which limits retardation, the numerical model results indicate that dissolved TCE that is not captured by the remedial systems will persist and migrate downgradient. The results of Model OU5-C suggest that substantial migration of TCE will occur, even if all planned and probable remedial actions are implemented, primarily because substantial TCE concentrations have migrated past the proposed extraction trench location along 300 West. In addition, the potential exists for TCE concentrations in excess of 5 µg/L to persist for over 100 years. If the magnitude of the dissolved TCE



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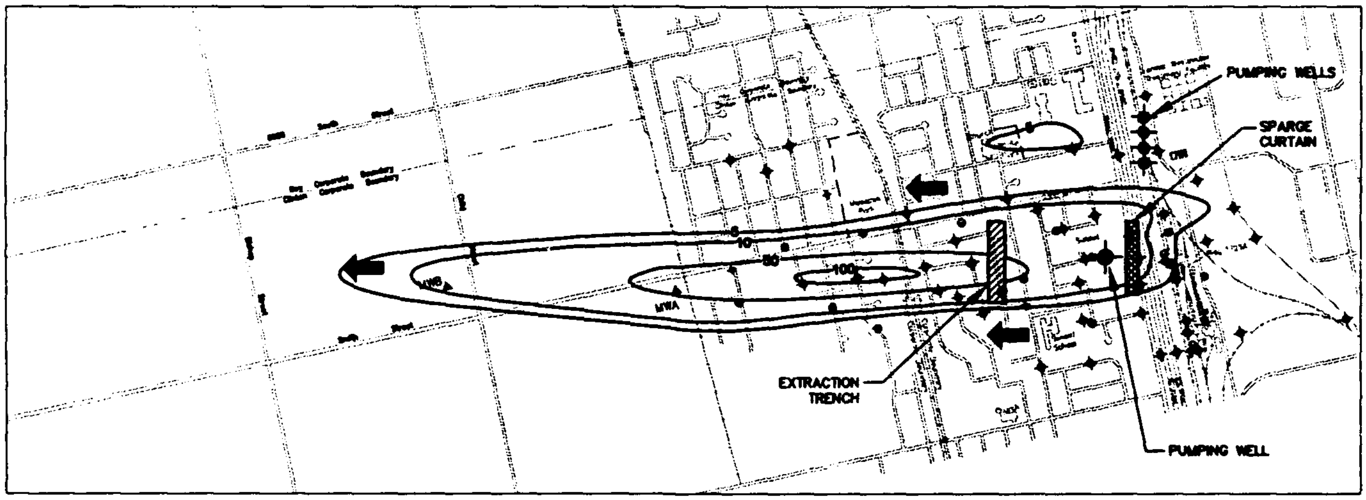

YEAR 2047

LEGEND

✦ SHALLOW MONITORING WELL

● DEEP MONITORING WELL

⊗ MONITORING POINT

MWA ▲ SIMULATED OBSERVATION WELL

—50— LINE OF EQUAL SIMULATED
TCE CONCENTRATION (µg/L)
CONTOUR INTERVAL = VARIABLE

⬅ DIRECTION OF GROUNDWATER FLOW

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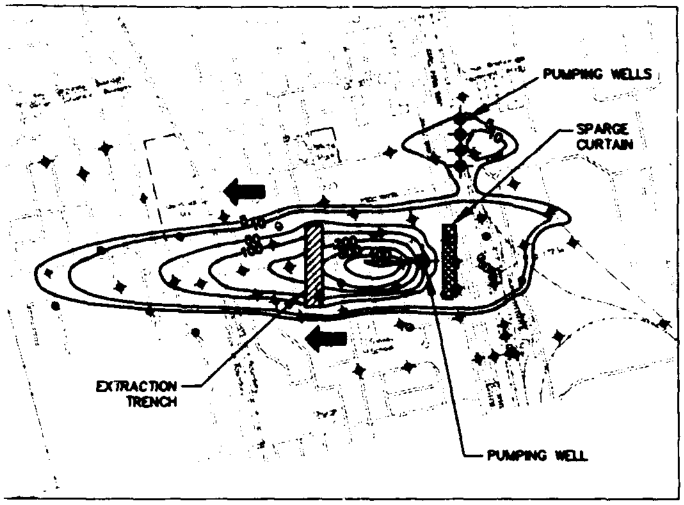

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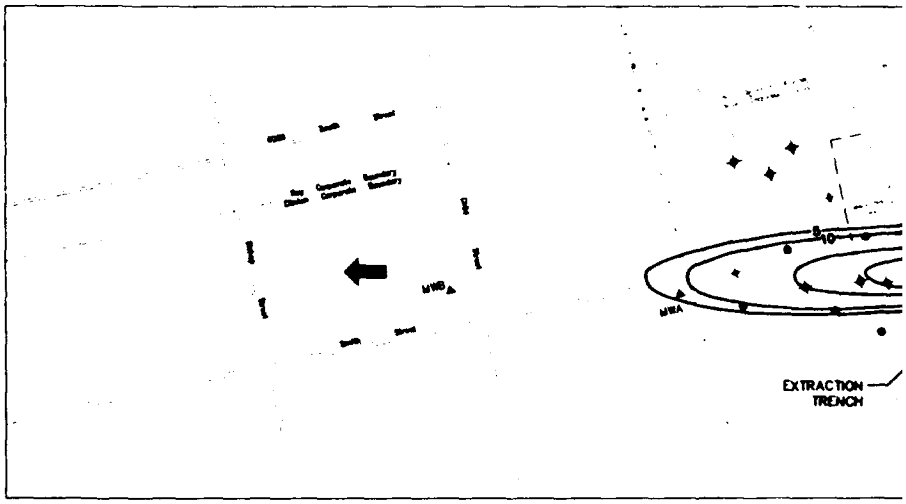

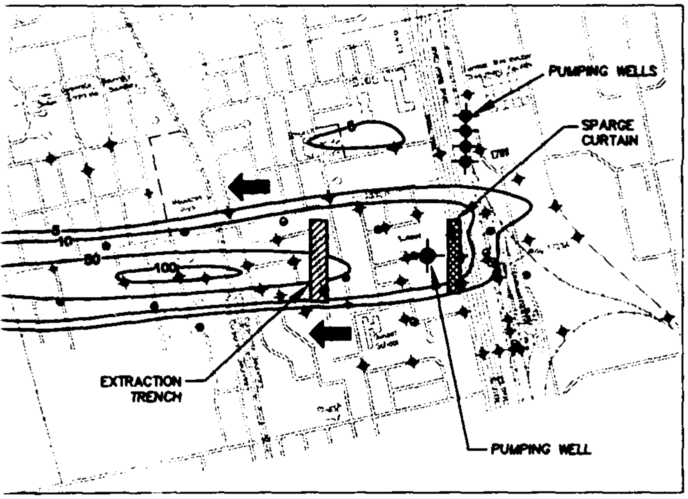

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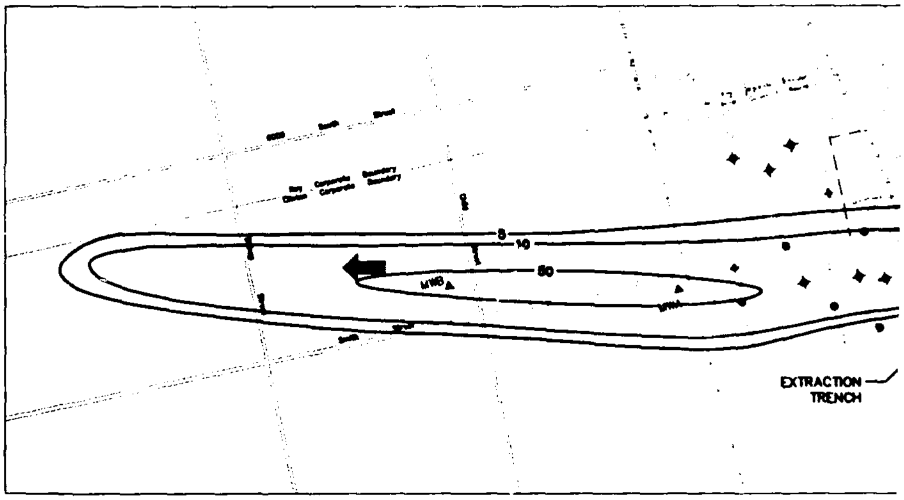

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E CONCENTRATION (µg/L)
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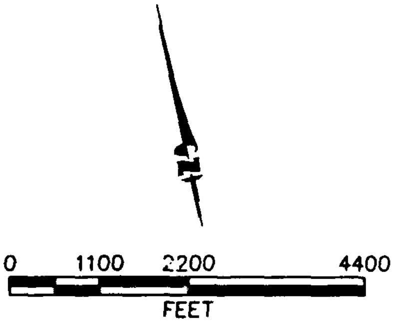
RECTION OF GROUNDWATER FLOW



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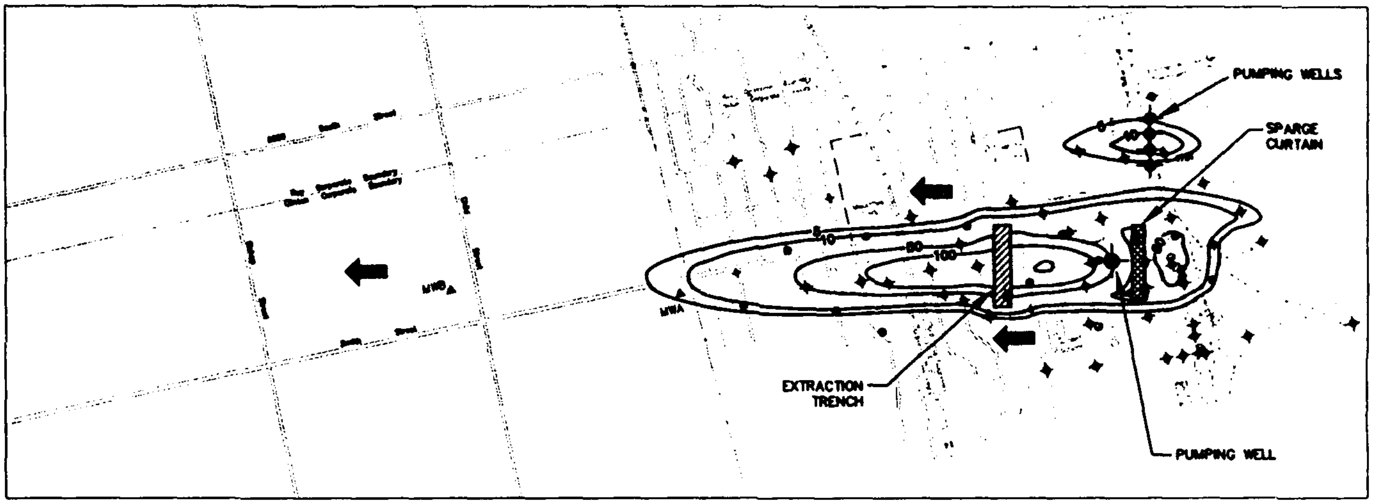

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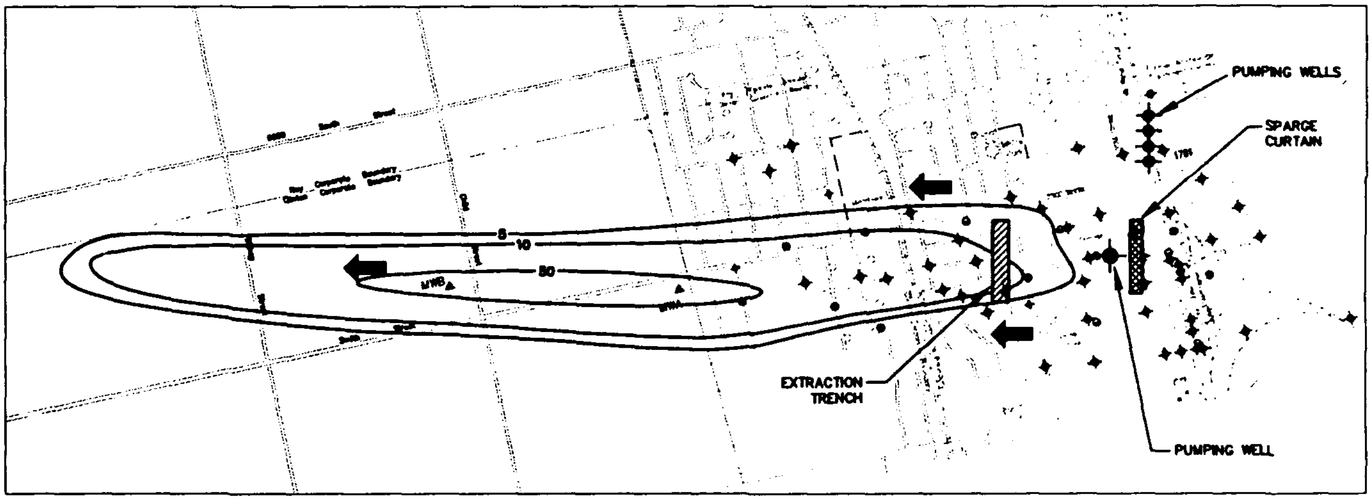

YEAR 2097

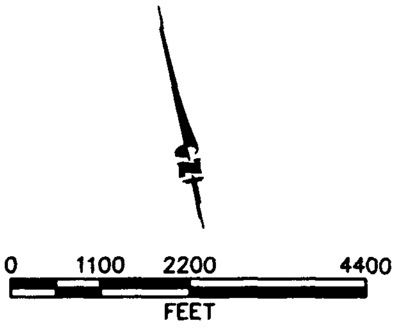

FIGURE 6.5

SIMULATED PLUME MIGRATION MODEL OU5-C

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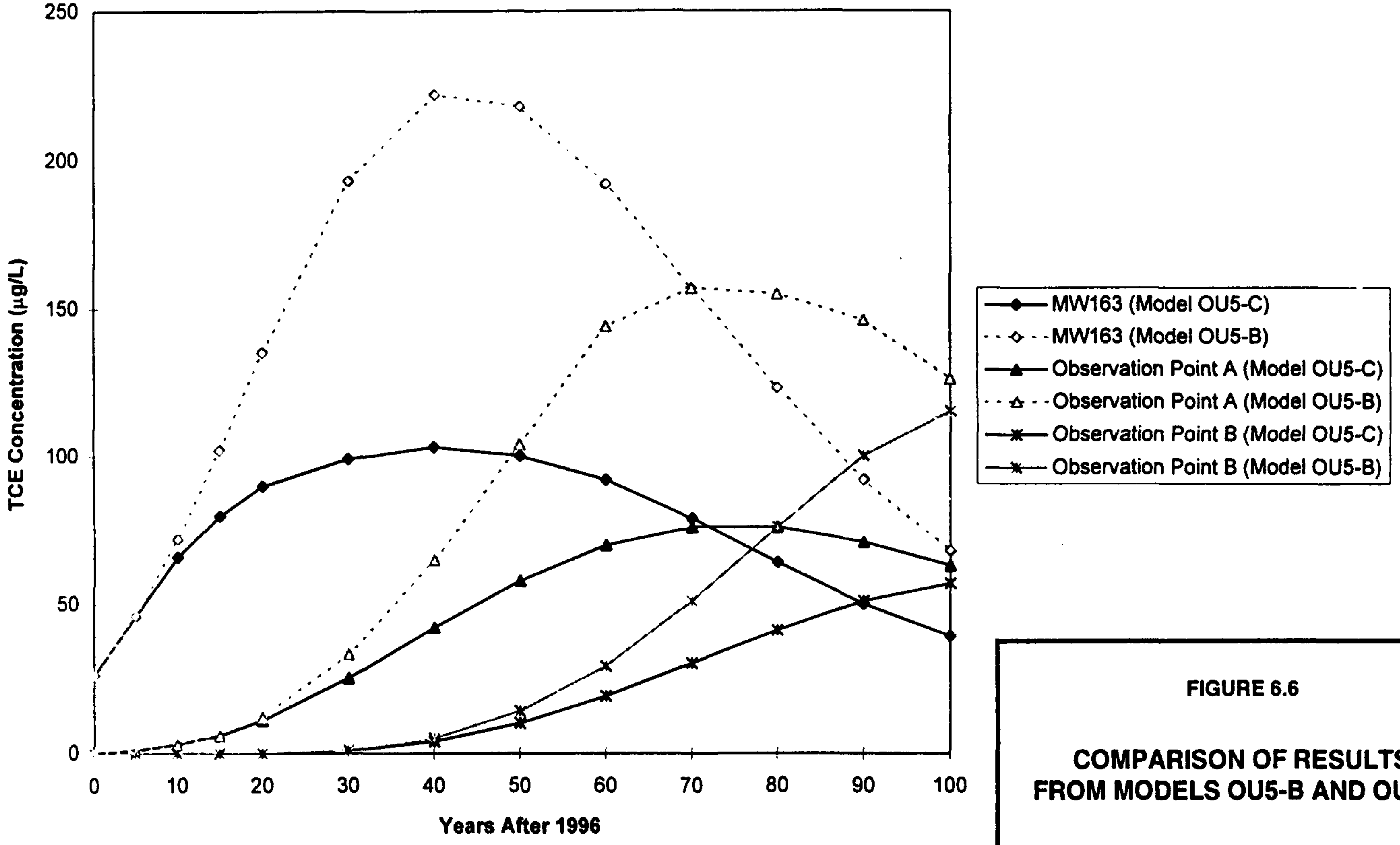

FIGURE 6.6

COMPARISON OF RESULTS FROM MODELS OU5-B AND OU5-C

OU5 RNA TS
Hill Air Force Base, Utah

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concentrations that are predicted to be present over time west of the simulated groundwater extraction trench are unacceptably high, then relocation of the extraction trench further to the west (or installation of another extraction system west of 300 West) should be considered.

The accuracy of these predictions is dependent to a large extent on whether contaminant transport parameters (specifically, retardation and decay) do not change (e.g., increase in magnitude) along the plume flowpath, and the degree to which discharge of contaminated groundwater to surface water occurs along the plume flowpath. Other factors that could cause plume migration and persistence to differ from model predictions include the following:

- The calibrated model is not necessarily unique, and different combinations of input parameters could potentially have been used to achieve an acceptable calibration;
- A wide range of potential TCE biodegradation rates were calculated for the OU5 groundwater system; therefore, the actual biodegradation rates may be different than the rate used in the model;
- Only one round of geochemical data has been collected from a subset of site monitoring wells; therefore, temporal and spatial variations in biodegradation rates have not been fully assessed; and
- The model does not account for the potential occurrence of abiotic degradation (e.g., hydrolysis and dehydrohalogenation) and volatilization of TCE.

Abiotic degradation and volatilization are generally considered to be relatively unimportant compared to other natural attenuation mechanisms. However, when plume biodegradation could require more than a century, the significance of these mechanisms in overall plume attenuation may become enhanced. Butler and Barker (1996) note that attributing changes in the presence, absence, or concentration of halogenated solvents to abiotic processes is usually difficult, particularly on the field scale.

The model results suggest that the dissolved TCE contamination detected west of Building 1781 in well MW129 has migrated off-Base. However, groundwater flow and contaminant transport parameters as well as TCE source characteristics have not been well defined in this area. Therefore, the degree to which the model predictions are accurate for this relatively minor plume is not known. As described in Section 7, at least one additional monitoring well should be installed west of Building 1781 to assess the downgradient extent of this contamination. Further definition of the areal extent and magnitude of the dissolved TCE will facilitate a decision as to whether to capture the contamination at the Base boundary or to continue monitoring to determine temporal trends and confirm model predictions.

SECTION 7

LONG-TERM MONITORING PLAN

7.1 OVERVIEW

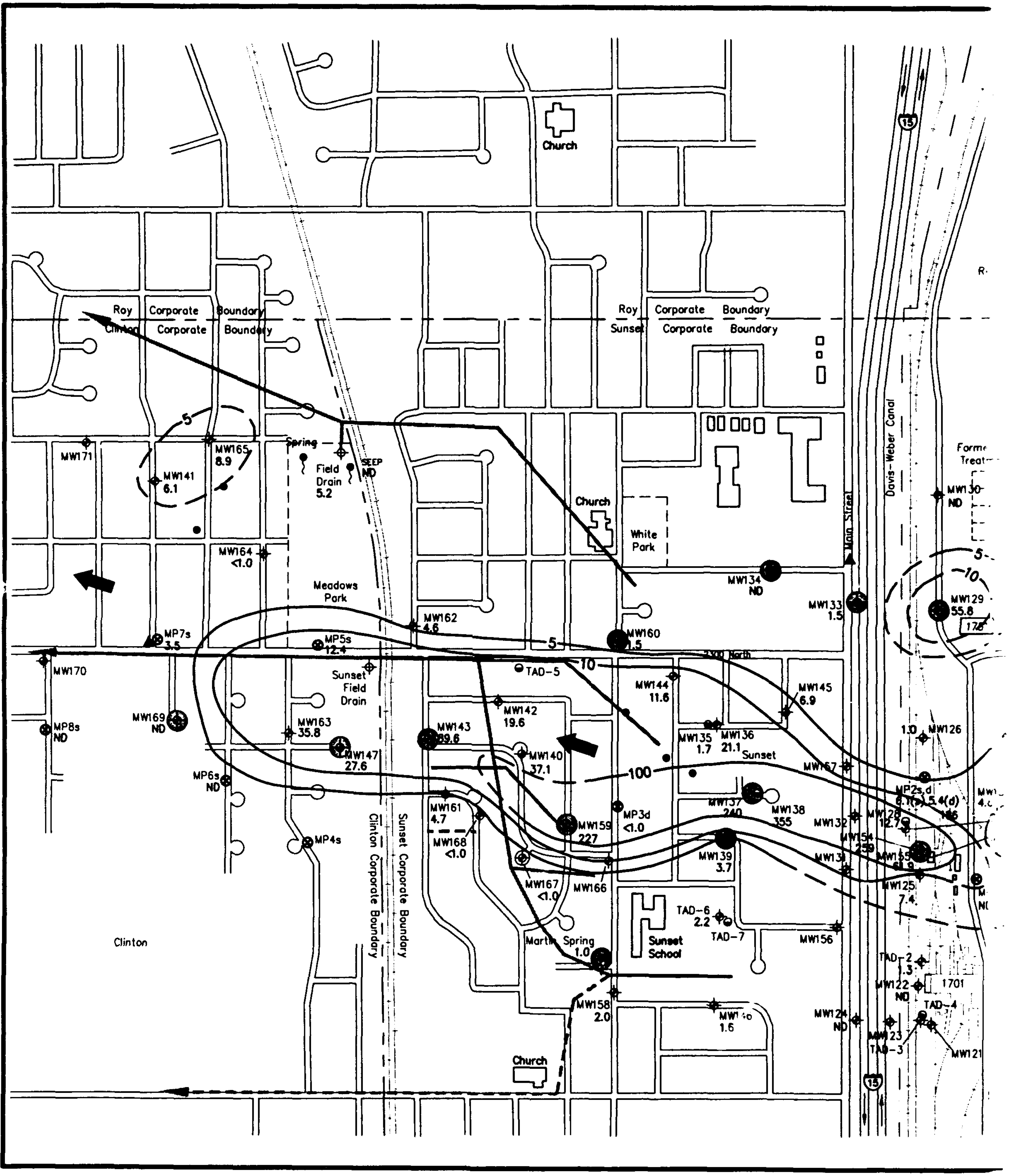
A groundwater SAP for OU5 was developed by Radian (1997). The SAP describes the groundwater monitoring schedule and rationale for the upcoming August 1997 sampling event, presents standard operating procedures for the field sampling program, and discusses field and laboratory quality assurance (QA)/QC. The long-term groundwater monitoring plan for OU5 presented in this section describes a monitoring scheme for the next 30 years for planning and budgeting purposes. It should be noted that this plan was devised on the basis of currently available data; the LTM program may be progressively revised as new data are obtained during this 30-year period. The LTM plan consists of identifying the locations of LTM wells and developing a groundwater sampling and analysis strategy to accomplish the following objectives:

- Monitor changes in site conditions, including [illegible] magnitude and extent, over time;
- Assess the effectiveness of engineered remedial actions and naturally occurring processes at reducing contaminant mass and minimizing contaminant migration;
- Assess the degree to which site-specific remediation goals (Section 6.1) are being attained and facilitate the evaluation of the need for additional remediation; and
- Verify the predictions of the numerical contaminant fate and transport model.

The strategy described in this section is designed to monitor plume migration over time and to verify that natural and engineered remedial processes are adequately protecting potential receptors. In the event that data collected under this LTM program indicate that the planned combination of naturally occurring processes and engineered remedial actions is insufficient to protect human health and the environment, contingency controls to more aggressively remediate the dissolved TCE plume would be necessary.

7.2 GROUNDWATER MONITORING NETWORK

LTM of a minimum of 11 existing monitoring wells and one new monitoring well located upgradient from, within, and on the periphery of the primary TCE plume is recommended. The existing wells include MW148, MW154, MW155, MW137, MW138, MW139, MW160, MW159, MW143, MW163, and MW169 (Figure 7.1). Well MW148 is located upgradient from the plume, and has historically contained TCE



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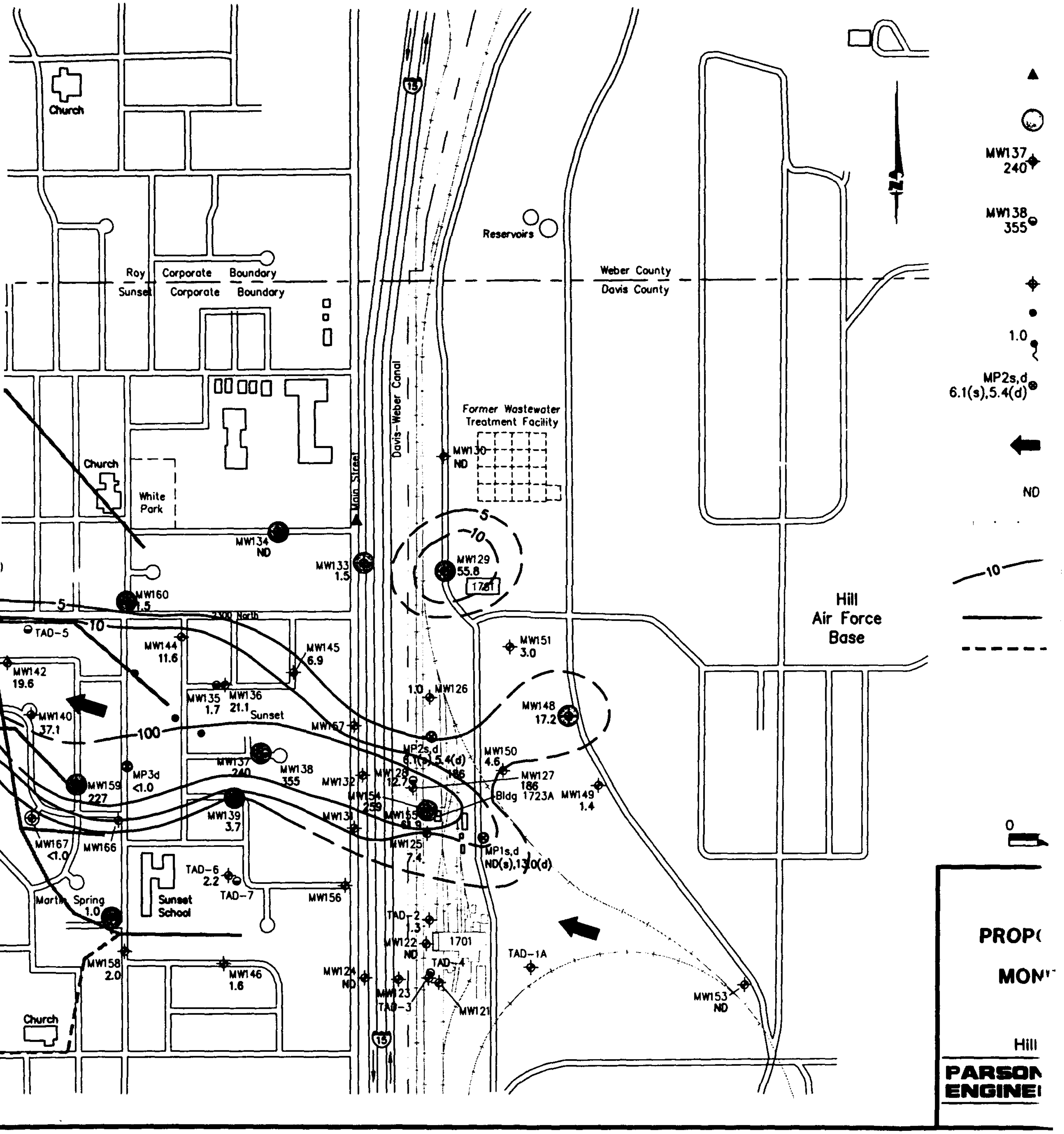
Church
Roy Corporate Boundary
Sunset Corporate Boundary
Weber County
Davis County
Reservoirs
Davis-Weber Canal
Main Street
Former Wastewater Treatment Facility
Church
White Park
MW134 ND
MW133 1.5
MW130 ND
MW129 55.8
1781
5
10
MW160 1.5
2300 North
TAD-5
MW144 11.6
MW145 6.9
MW142 19.6
MW140 37.1
MW135 1.7
MW136 21.1
Sunset
MW157
100
MW137 240
MW138 355
MW159 227
MP3d <1.0
MW139 3.7
MW132
MW128 12.7
MW154 259
MW155 61.9
MW131
MW125 7.4
MP2s,d 6.1(s),5.4(d)
186
MW150 4.6
MW127 186
Bldg 1723A
MW149 1.4
MP1s,d ND(s),13.0(d)
MW151 3.0
1.0 MW126
MW148 17.2
MW167 <1.0
MW166
TAD-6 2.2
TAD-7
MW156
Martin Spring 1.0
Sunset School
TAD-2 1.3
MW122 ND
1701
TAD-4
TAD-1A
MW124 ND
MW123
TAD-3
MW121
MW158 2.0
MW146 1.6
Church
MW153 ND
Hill Air Force Base
MW137 240
MW138 355
1.0
MP2s,d 6.1(s),5.4(d)
ND
10
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PROP
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Hill
PARSON
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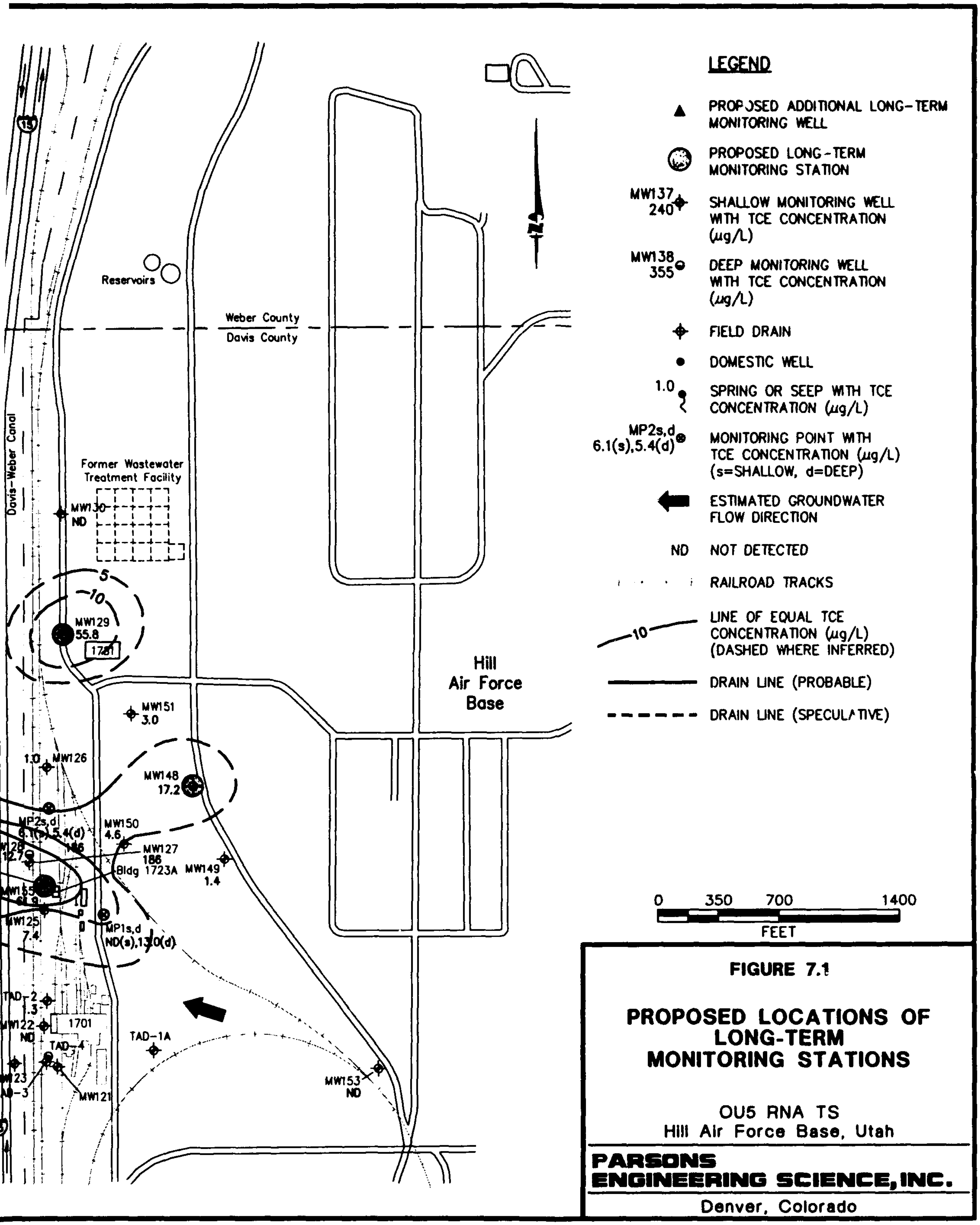

FIGURE 7.1

PROPOSED LOCATIONS OF LONG-TERM MONITORING STATIONS

OU5 RNA TS
Hill Air Force Base, Utah

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Denver, Colorado

concentrations in excess of the 5-µg/L groundwater quality standard. Wells MW160 and MW139 bound the plume on the north and south, respectively, and will allow assessment of the lateral migration of CAHs over time. The remaining wells are located along the approximate plume axis from the source area to the downgradient plume toe. Replacement of downgradient monitoring point MP7 with a conventionally-constructed LTM well is recommended.

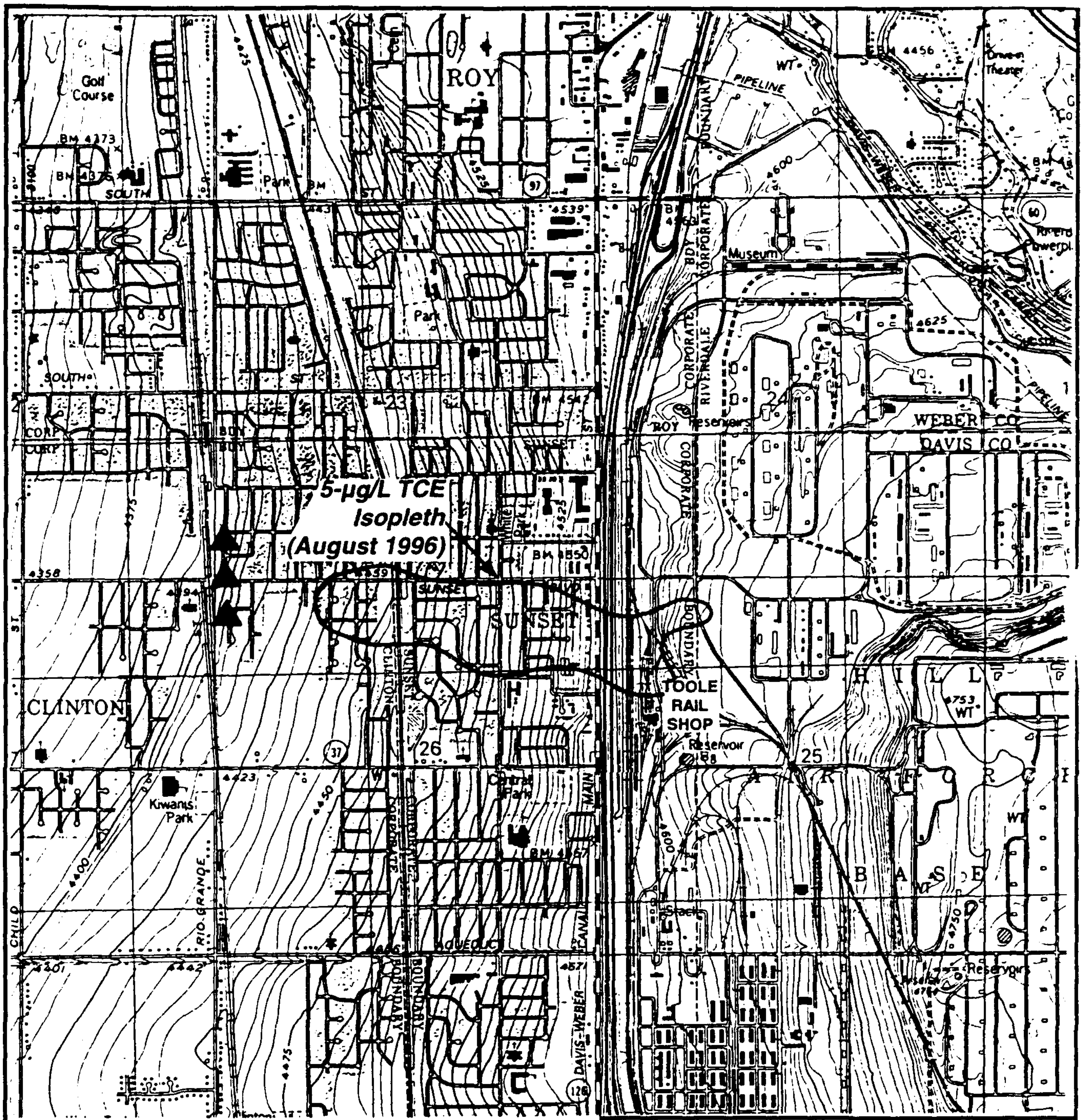
LTM of a minimum of three existing wells and one new well at and downgradient from the small TCE plume at Building 1781 also is recommended. The existing wells include MW129, MW133, and MW134 (Figure 7.1). Installation of a new well near Main Street north of MW133 is recommended because groundwater elevation data (Figure 3.8) indicate a northwesterly groundwater flow direction in this area.

On the basis of the contaminant transport modeling results presented in Section 6, the TCE plume may migrate more than 1 mile past the current downgradient plume boundary over the next 100 years. As stated in Section 6.5, this prediction assumes that contaminant transport properties (e.g., TCE decay rate, retardation coefficient) along the plume flowpath do not change significantly with time and distance as a result of changing subsurface geochemical conditions, and that a significant portion of the plume does not discharge to the ground surface in low-lying wetland areas, springs, or drainage ditches/creeks downgradient from the current plume boundary.

Because the groundwater flow direction and subsurface properties in the area downgradient from the current plume boundary have not been investigated, installation of additional LTM wells more than approximately 1,000 feet downgradient from the current plume boundary is not recommended. Instead, progressive tracking of the plume in the downgradient direction over time is recommended. In this way, the downgradient migration of the plume can be monitored, and additional LTM wells can be installed as required.

Installation and periodic sampling of three additional LTM wells along a line perpendicular to the prevailing groundwater flow direction approximately 1,000 feet west of (downgradient from) the current toe of the TCE plume is recommended to monitor future plume expansion. Suggested locations for these wells are shown on Figure 7.2; actual locations will depend on the accessibility of the specific locations. On the basis of hydraulic conductivity and hydraulic gradient information for the downgradient portion of the plume, and using an estimated retardation coefficient for TCE of 1.56, the TCE migration velocity in the downgradient portion of the plume is estimated to be 0.24 ft/day. Assuming that hydraulic and/or geochemical conditions do not change significantly in the downgradient direction, the plume should reach these wells in approximately 11 years. To be conservative, the wells could be installed and sampling could begin in approximately 5 years (calendar year 2002). If CAH contamination is detected in these wells in the future, then additional wells could be installed further downgradient. Estimates of the groundwater/CAH migration rate and direction should be progressively refined as new wells are installed to aid in locating additional LTM wells.

Prior to installation of the three LTM wells west of the current plume boundary, the stratigraphy at the well locations should be investigated to ensure that the wells are appropriately screened to intercept transmissive zones that may act as preferred



▲ PROPOSED FUTURE LONG-TERM MONITORING WELL

Source: USGS 7.5 Minute Series, Roy, Utah, 1990.

FIGURE 7.2

PROPOSED LOCATIONS OF FUTURE LONG-TERM MONITORING WELLS

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Denver, Colorado

contaminant migration pathways. This information could be obtained using a cone penetrometer, Geoprobe®, or conventional drilling rig.

7.3 SURFACE WATER MONITORING

Continued periodic sampling of Martin Spring is recommended, because this spring discharges into a swimming pool. As described in Section 6.2, drainage ditches have been constructed in the area west of the TCE plume, presumably to lower the water table and facilitate development. In addition, isolated low-lying, marshy areas are present. The occurrence of springs in this downgradient area has not been investigated. If future groundwater monitoring indicates that the plume is approaching or has reached a potential surface discharge area, then surface water samples should be collected in the affected area to evaluate whether significant surface discharge of TCE is occurring.

7.4 ANALYTICAL PROTOCOL

All LTM wells should be sampled and analyzed to determine compliance with chemical-specific remediation goals and to verify the effectiveness of remediation at the site. Groundwater level measurements should be made during each sampling event. Groundwater samples from LTM wells should be analyzed for the parameters listed in Table 7.1. Surface water samples should be analyzed for VOCs using USEPA Method SW8260A. Pertinent portions of the site-specific SAP (Radian, 1997) could be incorporated into the remedial action plan (in compliance with regulatory requirements), as appropriate, to support the LTM program.

7.5 SAMPLING FREQUENCY

Under the current remedial strategy, dissolved TCE concentrations in excess of the 5 µg/L standard may be present for more than 100 years. Estimated LTM costs for a 30-year period beginning in 1998 are presented in Section 7.6. These costs incorporate the following sampling frequency assumptions:

- The 16 LTM wells (14 existing and 2 proposed) located within or on the periphery of the primary TCE plume and the secondary plume at Building 1781 will be sampled annually for 15 years beginning in 1998, which is the projected maximum duration of the engineered remedial actions, and every second year for the remaining 15 years of the 30-year period.

- The three proposed LTM wells located 1,000 feet downgradient from the 1996 plume front will be sampled every second year from the time of their installation (assumed to occur in year 2002) throughout the remainder of the 30-year LTM period ending in year 2028.

- A total of six additional LTM wells will be installed further downgradient during the 30-year LTM period to monitor plume migration. Three of the six wells will be installed in year 2012 and the remaining three wells will be installed in year 2022. The stratigraphy at each well location will be investigated prior to well installation as described in Section 7.2. Each of the newly-installed wells will be sampled every second year until year 2028, at which time the LTM program will be reevaluated and modified as necessary.

TABLE 7.1
LONG-TERM GROUNDWATER MONITORING ANALYTICAL PROTOCOL
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Analyte	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Ferrous Iron (Fe^{2+})	Colorimetric A3500-Fe D	Filter if turbid	May indicate an anaerobic degradation process due to the depletion of oxygen, nitrate, and manganese	Each sampling event	Collect 100 mL of water in a glass container; acidify with hydrochloric acid per method	Field
Ferrous Iron (Fe^{2+})	Colorimetric Hach 25140-25	Alternate method	Same as above.	Same as above	Collect 100 mL of water in a glass container	Field
Temperature	E170.1, direct-reading meter	Measure at well-head	Purging adequacy; metabolism rates for microorganisms depend on temperature	Each sampling event	Measure at well-head using a flow-through cell	Field
Dissolved Oxygen	Dissolved oxygen meter	Measure at well-head; refer to Method A4500 for a comparable laboratory procedure	Purging adequacy; concentrations less than 1 mg/L generally indicate an anaerobic pathway	Each sampling event	Measure at well-head using a flow-through cell	Field
pH	E150.1/SW9040, direct-reading meter	Measure at well-head	Purging adequacy; aerobic and anaerobic processes are pH-sensitive	Each sampling event	Measure at well-head using a flow-through cell	Field
Conductivity	E120.1/SW9050, direct-reading meter	Measure at well-head	General water quality parameter used as a marker to verify that site samples are obtained from the same groundwater system	Each sampling event	Collect 100–250 mL of water in a glass or plastic container	Field
Nitrate (NO_3^{-1})	IC method E300 or method SW9056; colorimetric, method E353.2	Method E300 is a Handbook[a/] method; method SW9056 is an equivalent procedure	Substrate for microbial respiration if oxygen is depleted	Each sampling event	Collect up to 40 mL of water in a glass or plastic container; cool to 4°C; analyze within 48 hours	Fixed-base

TABLE 7.1 (Concluded)
LONG-TERM GROUNDWATER MONITORING ANALYTICAL PROTOCOL
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Analyte	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Sulfate (SO_4^{2-})	IC method E300 or method SW9056 or Hach SulfaVer 4 method	Method E300 is a Handbook method; method SW9056 is an equivalent procedure. Hach method is Photometric	Substrate for anaerobic microbial respiration	Each sampling event	Collect up to 40 mL of water in a glass or plastic container; cool to 4°C	Fixed-base or field (for Hach method)
Oxidation-Reduction Potential (ORP)	A2580 B, direct-reading meter	Measurements are made with electrodes; results are displayed on a meter; samples should be protected from exposure to atmospheric oxygen	The redox potential of groundwater influences and is influenced by biologically mediated reactions; the redox potential of groundwater may range from more than 200 mV to less than -400 mV	Each sampling event	Measure at well-head using a flow-through cell	Field
Methane, Ethane, and Ethene	RSKSOP-114 modified to analyze water samples for methane by headspace sampling with dual thermal conductivity and flame ionization detection.	Method published and used by the USEPA Robert S. Kerr Laboratory	The presence of methane indicates the presence of sufficiently reducing conditons for reductive dehalogenation to occur	Each sampling event	Collect water samples in 40 mL volatile organic analysis (VOA) vials with butyl gray/Teflon-lined caps (zero headspace); cool to 4°C	Fixed-base
Volatile Organics	GC method SW8021B	Replaces Method SW8010B. Analytes could be limited to TCE, *cis*- and *trans*-1,2-DCE, and VC.	Measured for regulatory compliance	Each sampling event	Collect water samples in a 40 mL VOA vial; cool to 4°C; add hydrochloric acid to pH < 2	Fixed-base

a/ Handbook refers to "AFCEE Handbook to Support the Installation Restoration Program (IRP) Remedial Investigation / Feasibility Study (RI/FS)."

- Martin Spring will be sampled annually from 1998 to 2012, and every second year for the remainder of the 30-year period ending in 2028. Four additional surface water samples will be collected from potential downgradient surface discharge locations during each biennial sampling event beginning in year 2013 and ending in year 2028.

The LTM plan should be periodically reviewed and revised as appropriate on the basis of available groundwater quality data. For example, if the data collected during this time period indicate that the plume has stabilized or is receding, and that CAH concentrations are diminishing, then the sampling frequency can be reduced. If sampling results indicate that geochemical conditions in the plume area are stable over time (e.g., nitrate, sulfate, and ferrous iron concentrations), then the sampling frequency for these parameters could be reduced. If the data collected at any time during the monitoring period indicate the need for additional remedial activities at the site, sampling frequency should be adjusted accordingly.

7.6 LTM COST ESTIMATE

The estimated present worth cost for the LTM program described in the preceding sections is shown in Table 7.2. Included in the total present worth cost of $313,360 are the estimated costs for installing additional LTM wells, performing the recommended groundwater and surface water monitoring, maintaining institutional controls, public education, project management, and reporting.

TABLE 7.2
ESTIMATED LTM COSTS
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Capital Costs	**Present Worth Cost**
Design/construct two LTM wells in 1998	$11,220
Design/construct three LTM wells in 2002	$10,285
Design/construct three LTM wells in 2012	$5,228
Design/construct three LTM wells in 2022	$2,658
Monitoring Costs	**Present Worth Cost**
Conduct Annual Groundwater Monitoring of 16 Wells from 1998 to 2012, Biennial Monitoring of 3 Wells from 2002 to 2012, and Annual Monitoring of Martin Spring from 1998 to 2012	$167,045
Conduct Biennial Groundwater Monitoring of 22 Wells from 2012 to 2022, of 25 Wells from 2023 to 2028, and of 5 Surface Water Stations from 2013 to 2028	$42,470
Site Management (Maintain Institutional Controls/Public Education) (30 years)	$74,454
Total Present Worth of LTM Program [a/]	**$313,360**

a/ Based on an annual inflation (discount) factor of 7 percent (USEPA, 1993).

Note: Cost assume that well installation and LTM are performed by local (Salt Lake City area) personnel.

SECTION 8

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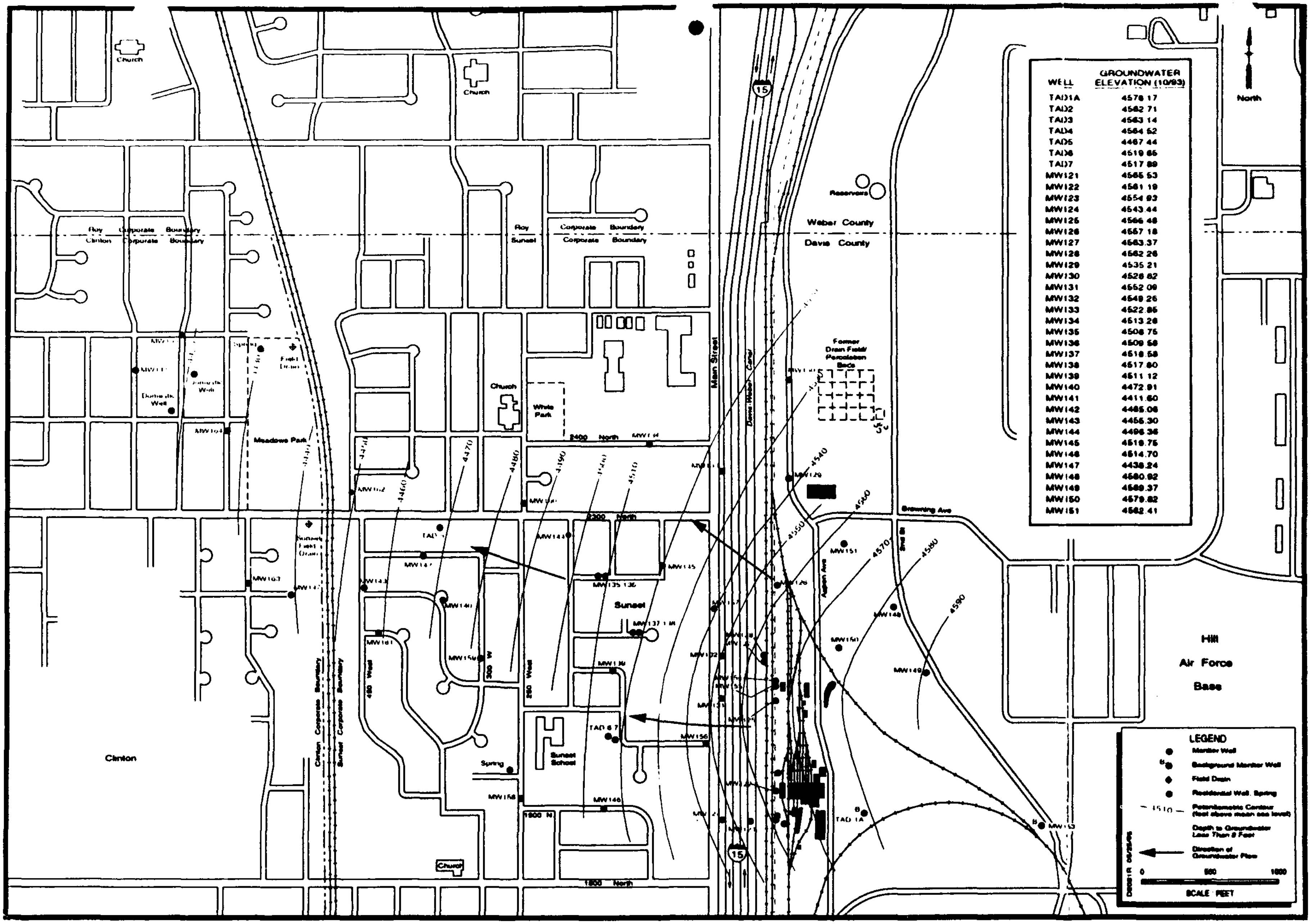
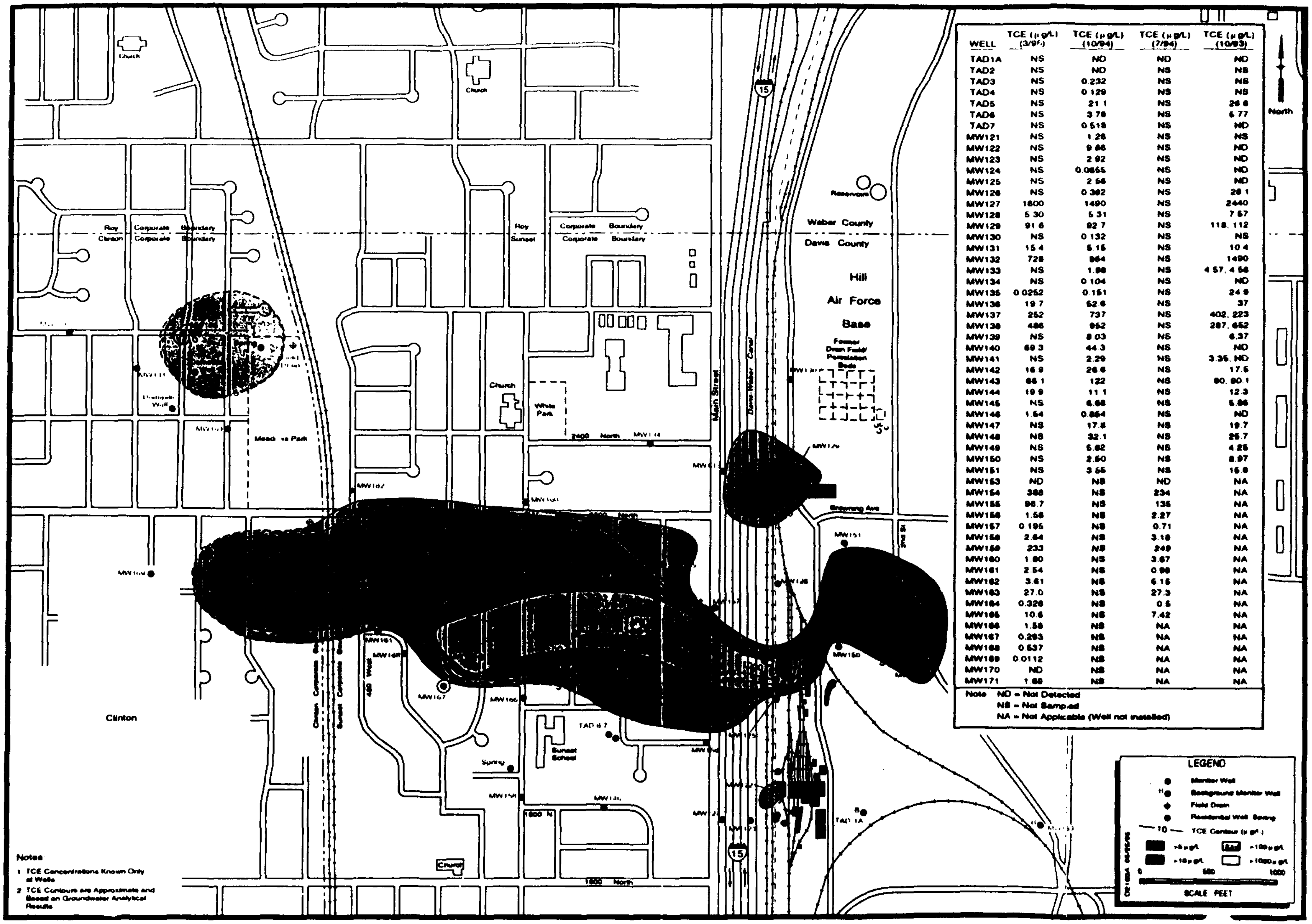
APPENDIX A

INFORMATION FROM PREVIOUS REPORTS PRODUCED BY RADIAN CORPORATION



WELL	GROUNDWATER ELEVATION (10/93)
TAD1A	4578.17
TAD2	4582.71
TAD3	4583.14
TAD4	4584.52
TAD5	4467.44
TAD6	4519.85
TAD7	4517.89
MW121	4565.53
MW122	4561.19
MW123	4554.93
MW124	4543.44
MW125	4566.48
MW126	4567.18
MW127	4583.37
MW128	4582.28
MW129	4535.21
MW130	4528.82
MW131	4552.09
MW132	4549.26
MW133	4522.85
MW134	4513.28
MW135	4508.75
MW136	4509.58
MW137	4518.58
MW138	4517.80
MW139	4511.12
MW140	4472.91
MW141	4411.60
MW142	4485.06
MW143	4455.30
MW144	4496.36
MW145	4519.75
MW146	4514.70
MW147	4438.24
MW148	4580.92
MW149	4589.37
MW150	4579.82
MW151	4582.41

Figure 3-14. Potentiometric Surface Map of the Tooele Rail Shop and Off-Base Areas (October 1993)

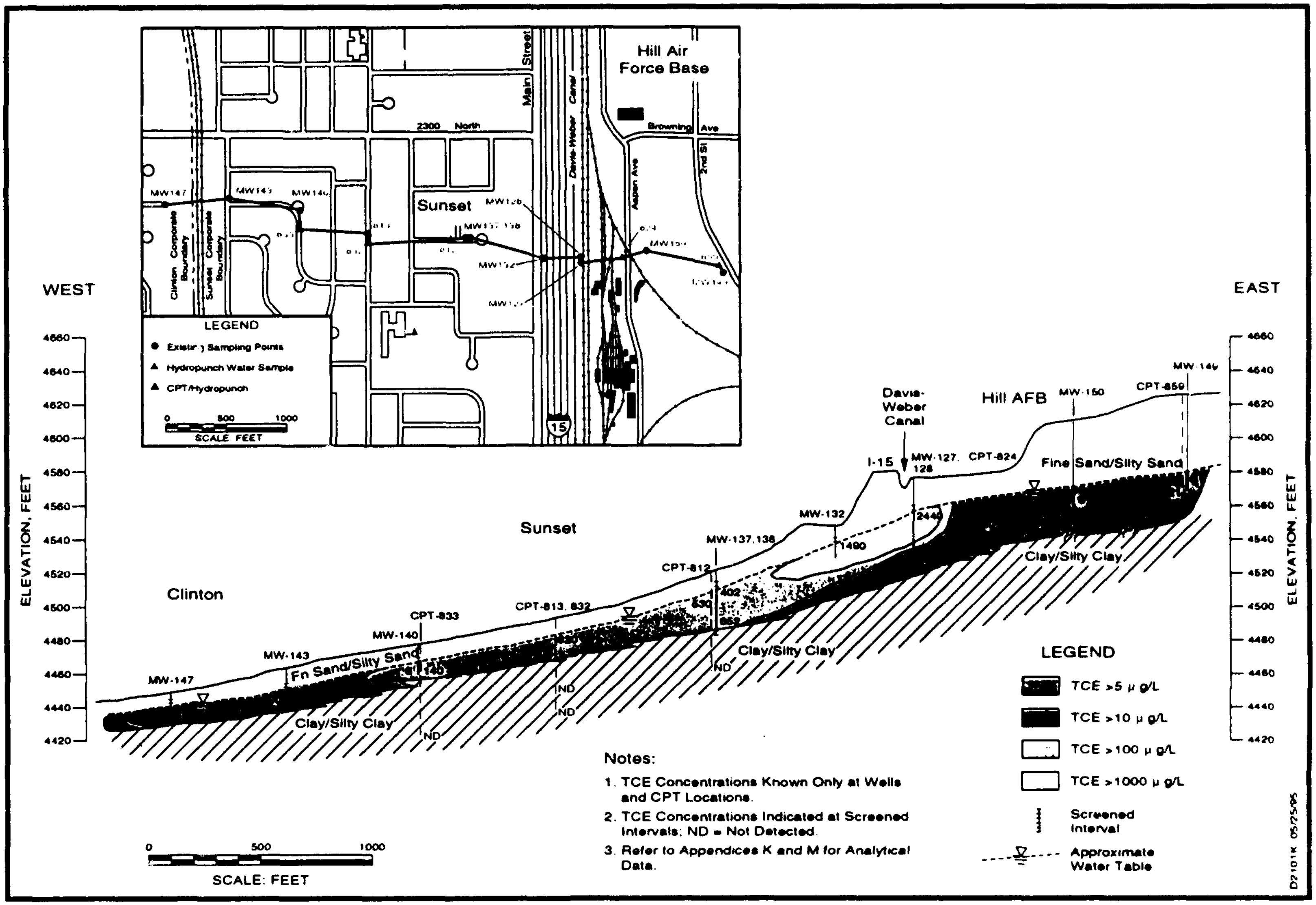


WELL	TCE (µg/L) (3/95)	TCE (µg/L) (10/94)	TCE (µg/L) (7/94)	TCE (µg/L) (10/93)
TAD1A	NS	ND	ND	ND
TAD2	NS	ND	NS	NS
TAD3	NS	0.232	NS	NS
TAD4	NS	0.129	NS	NS
TAD5	NS	21.1	NS	26.6
TAD6	NS	3.78	NS	6.77
TAD7	NS	0.518	NS	ND
MW121	NS	1.26	NS	NS
MW122	NS	9.86	NS	ND
MW123	NS	2.92	NS	ND
MW124	NS	0.0655	NS	ND
MW125	NS	2.66	NS	ND
MW126	NS	0.392	NS	28.1
MW127	1600	1490	NS	2440
MW128	5.30	5.31	NS	7.67
MW129	91.6	92.7	NS	118, 112
MW130	NS	0.132	NS	NS
MW131	15.4	5.16	NS	10.4
MW132	728	964	NS	1490
MW133	NS	1.98	NS	4.57, 4.58
MW134	NS	0.104	NS	ND
MW135	0.0252	0.151	NS	24.9
MW136	19.7	52.6	NS	37
MW137	252	737	NS	402, 223
MW138	486	952	NS	287, 652
MW139	NS	8.03	NS	6.37
MW140	69.3	44.3	NS	ND
MW141	NS	2.29	NS	3.35, ND
MW142	16.9	26.6	NS	17.5
MW143	66.1	122	NS	90, 90.1
MW144	19.9	11.1	NS	12.3
MW145	NS	6.68	NS	5.86
MW146	1.54	0.864	NS	ND
MW147	NS	17.8	NS	19.7
MW148	NS	32.1	NS	25.7
MW149	NS	5.62	NS	4.25
MW150	NS	2.50	NS	8.97
MW151	NS	3.56	NS	16.6
MW153	ND	NS	ND	NA
MW154	388	NS	234	NA
MW155	96.7	NS	136	NA
MW156	1.58	NS	2.27	NA
MW157	0.195	NS	0.71	NA
MW158	2.84	NS	3.18	NA
MW159	233	NS	249	NA
MW160	1.80	NS	3.67	NA
MW161	2.54	NS	0.98	NA
MW162	3.61	NS	6.15	NA
MW163	27.0	NS	27.3	NA
MW164	0.328	NS	0.5	NA
MW165	10.6	NS	7.42	NA
MW166	1.58	NS	NA	NA
MW167	0.293	NS	NA	NA
MW168	0.537	NS	NA	NA
MW169	0.0112	NS	NA	NA
MW170	ND	NS	NA	NA
MW171	1.69	NS	NA	NA

Note ND = Not Detected
NS = Not Sampled
NA = Not Applicable (Well not installed)

Notes
1 TCE Concentrations Known Only at Wells
2 TCE Contours are Approximate and Based on Groundwater Analytical Results

Figu Extent of TCE in Groundwater at the Tooele Rail Shop and Sunset/Clinton (March 1)
3.57

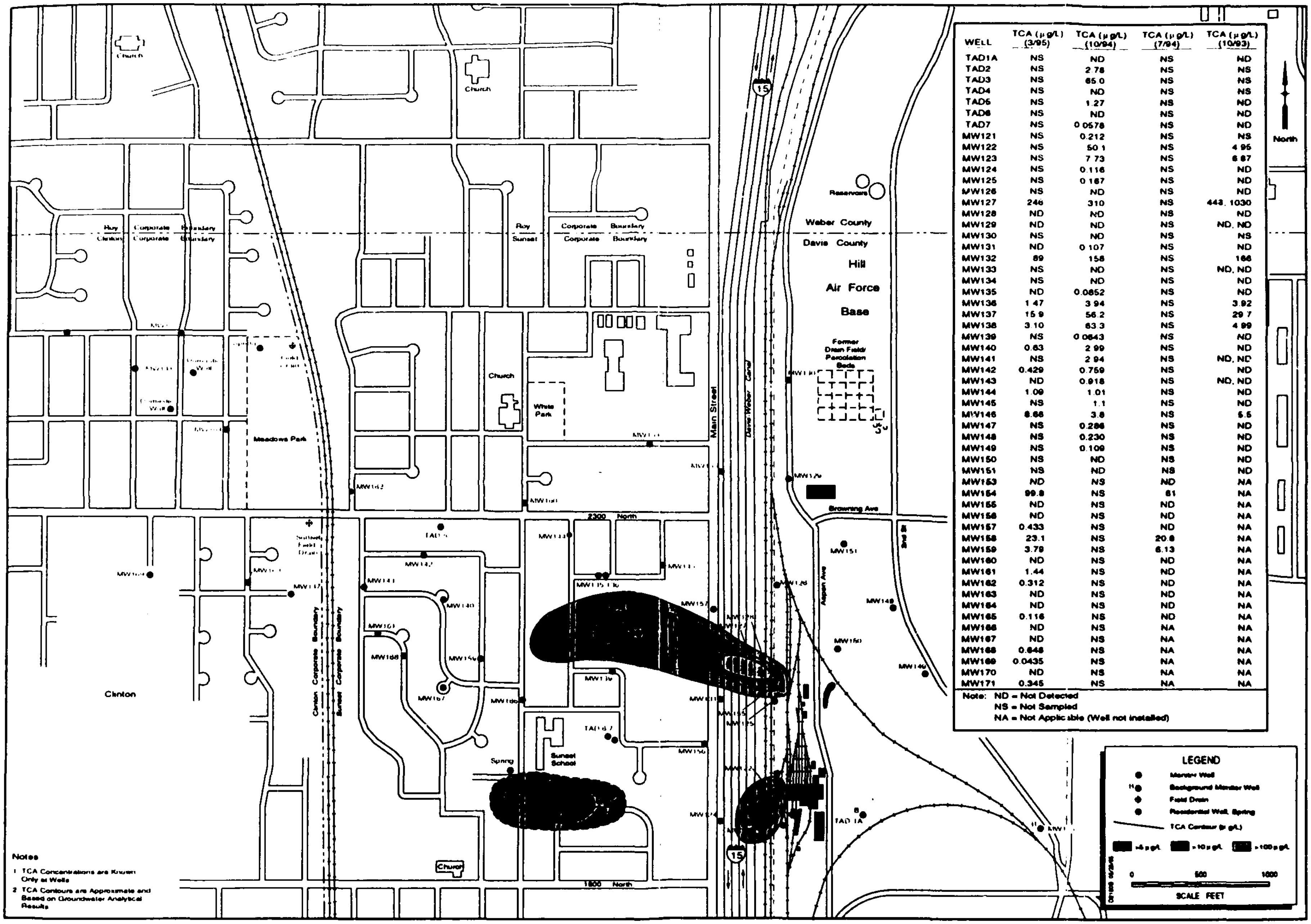


Notes:

1. TCE Concentrations Known Only at Wells and CPT Locations.
2. TCE Concentrations Indicated at Screened Intervals; ND = Not Detected.
3. Refer to Appendices K and M for Analytical Data.

Figure 3-23. Cross-Section of the TCE Plume in Groundwater, Tooele Rail Shop and Off-Base Areas

(March 1995)

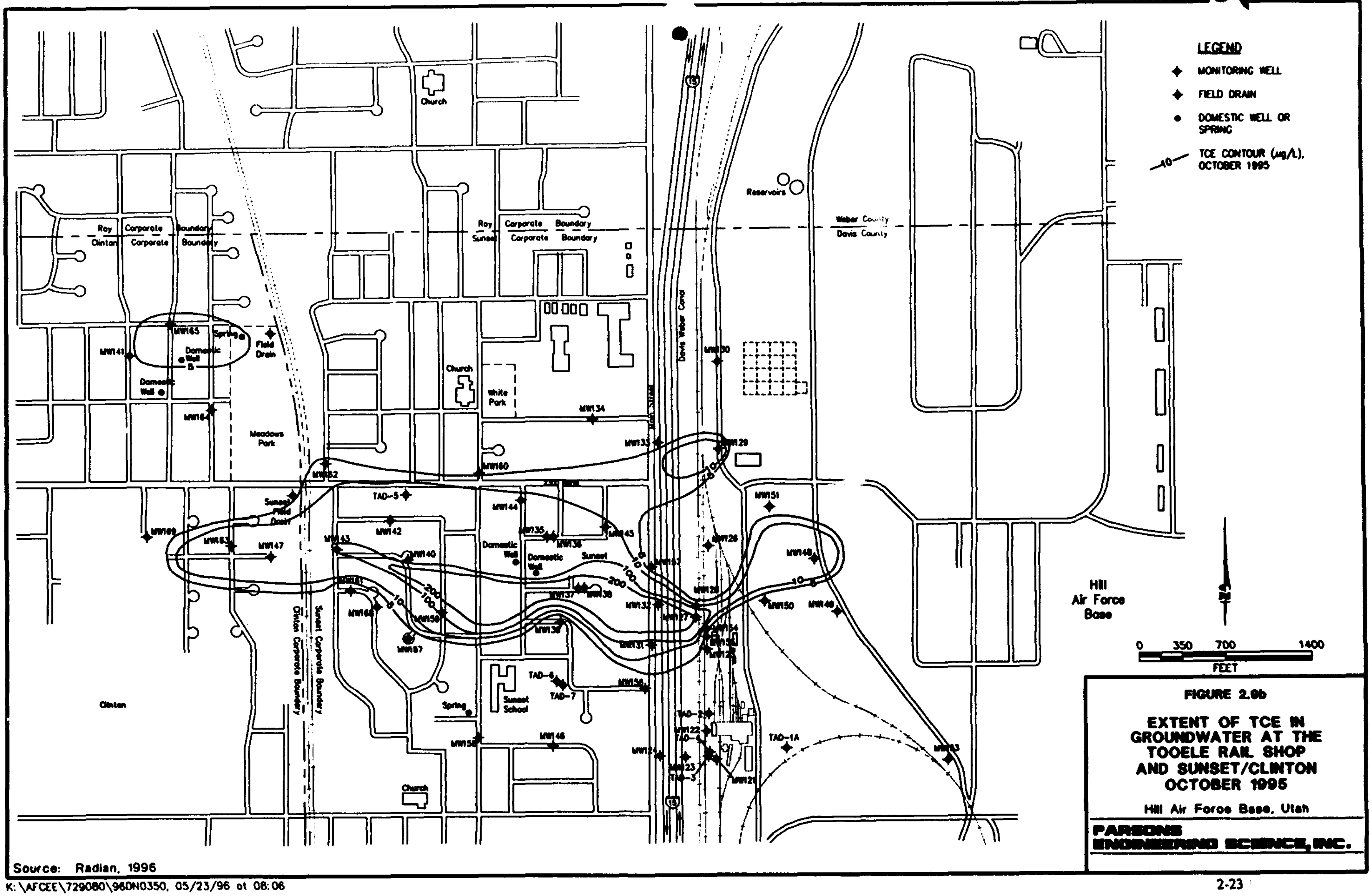


WELL	TCA (µ g/L) (3/95)	TCA (µ g/L) (10/94)	TCA (µ g/L) (7/94)	TCA (µ g/L) (10/93)
TAD1A	NS	ND	NS	ND
TAD2	NS	2.78	NS	NS
TAD3	NS	65.0	NS	NS
TAD4	NS	ND	NS	NS
TAD5	NS	1.27	NS	ND
TAD6	NS	ND	NS	ND
TAD7	NS	0.0578	NS	ND
MW121	NS	0.212	NS	NS
MW122	NS	50.1	NS	4.96
MW123	NS	7.73	NS	6.87
MW124	NS	0.116	NS	ND
MW125	NS	0.167	NS	ND
MW126	NS	ND	NS	ND
MW127	246	310	NS	443, 1030
MW128	ND	ND	NS	ND
MW129	ND	ND	NS	ND, ND
MW130	NS	ND	NS	NS
MW131	ND	0.107	NS	ND
MW132	89	158	NS	166
MW133	NS	ND	NS	ND, ND
MW134	NS	ND	NS	ND
MW135	ND	0.0852	NS	ND
MW136	1.47	3.94	NS	3.92
MW137	15.9	56.2	NS	29.7
MW138	3.10	63.3	NS	4.99
MW139	NS	0.0643	NS	ND
MW140	0.63	2.99	NS	ND
MW141	NS	2.94	NS	ND, ND
MW142	0.429	0.759	NS	ND
MW143	ND	0.918	NS	ND, ND
MW144	1.09	1.01	NS	ND
MW145	NS	1.1	NS	ND
MW146	8.66	3.8	NS	6.5
MW147	NS	0.286	NS	ND
MW148	NS	0.230	NS	ND
MW149	NS	0.109	NS	ND
MW150	NS	ND	NS	ND
MW151	NS	ND	NS	ND
MW153	ND	NS	ND	NA
MW154	99.8	NS	61	NA
MW155	ND	NS	ND	NA
MW156	ND	NS	ND	NA
MW157	0.433	NS	ND	NA
MW158	23.1	NS	20.8	NA
MW159	3.79	NS	6.13	NA
MW160	ND	NS	ND	NA
MW161	1.44	NS	ND	NA
MW162	0.312	NS	ND	NA
MW163	ND	NS	ND	NA
MW164	ND	NS	ND	NA
MW165	0.116	NS	ND	NA
MW166	ND	NS	NA	NA
MW167	ND	NS	NA	NA
MW168	0.648	NS	NA	NA
MW169	0.0435	NS	NA	NA
MW170	ND	NS	NA	NA
MW171	0.345	NS	NA	NA

Note: ND = Not Detected
NS = Not Sampled
NA = Not Applicable (Well not installed)

Notes
1 TCA Concentrations are Known Only at Wells
2 TCA Contours are Approximate and Based on Groundwater Analytical Results

re 3-22. Extent of TCA at the Tooele Rail Shop and Sunset/Clinton (March 1995)



Source: Radian, 1996

FIGURE 2.9b

EXTENT OF TCE IN GROUNDWATER AT THE TOOELE RAIL SHOP AND SUNSET/CLINTON OCTOBER 1995

Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.

K:\AFCEE\729080\96DN0350, 05/23/96 at 08:06

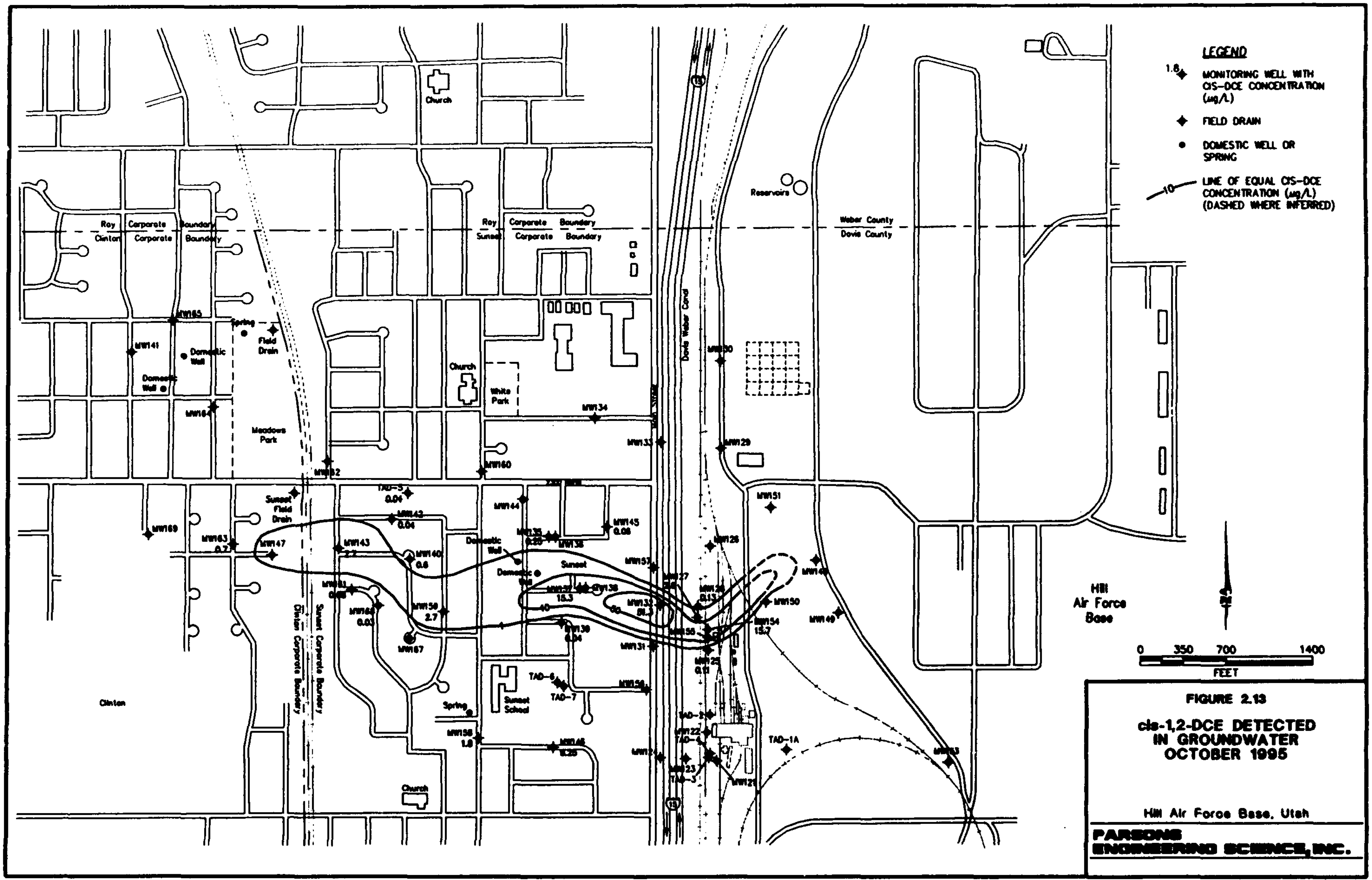


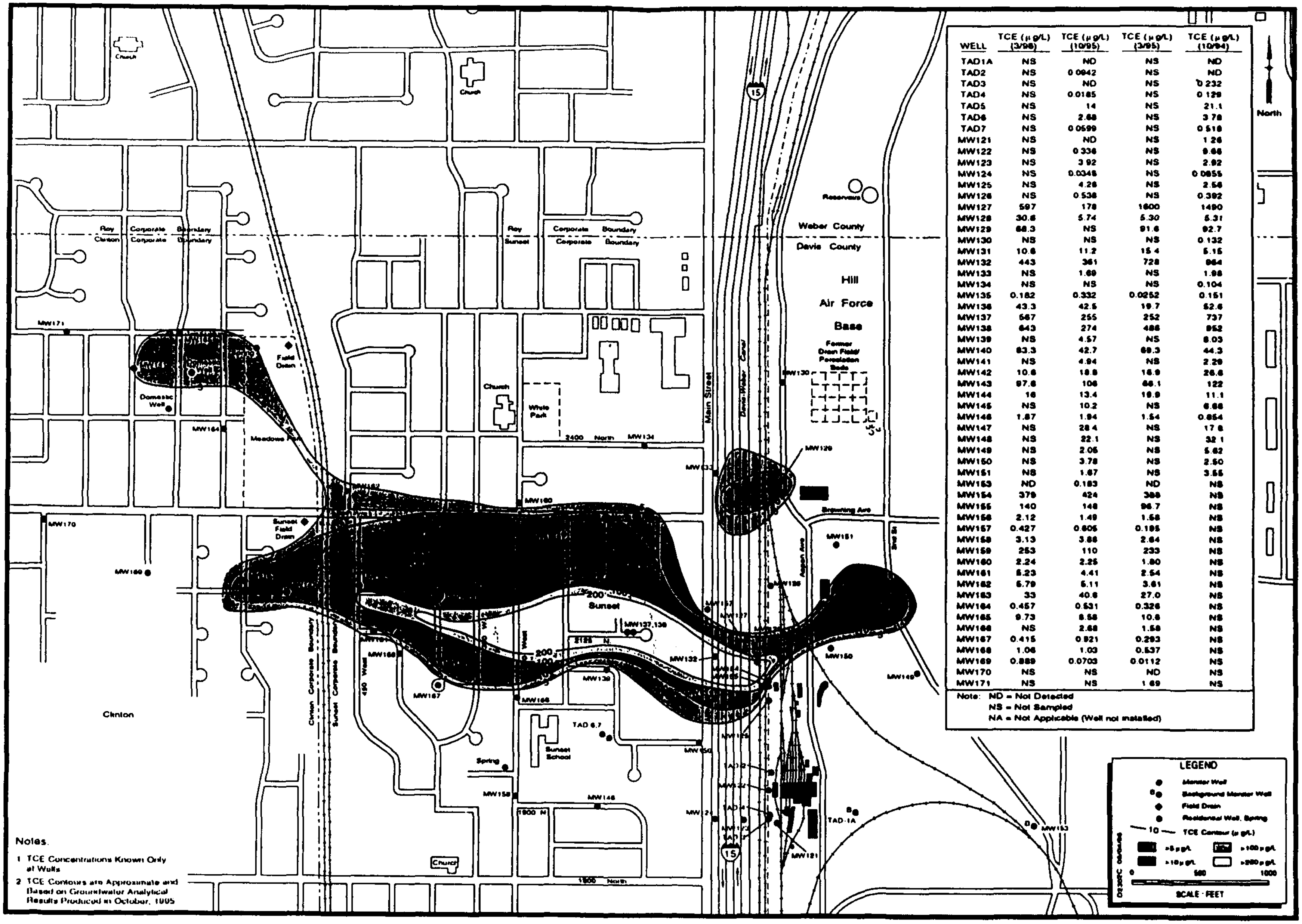
FIGURE 2.13

cis-1,2-DCE DETECTED IN GROUNDWATER OCTOBER 1995

Hill Air Force Base, Utah

PARSONS ENGINEERING SCIENCE, INC.

K:\AFCEE\729080\96DN0298, 05/23/96 at 12:19

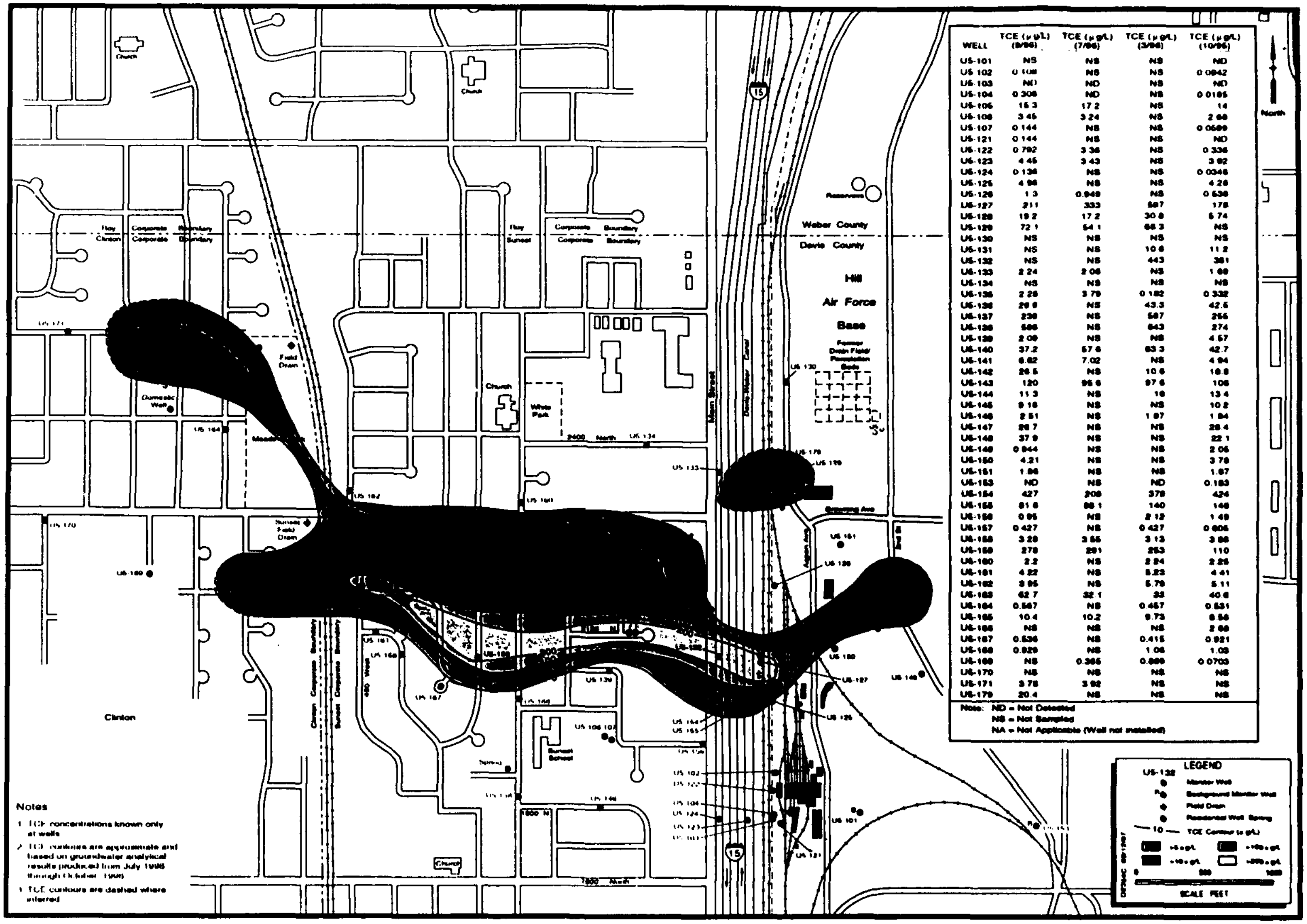


WELL	TCE (μ g/L) (3/96)	TCE (μ g/L) (10/95)	TCE (μ g/L) (3/95)	TCE (μ g/L) (10/94)
TAD1A	NS	ND	NS	ND
TAD2	NS	0 0942	NS	ND
TAD3	NS	ND	NS	0 232
TAD4	NS	0.0185	NS	0 129
TAD5	NS	14	NS	21.1
TAD6	NS	2.68	NS	3 78
TAD7	NS	0 0599	NS	0 518
MW121	NS	ND	NS	1 26
MW122	NS	0 336	NS	9.66
MW123	NS	3 92	NS	2.92
MW124	NS	0.0346	NS	0 0855
MW125	NS	4.26	NS	2.56
MW126	NS	0.538	NS	0.392
MW127	597	178	1600	1490
MW128	30.6	5.74	5.30	6.31
MW129	68.3	NS	91.6	92.7
MW130	NS	NS	NS	0.132
MW131	10.6	11.2	15 4	5.15
MW132	443	361	728	964
MW133	NS	1.69	NS	1.98
MW134	NS	NS	NS	0.104
MW135	0.182	0.332	0.0252	0.151
MW136	43.3	42.5	19.7	52.6
MW137	567	255	252	737
MW138	643	274	486	952
MW139	NS	4.57	NS	8.03
MW140	83.3	42.7	69.3	44.3
MW141	NS	4.94	NS	2.29
MW142	10.6	18.8	16.9	26.6
MW143	97.6	106	66.1	122
MW144	16	13.4	18.9	11.1
MW145	NS	10.2	NS	6.66
MW146	1.87	1.94	1.54	0.854
MW147	NS	28 4	NS	17 6
MW148	NS	22.1	NS	32 1
MW149	NS	2.05	NS	5.62
MW150	NS	3.78	NS	2.50
MW151	NS	1.67	NS	3.55
MW153	ND	0.183	ND	NS
MW154	379	424	388	NS
MW155	140	146	96.7	NS
MW156	2.12	1.49	1.58	NS
MW157	0.427	0.605	0.195	NS
MW158	3.13	3.86	2.64	NS
MW159	253	110	233	NS
MW160	2.24	2.25	1.80	NS
MW161	5.23	4.41	2.54	NS
MW162	6.79	5.11	3.61	NS
MW163	33	40.6	27.0	NS
MW164	0.457	0.531	0.326	NS
MW165	9.73	8.56	10.6	NS
MW166	NS	2.68	1.58	NS
MW167	0.415	0.921	0.293	NS
MW168	1.06	1.03	0.537	NS
MW169	0.889	0.0703	0.0112	NS
MW170	NS	NS	ND	NS
MW171	NS	NS	1 69	NS

Note: ND = Not Detected
NS = Not Sampled
NA = Not Applicable (Well not installed)

Notes.
1 TCE Concentrations Known Only at Wells
2 TCE Contours are Approximate and Based on Groundwater Analytical Results Produced in October, 1995

Figure 3-4. Extent of TCE in Groundwater at the Tooele Rail Shop and Off-Base Areas (Spring 1996)



WELL	TCE (µ g/L) (8/96)	TCE (µ g/L) (7/96)	TCE (µ g/L) (3/96)	TCE (µ g/L) (10/95)
US-101	NS	NS	NS	ND
US-102	0.108	NS	NS	0.0942
US-103	ND	ND	NS	ND
US-104	0.308	ND	NS	0.0185
US-105	15.3	17.2	NS	14
US-106	3.45	3.24	NS	2.88
US-107	0.144	NS	NS	0.0589
US-121	0.144	NS	NS	ND
US-122	0.792	3.36	NS	0.336
US-123	4.45	3.43	NS	3.92
US-124	0.136	NS	NS	0.0346
US-125	4.96	NS	NS	4.28
US-126	1.3	0.949	NS	0.636
US-127	211	333	597	178
US-128	19.2	17.2	30.8	6.74
US-129	72.1	54.1	68.3	NS
US-130	NS	NS	NS	NS
US-131	NS	NS	10.6	11.2
US-132	NS	NS	443	381
US-133	2.24	2.06	NS	1.88
US-134	NS	NS	NS	NS
US-135	2.28	3.79	0.182	0.332
US-136	29.9	NS	43.3	42.5
US-137	239	NS	587	256
US-138	586	NS	843	274
US-139	2.09	NS	NS	4.57
US-140	37.2	57.8	63.3	42.7
US-141	6.82	7.02	NS	4.94
US-142	26.5	NS	10.6	18.8
US-143	120	95.6	97.6	106
US-144	11.3	NS	16	13.4
US-145	9.16	NS	NS	10.2
US-146	2.51	NS	1.97	1.84
US-147	26.7	NS	NS	28.4
US-148	37.9	NS	NS	22.1
US-149	0.844	NS	NS	2.06
US-150	4.21	NS	NS	3.78
US-151	1.86	NS	NS	1.87
US-153	ND	NS	ND	0.183
US-154	427	209	378	424
US-155	81.6	88.1	140	148
US-156	0.95	NS	2.12	1.49
US-157	0.427	NS	0.427	0.606
US-158	3.28	3.55	3.13	3.86
US-159	278	281	253	110
US-160	2.2	NS	2.24	2.25
US-161	4.22	NS	5.23	4.41
US-162	3.95	NS	5.78	5.11
US-163	62.7	32.1	33	40.6
US-164	0.567	NS	0.457	0.531
US-165	10.4	10.2	9.73	8.56
US-166	NS	NS	NS	2.88
US-167	0.536	NS	0.415	0.921
US-168	0.829	NS	1.06	1.08
US-169	NS	0.365	0.889	0.0703
US-170	NS	NS	NS	NS
US-171	3.78	3.92	NS	NS
US-179	20.4	NS	NS	NS

Note: ND = Not Detected
NS = Not Sampled
NA = Not Applicable (Well not installed)

Notes

1. TCE concentrations known only at wells
2. TCE contours are approximate and based on groundwater analytical results produced from July 1995 through October 1996
3. TCE contours are dashed where inferred

September 1996 TCE plume
Source: Radian, 1997

Table C-1
Summary of Volatile Organic Compounds Detected in Groundwater, Fall 1995 and Spring 1996
Operable Unit 5, Hill AFB

All Results Reported in μg/L

			TAD-1A		TAD-2		TAD-3		TAD-4		TAD-5	
Analyte (μg/L)	MCL (μg/L)	UGWQS (μg/L)	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996
Bromodichloromethane	100	100	ND	NA	0.134	NA	0.150	NA	ND	NA	ND	NA
Bromoform	100	100	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
Bromomethane	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
Carbon tetrachloride	5	5	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
Chlorobenzene	100	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
Chloroethane	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
2-Chloroethylvinylether	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
Chloroform	100	100	ND	NA	0.400	NA	1.70	NA	ND	NA	0.970	NA
Chloromethane	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
Dibromochloromethane	100	100	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
1,2-Dichlorobenzene	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
1,3-Dichlorobenzene	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
1,4-Dichlorobenzene	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
1,1-Dichloroethane	none	none	ND	NA	ND	NA	0.239	NA	ND	NA	ND	NA
1,2-Dichloroethane	5	5	ND	NA	ND	NA	ND	NA	ND	NA	0.0143 J	NA
1,1-Dichloroethene	7	none	ND	NA	ND	NA	0.0230 PJ	NA	ND	NA	ND	NA
cis-1,2-Dichloroethene	70	70	ND	NA	ND	NA	ND	NA	ND	NA	0.0393	NA
trans-1,2-Dichloroethene	100	100	ND	NA	ND	NA	ND	NA	ND	NA	0.0397 P	NA
1,2-Dichloropropane	5	5	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
cis-1,3-Dichloropropene	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
trans-1,3-Dichloropropene	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
Methylene chloride	none	none	0.0700 B	NA	0.0538 PB	NA	0.126 B	NA	0.118 B	NA	0.0398 PB	NA
1,1,2,2-Tetrachloroethane	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
Tetrachloroethene	5	5	ND	NA	ND	NA	ND	NA	ND	NA	0.887	NA
1,1,1-Trichloroethane	200	200	ND	NA	0.342	NA	4.03	NA	ND	NA	ND	NA
1,1,2-Trichloroethane	5	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
Trichloroethene	5	5	ND	NA	0.0942 B	NA	ND	NA	0.0185 BJ	NA	**14.0**	NA
Trichlorofluoromethane	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
Vinyl chloride	2	2	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA

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Table C-1
(Continued)

			TAD-6		TAD-7		MW-121		MW-122		MW-123	
Analyte	MCL (µg/L)	UGWQS (µg/L)	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996
Bromodichloromethane	100	100	ND	NA	ND	NA	0.311	NA	ND	NA	ND	NA
Bromoform	100	100	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
Bromomethane	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
Carbon tetrachloride	5	5	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
Chlorobenzene	100	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
Chloroethane	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
2-Chloroethylvinylether	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
Chloroform	100	100	1.53	NA	ND	NA	1.61	NA	0.709	NA	0.787	NA
Chloromethane	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
Dibromochloromethane	100	100	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
1,2-Dichlorobenzene	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
1,3-Dichlorobenzene	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
1,4-Dichlorobenzene	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
1,1-Dichloroethane	none	none	ND	NA	ND	NA	ND	NA	0.658	NA	7.39	NA
1,2-Dichloroethane	5	5	ND	NA	ND	NA	ND	NA	ND	NA	0.139	NA
1,1-Dichloroethene	7	none	ND	NA	ND	NA	ND	NA	0.304 P	NA	1.04 P	NA
cis-1,2-Dichloroethene	70	70	ND	NA	ND	NA	ND	NA	0.175	NA	2.49	NA
trans-1,2-Dichloroethene	100	100	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
1,2-Dichloropropane	5	5	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
cis-1,3-Dichloropropene	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
trans-1,3-Dichloropropene	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
Methylene chloride	none	none	0.0695 B	NA	0.185 B	NA	0.156 B	NA	0.0949 PB	NA	0.127 B	NA
1,1,2,2-Tetrachloroethane	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
Tetrachloroethene	5	5	ND	NA	ND	NA	ND	NA	0.556	NA	0.242 B	NA
1,1,1-Trichloroethane	200	200	ND	NA	ND	NA	0.0421 PJ	NA	15.0	NA	24.4	NA
1,1,2-Trichloroethane	5	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
Trichloroethene	5	5	2.68	NA	ND	NA	ND	NA	0.336 B	NA	3.92 B	NA
Trichlorofluoromethane	none	none	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA
Vinyl chloride	2	2	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA

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Table C-1
(Continued)

			MW-124		MW-125		MW-126		MW-127		MW-128	
Analyte	MCL (µg/L)	UGWQS (µg/L)	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996
Bromodichloromethane	100	100	ND	NA	ND	NA	0.223	NA	ND	ND	ND	ND
Bromoform	100	100	ND	NA	ND	NA	ND	NA	ND	ND	ND	ND
Bromomethane	none	none	ND	NA	ND	NA	ND	NA	ND	ND	ND	ND
Carbon tetrachloride	5	5	ND	NA	ND	NA	0.0630	NA	ND	ND	ND	ND
Chlorobenzene	100	none	ND	NA	ND	NA	ND	NA	ND	ND	ND	ND
Chloroethane	none	none	ND	NA	ND	NA	ND	NA	ND	ND	ND	ND
2-Chloroethylvinylether	none	none	ND	NA	ND	NA	ND	NA	ND	ND	ND	ND
Chloroform	100	100	ND	NA	1.07	NA	4.12	NA	1.44 P	ND	ND	ND
Chloromethane	none	none	ND	NA	ND	NA	ND	NA	ND	ND	ND	ND
Dibromochloromethane	100	100	ND	NA	ND	NA	ND	NA	ND	ND	ND	ND
1,2-Dichlorobenzene	none	none	ND	NA	ND	NA	ND	NA	ND	ND	ND	ND
1,3-Dichlorobenzene	none	none	ND	NA	ND	NA	ND	NA	ND	ND	ND	ND
1,4-Dichlorobenzene	none	none	ND	NA	ND	NA	ND	NA	ND	ND	ND	ND
1,1-Dichloroethane	none	none	ND	NA	ND	NA	ND	NA	0.976	2.56	ND	ND
1,2-Dichloroethane	5	5	ND	NA	ND	NA	ND	NA	ND	ND	ND	ND
1,1-Dichloroethene	7	none	ND	NA	ND	NA	ND	NA	0.394 P	0.572 PJ	ND	ND
cis-1,2-Dichloroethene	70	70	ND	NA	0.1092	NA	ND	NA	2.5953	0.347 PJ	0.1296	0.522
trans-1,2-Dichloroethene	100	100	ND	NA	ND	NA	ND	NA	ND	ND	ND	ND
1,2-Dichloropropane	5	5	ND	NA	ND	NA	ND	NA	ND	ND	ND	ND
cis-1,3-Dichloropropene	none	none	ND	NA	ND	NA	ND	NA	ND	ND	ND	ND
trans-1,3-Dichloropropene	none	none	ND	NA	ND	NA	ND	NA	ND	ND	ND	ND
Methylene chloride	none	none	0.0339 B	NA	0.104 B	NA	0.0783 B	NA	0.552 B	2.39 PB	0.0620 B	0.150 PB
1,1,2,2-Tetrachloroethane	*none*	*none*	ND	NA	ND	NA	ND	NA	ND	ND	ND	ND
Tetrachloroethene	5	5	ND	NA	ND	NA	ND	NA	ND	ND	ND	ND
1,1,1-Trichloroethane	200	200	0.208	NA	0.174	NA	ND	NA	26.8	49.6	ND	ND
1,1,2-Trichloroethane	5	none	ND	NA	ND	NA	ND	NA	ND	ND	ND	ND
Trichloroethene	5	5	0.0346 BJ	NA	4.28	NA	0.538	NA	**178 B**	**597 B**	**5.74 B**	**30.8 B**
Trichlorofluoromethane	none	none	ND	NA	ND	NA	ND	NA	ND	ND	ND	ND
Vinyl chloride	2	2	ND	NA	ND	NA	ND	NA	ND	ND	ND	ND

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Table C-1
(Continued)

			MW-129		MW-131		MW-132		MW-133		MW-135	
Analyte	MCL (µg/L)	UGWQS (µg/L)	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996
Bromodichloromethane	100	100	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND
Bromoform	100	100	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND
Bromomethane	none	none	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND
Carbon tetrachloride	5	5	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND
Chlorobenzene	100	none	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND
Chloroethane	none	none	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND
2-Chloroethylvinylether	none	none	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND
Chloroform	100	100	NA	2.97	1.04	1.92	0.520 P	ND	ND	NA	ND	ND
Chloromethane	none	none	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND
Dibromochloromethane	100	100	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND
1,2-Dichlorobenzene	none	none	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND
1,3-Dichlorobenzene	none	none	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND
1,4-Dichlorobenzene	none	none	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND
1,1-Dichloroethane	none	none	NA	ND	ND	ND	8.37	4.49	ND	NA	ND	ND
1,2-Dichloroethane	5	5	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND
1,1-Dichloroethene	7	none	NA	ND	ND	ND	2.24	ND	ND	NA	ND	ND
cis-1,2-Dichloroethene	70	70	NA	ND	ND	ND	67.0178	26.2	ND	NA	ND	ND
trans-1,2-Dichloroethene	100	100	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND
1,2-Dichloropropane	5	5	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND
cis-1,3-Dichloropropene	none	none	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND
trans-1,3-Dichloropropene	none	none	NA	ND	ND	ND	ND	ND	ND	NA	ND	0.361 B
Methylene chloride	none	none	NA	0.329 PB	0.0220 B	0.0157 PBJ	1.08 B	9.71 PB	0.0807 B	NA	0.0678 B	ND
1,1,2,2-Tetrachloroethane	none	none	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND
Tetrachloroethene	5	5	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND
1,1,1-Trichloroethane	200	200	NA	ND	0.0367 PJ	0.0422 J	35.8	53.6	ND	NA	0.0540 J	ND
1,1,2-Trichloroethane	5	none	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND
Trichloroethene	5	5	NA	68.3 B	11.2	10.6	361	484	1.69	NA	0.332	0.182
Trichlorofluoromethane	none	none	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND
Vinyl chloride	2	2	NA	ND	ND	ND	ND	ND	ND	NA	ND	ND

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Tab[illegible]-1
(Continued)

			MW-136		MW-137		MW-138		MW-139		MW-140	
Analyte	MCL (µg/L)	UGWQS (µg/L)	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996
Bromodichloromethane	100	100	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
Bromoform	100	100	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
Bromomethane	none	none	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
Carbon tetrachloride	5	5	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
Chlorobenzene	100	none	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
Chloroethane	none	none	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
2-Chloroethylvinylether	none	none	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
Chloroform	100	100	0.875	2.08	ND	ND	ND	ND	0.545	NA	0.624	1.32
Chloromethane	none	none	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
Dibromochloromethane	100	100	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
1,2-Dichlorobenzene	none	none	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
1,3-Dichlorobenzene	none	none	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
1,4-Dichlorobenzene	none	none	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
1,1-Dichloroethane	none	none	0.0775	ND	1.89	3.62	ND	ND	ND	NA	0.0813	0.190
1,2-Dichloroethane	5	5	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
1,1-Dichloroethene	7	none	0.522	0.262 P	ND	ND	ND	ND	ND	NA	0.141	ND
cis-1,2-Dichloroethene	70	70	0.2112	0.139	22.8243	21.4	1.3326	0.455 J	0.0383	NA	0.5663	1.21
trans-1,2-Dichloroethene	100	100	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
1,2-Dichloropropane	5	5	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
cis-1,3-Dichloropropene	none	none	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
trans-1,3-Dichloropropene	none	none	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
Methylene chloride	none	none	0.0979 B	0.839 PB	1.12 B	2.52 B	2.09 PB	ND	0.130 B	NA	0.216 PB	0.760 B
1,1,2,2-Tetrachloroethane	none	none	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
Tetrachloroethene	5	5	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
1,1,1-Trichloroethane	200	200	3.44	3.66	18.5	43.3	1.44 J	5.61	ND	NA	0.755	1.00
1,1,2-Trichloroethane	5	none	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
Trichloroethene	5	5	42.5	43.3	255	567	274	643	4.57	NA	42.7 B	83.3
Trichlorofluoromethane	none	none	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND
Vinyl chloride	2	2	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND

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Table C-1
(Continued)

			MW-141		MW-142		MW-143		MW-144		MW-145	
Analyte	MCL (µg/L)	UGWQS (µg/L)	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996
Bromodichloromethane	100	100	ND	NA	ND	ND	ND	ND	ND	ND	ND	NA
Bromoform	100	100	ND	NA	ND	ND	ND	ND	ND	ND	ND	NA
Bromomethane	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	NA
Carbon tetrachloride	5	5	ND	NA	ND	ND	ND	ND	ND	ND	ND	NA
Chlorobenzene	100	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	NA
Chloroethane	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	NA
2-Chloroethylvinylether	none	none	ND	NA	ND	ND	3.40	ND	ND	ND	ND	NA
Chloroform	100	100	ND	NA	0.575	0.567	ND	2.88	1.03	1.21	0.751	NA
Chloromethane	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	NA
Dibromochloromethane	100	100	ND	NA	ND	ND	ND	ND	ND	ND	ND	NA
1,2-Dichlorobenzene	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	NA
1,3-Dichlorobenzene	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	NA
1,4-Dichlorobenzene	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	NA
1,1-Dichloroethane	none	none	ND	NA	0.0383 J	ND	ND	ND	ND	ND	ND	NA
1,2-Dichloroethane	5	5	ND	NA	ND	ND	ND	ND	ND	ND	ND	NA
1,1-Dichloroethene	7	none	ND	NA	0.0623	ND	ND	ND	0.0661	ND	ND	NA
cis-1,2-Dichloroethene	70	70	ND	NA	0.0439	ND	2.75	2.19	ND	ND	0.0616	NA
trans-1,2-Dichloroethene	100	100	ND	NA	ND	ND	ND	ND	ND	ND	0.0521	NA
1,2-Dichloropropane	5	5	ND	NA	ND	ND	ND	ND	ND	ND	ND	NA
cis-1,3-Dichloropropene	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	NA
trans-1,3-Dichloropropene	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	NA
Methylene chloride	none	none	2.53 B	NA	0.344 B	0.343 PB	0.262 PB	1.74 PB	0.271 B	0.124 PB	0.170 B	NA
1,1,2,2-Tetrachloroethane	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	NA
Tetrachloroethene	5	5	**333**	NA	ND	ND	ND	ND	ND	ND	ND	NA
1,1,1-Trichloroethane	200	200	ND	NA	0.779	0.377	0.349	0.521	0.917	1.09	1.19	NA
1,1,2-Trichloroethane	5	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	NA
Trichloroethene	5	5	4.94 B	NA	**18.8 B**	**10.6**	**106**	**97.6**	**13.4**	**16.0**	**10.2**	NA
Trichlorofluoromethane	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	NA
Vinyl chloride	2	2	ND	NA	ND	ND	ND	ND	ND	ND	ND	NA

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Table C-1
(Continued)

			MW-146		MW-147		MW-148		MW-149		MW-150	
Analyte	MCL (µg/L)	UGWQS (µg/L)	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996
Bromodichloromethane	100	100	ND	ND	ND	NA	ND	NA	ND	NA	0.757	NA
Bromoform	100	100	ND	ND	ND	NA	ND	NA	ND	NA	ND	NA
Bromomethane	none	none	ND	ND	ND	NA	ND	NA	ND	NA	ND	NA
Carbon tetrachloride	5	5	ND	ND	ND	NA	ND	NA	ND	NA	0.0441	NA
Chlorobenzene	100	none	ND	ND	ND	NA	ND	NA	ND	NA	ND	NA
Chloroethane	none	none	ND	ND	ND	NA	ND	NA	ND	NA	ND	NA
2-Chloroethylvinylether	none	none	ND	ND	ND	NA	ND	NA	ND	NA	ND	NA
Chloroform	100	100	0.661	0.794	0.727	NA	0.932	NA	ND	NA	3.99	NA
Chloromethane	none	none	ND	ND	ND	NA	ND	NA	ND	NA	ND	NA
Dibromochloromethane	100	100	ND	ND	ND	NA	ND	NA	ND	NA	0.155	NA
1,2-Dichlorobenzene	none	none	ND	ND	ND	NA	ND	NA	ND	NA	ND	NA
1,3-Dichlorobenzene	none	none	ND	ND	ND	NA	ND	NA	ND	NA	ND	NA
1,4-Dichlorobenzene	none	none	ND	ND	ND	NA	ND	NA	ND	NA	ND	NA
1,1-Dichloroethane	none	none	1.28	1.64	ND	NA	ND	NA	ND	NA	ND	NA
1,2-Dichloroethane	5	5	ND	ND	ND	NA	ND	NA	ND	NA	ND	NA
1,1-Dichloroethene	7	none	0.194	ND	ND	NA	ND	NA	ND	NA	ND	NA
cis-1,2-Dichloroethene	70	70	0.2528	0.346	0.6997	NA	ND	NA	ND	NA	ND	NA
trans-1,2-Dichloroethene	100	100	ND	ND	ND	NA	ND	NA	ND	NA	ND	NA
1,2-Dichloropropane	5	5	ND	ND	ND	NA	ND	NA	ND	NA	ND	NA
cis-1,3-Dichloropropene	none	none	ND	ND	ND	NA	ND	NA	ND	NA	ND	NA
trans-1,3-Dichloropropene	none	none	ND	ND	ND	NA	ND	NA	ND	NA	ND	NA
Methylene chloride	none	none	0.0618 PB	ND	0.0263 PB	NA	0.155 B	NA	0.0518 B	NA	0.0806 B	NA
1,1,2,2-Tetrachloroethane	none	none	ND	ND	ND	NA	ND	NA	ND	NA	ND	NA
Tetrachloroethene	5	5	0.543	0.418	ND	NA	ND	NA	ND	NA	ND	NA
1,1,1-Trichloroethane	200	200	5.16	5.96	0.0856	NA	ND	NA	ND	NA	ND	NA
1,1,2-Trichloroethane	5	none	ND	ND	ND	NA	ND	NA	ND	NA	ND	NA
Trichloroethene	5	5	1.94 B	1.87	**28.4**	NA	**22.1**	NA	2.05	NA	3.78 B	NA
Trichlorofluoromethane	none	none	ND	ND	ND	NA	ND	NA	ND	NA	ND	NA
Vinyl chloride	2	2	ND	ND	ND	NA	ND	NA	ND	NA	ND	NA

MCL - Maximum Contaminant Level (UAC R309)

UGWQS - Utah Groundwater Quality Standard (UAC R317-6)

Numbers shown in bold exceed MCL or UGWQS

ND - Not Detected

NA - Not Analyzed

B - Analyte detected in method blank at concentration greater than Reporting Limit (and greater than zero).

J - Result is less than stated Detection Limit but greater than or equal to specified Reporting Limit.

P - Analyte not confirmed. Results from primary and secondary GC columns differ by greater than a factor of 3.

Table C-1
(Continued)

			MW-151		MW-152		MW-153		MW-154		MW-155	
Analyte	MCL (μg/L)	UGWQS (μg/L)	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996
Bromodichloromethane	100	100	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	100	100	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	5	5	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	100	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
2-Chloroethylvinylether	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	100	100	0.0906	NA	0.0342	ND	0.0281 J	ND	ND	ND	0.979	3.44
Chloromethane	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	100	100	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	none	none	ND	NA	ND	ND	ND	ND	3.47	2.31	ND	ND
1,2-Dichloroethane	5	5	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	7	none	ND	NA	ND	ND	ND	ND	2.32 P	ND	ND	ND
cis-1,2-Dichloroethene	70	70	ND	NA	ND	ND	ND	ND	14.536	35.2	0.2546	ND
trans-1,2-Dichloroethene	100	100	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	5	5	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	none	none	0.227 B	NA	0.0790 B	0.0121 BJ	0.0382 B	0.0254 B	3.00 B	5.02 B	0.487 PB	0.268 PB
1,1,2,2-Tetrachloroethane	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	5	5	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	200	200	ND	NA	ND	ND	0.0432 J	0.0658	91.0	66.3	ND	ND
1,1,2-Trichloroethane	5	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	5	5	1.67 B	NA	ND	0.0293 J	0.183	0.108	**424 B**	**379 B**	**146**	**140 B**
Trichlorofluoromethane	none	none	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl chloride	2	2	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND

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Numbers shown in bold exceed MCL or UGWQS
ND - Not Detected
NA - Not Analyzed
B - Analyte detected in method blank at concentration greater than Reporting Limit (and greater than zero).
J - Result is less than stated Detection Limit but greater than or equal to specified Reporting Limit.
P - Analyte not confirmed. Results from primary and secondary GC columns differ by greater than a factor of 3.

Table C-1
(Continued)

			MW-156		MW-157		MW-158		MW-159		MW-160	
Analyte	MCL (µg/L)	UGWQS (µg/L)	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996
Bromodichloromethane	100	100	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	100	100	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	5	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	100	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Chloroethylvinylether	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	100	100	1.97	2.14	0.694	0.703	2.08	4.15	2.27	4.63	0.827	3.92
Chloromethane	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	100	100	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	none	none	ND	ND	ND	ND	2.29	2.09	ND	ND	ND	ND
1,2-Dichloroethane	5	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	7	none	ND	ND	ND	ND	1.71	0.942	0.534	0.308 P	ND	ND
cis-1,2-Dichloroethene	70	70	ND	ND	ND	ND	1.8315	1.36	2.7117	2.79	ND	ND
trans-1,2-Dichloroethene	100	100	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	5	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	none	none	0.0816 B	0.0483 PB	0.199 PB	0.0292 PB	0.0965 B	1.15 B	0.720 B	3.43 PB	0.911 PB	0.310 PB
1,1,2,2-Tetrachloroethane	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	5	5	ND	ND	ND	ND	0.0273 J	0.0907	ND	ND	ND	ND
1,1,1-Trichloroethane	200	200	ND	ND	0.615	0.454	18.0	15.0	2.71	5.18	0.0623	0.0541 PJ
1,1,2-Trichloroethane	5	none	ND	ND	ND	ND	0.0301 J	ND	ND	ND	ND	ND
Trichloroethene	5	5	1.49	2.12	0.605 B	0.427	3.86	3.13	110 B	253	2.25	2.24
Trichlorofluoromethane	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl chloride	2	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

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Table C-1
(Continued)

			MW-161		MW-162		MW-163		MW-164		MW-165	
Analyte	MCL (µg/L)	UGWQS (µg/L)	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996
Bromodichloromethane	100	100	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	100	100	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	5	5	ND	ND	ND	ND	ND	ND	ND	ND	5.62	5.25
Chlorobenzene	100	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Chloroethylvinylether	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	100	100	0.719	0.896	1.35	1.26	0.661	0.617	1.14	1.18	3.09	3.87
Chloromethane	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	100	100	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	none	none	0.174	0.196	ND	ND	0.0451	ND	ND	ND	ND	ND
1,2-Dichloroethane	5	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	7	none	0.296	0.0943 P	ND	ND	0.0428	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	70	70	0.0787	0.0746	ND	ND	0.6918	0.303	ND	ND	ND	ND
trans-1,2-Dichloroethene	100	100	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	5	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	none	none	0.110 B	0.379 PB	0.0466 B	0.341 PB	0.0557 B	0.332 PB	0.0420 PB	0.726 B	0.0356 PB	0.433 PB
1,1,2,2-Tetrachloroethane	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	5	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	200	200	1.91	1.56	0.357	0.321	0.0861	0.0628	0.0248 J	0.0304 J	0.0587 J	0.0748
1,1,2-Trichloroethane	5	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	5	5	4.41 B	5.23	5.11	5.79	40.6	33.0	0.531	0.457 B	8.58	9.73 B
Trichlorofluoromethane	none	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl chloride	2	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

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Table C-1
(Continued)

			MW-166		MW-167		MW-168		MW-169		Bowen Well	
Analyte	MCL (μg/L)	UGWQS (μg/L)	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996
Bromodichloromethane	100	100	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
Bromoform	100	100	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
Bromomethane	none	none	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
Carbon tetrachloride	5	5	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
Chlorobenzene	100	none	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
Chloroethane	none	none	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
2-Chloroethylvinylether	none	none	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
Chloroform	100	100	ND	NA	1.22	0.921	0.946	0.972	0.447	0.726	NA	0.0474
Chloromethane	none	none	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
Dibromochloromethane	100	100	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
1,2-Dichlorobenzene	none	none	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
1,3-Dichlorobenzene	none	none	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
1,4-Dichlorobenzene	none	none	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
1,1-Dichloroethane	none	none	ND	NA	ND	ND	0.234	0.177	ND	ND	NA	0.0669
1,2-Dichloroethane	5	5	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
1,1-Dichloroethene	7	none	ND	NA	ND	ND	0.0909	ND	ND	ND	NA	ND
cis-1,2-Dichloroethene	70	70	ND	NA	ND	ND	ND	0.0305	ND	ND	NA	0.298
trans-1,2-Dichloroethene	100	100	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
1,2-Dichloropropane	5	5	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
cis-1,3-Dichloropropene	none	none	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
trans-1,3-Dichloropropene	none	none	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
Methylene chloride	none	none	0.176 PB	NA	0.209 B	0.381 PB	0.197 B	0.341 PB	0.202 PB	0.411 PB	NA	0.165 B
1,1,2,2-Tetrachloroethane	none	none	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
Tetrachloroethene	5	5	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
1,1,1-Trichloroethane	200	200	ND	NA	0.108	0.0972	1.29	0.655	0.135	0.0655	NA	0.917
1,1,2-Trichloroethane	5	none	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
Trichloroethene	5	5	2.68	NA	0.921 B	0.415	1.03 B	1.06	0.0703 BJ	0.889 B	NA	6.45
Trichlorofluoromethane	none	none	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND
Vinyl chloride	2	2	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND

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Table C-1
(Continued)

			Omer Well		Chicado Well		Martin Spring		Sunset Drain		Martin Well	
Analyte	MCL (μg/L)	UGWQS (μg/L)	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996
Bromodichloromethane	100	100	NA	ND	ND	NA	ND	ND	ND	NA	ND	ND
Bromoform	100	100	NA	ND	ND	NA	ND	ND	ND	NA	ND	ND
Bromomethane	none	none	NA	ND	ND	NA	ND	ND	ND	NA	ND	ND
Carbon tetrachloride	5	5	NA	ND	ND	NA	ND	ND	ND	NA	ND	ND
Chlorobenzene	100	none	NA	ND	ND	NA	ND	ND	ND	NA	ND	ND
Chloroethane	none	none	NA	ND	ND	NA	ND	ND	ND	NA	ND	ND
2-Chloroethylvinylether	none	none	NA	ND	ND	NA	ND	ND	ND	NA	ND	ND
Chloroform	100	100	NA	ND	0.972	NA	1.11	0.858	ND	NA	1.46	1.83
Chloromethane	none	none	NA	ND	ND	NA	ND	ND	ND	NA	ND	ND
Dibromochloromethane	100	100	NA	ND	ND	NA	ND	ND	ND	NA	ND	ND
1,2-Dichlorobenzene	none	none	NA	ND	ND	NA	ND	ND	ND	NA	ND	ND
1,3-Dichlorobenzene	none	none	NA	ND	ND	NA	ND	ND	ND	NA	ND	ND
1,4-Dichlorobenzene	none	none	NA	ND	ND	NA	1.73	1.24	ND	NA	0.279	0.283
1,1-Dichloroethane	none	none	NA	ND	ND	NA	ND	ND	ND	NA	ND	ND
1,2-Dichloroethane	5	5	NA	ND	ND	NA	0.263	0.406	ND	NA	0.184	ND
1,1-Dichloroethene	7	none	NA	ND	0.0788	NA	3.2269	2.24	ND	NA	0.8014	1.1
cis-1,2-Dichloroethene	70	70	NA	ND	ND	NA	ND	ND	ND	NA	ND	ND
trans-1,2-Dichloroethene	100	100	NA	ND	ND	NA	*ND*	*ND*	*ND*	*NA*	*ND*	*ND*
1,2-Dichloropropane	5	5	NA	ND	ND	NA	ND	ND	ND	NA	ND	ND
cis-1,3-Dichloropropene	none	none	NA	ND	ND	NA	ND	ND	ND	NA	ND	ND
trans-1,3-Dichloropropene	none	none	NA	ND	ND	NA	ND	ND	ND	NA	ND	ND
Methylene chloride	none	none	NA	0.588B	*0.0744 PB*	NA	*0.0676 B*	ND	0.0353 B	NA	0.0437 B	0.316 B
1,1,2,2-Tetrachloroethane	none	none	NA	ND	ND	NA	ND	ND	ND	NA	ND	ND
Tetrachloroethene	5	5	NA	ND	ND	NA	0.112	0.108	ND	NA	ND	ND
1,1,1-Trichloroethane	200	200	NA	0.0794	1.39	NA	4.37	3.5	0.0545 J	NA	3.07	3.32
1,1,2-Trichloroethane	5	none	NA	ND	ND	NA	ND	ND	ND	NA	ND	ND
Trichloroethene	5	5	NA	6.92	1.05	NA	1.43	0.803	0.115	NA	40.8	30.2
Trichlorofluoromethane	none	none	NA	ND	ND	NA	ND	ND	ND	NA	ND	ND
Vinyl chloride	2	2	NA	ND	ND	NA	ND	ND	ND	NA	ND	ND

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Table C-1
(Continued)

			Meadow Park Spring		Meadow Park Drain		BAT-1A		BAT-2		BAT-3	
Analyte	MCL (µg/L)	UGWQS (µg/L)	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996	Fall 1995	Spring 1996
Bromodichloromethane	100	100	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
Bromoform	100	100	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
Bromomethane	none	none	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	5	5	2.56	NA	0.0648	NA	ND	ND	ND	ND	ND	ND
Chlorobenzene	100	none	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
Chloroethane	none	none	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
2-Chloroethylvinylether	none	none	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
Chloroform	100	100	2.77	NA	0.0488	NA	ND	ND	ND	ND	ND	ND
Chloromethane	none	none	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
Dibromochloromethane	100	100	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	none	none	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	none	none	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	none	none	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	none	none	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	5	5	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	7	none	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	70	70	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	100	100	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	5	5	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	none	none	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	none	none	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
Methylene chloride	none	none	0.0243 PB	NA	0.0531 B	NA	0.0445 B	0.0297 B	0.133 B	0.0230 B	0.256 B	0.0184 BJ
1,1,2,2-Tetrachloroethane	none	none	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
Tetrachloroethene	5	5	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	200	200	0.0404 J	NA	0.0169 J	NA	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	5	none	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
Trichloroethene	5	5	5.50	NA	0.0648	NA	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	none	none	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
Vinyl chloride	2	2	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND

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Table C-1
(Continued)

			BAT-4	
Analyte	MCL (μg/L)	UGWQS (μg/L)	Fall 1995	Spring 1996
Bromodichloromethane	100	100	ND	ND
Bromoform	100	100	ND	ND
Bromomethane	none	none	ND	ND
Carbon tetrachloride	5	5	ND	ND
Chlorobenzene	100	none	ND	ND
Chloroethane	none	none	ND	ND
2-Chloroethylvinylether	none	none	ND	ND
Chloroform	100	100	ND	ND
Chloromethane	none	none	ND	ND
Dibromochloromethane	100	100	ND	ND
1,2-Dichlorobenzene	none	none	ND	ND
1,3-Dichlorobenzene	none	none	ND	ND
1,4-Dichlorobenzene	none	none	ND	ND
1,1-Dichloroethane	none	none	ND	ND
1,2-Dichloroethane	5	5	ND	ND
1,1-Dichloroethene	7	none	ND	ND
cis-1,2-Dichloroethene	70	70	ND	ND
trans-1,2-Dichloroethene	100	100	ND	ND
1,2-Dichloropropane	5	5	ND	ND
cis-1,3-Dichloropropene	none	none	ND	ND
trans-1,3-Dichloropropene	none	none	ND	ND
Methylene chloride	none	none	0.105 B	0.193 B
1,1,2,2-Tetrachloroethane	none	none	ND	ND
Tetrachloroethene	5	5	ND	ND
1,1,1-Trichloroethane	200	200	ND	ND
1,1,2-Trichloroethane	5	none	ND	ND
Trichloroethene	5	5	0.771	ND
Trichlorofluoromethane	none	none	ND	ND
Vinyl chloride	2	2	ND	ND

MCL - Maximum Contaminant Level (UAC R309)
UGWQS - Utah Groundwater Quality Standard (UAC R317-6)
Numbers shown in bold exceed MCL or UGWQS
ND - Not Detected
NA - Not Analyzed
B - Analyte detected in method blank at concentration greater than Reporting Limit (and greater than zero).
J - Result is less than stated Detection Limit but greater than or equal to specified Reporting Limit.
P - Analyte not confirmed. Results from primary and secondary GC columns differ by greater than a factor of 3.

APPENDIX B

GEOLOGIC LOGS,
MONITORING POINT INSTALLATION RECORDS,
MONITORING POINT/WELL DEVELOPMENT AND
SAMPLING RECORDS, AND
SURVEY DATA

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

LOG OF BORING MP 1S

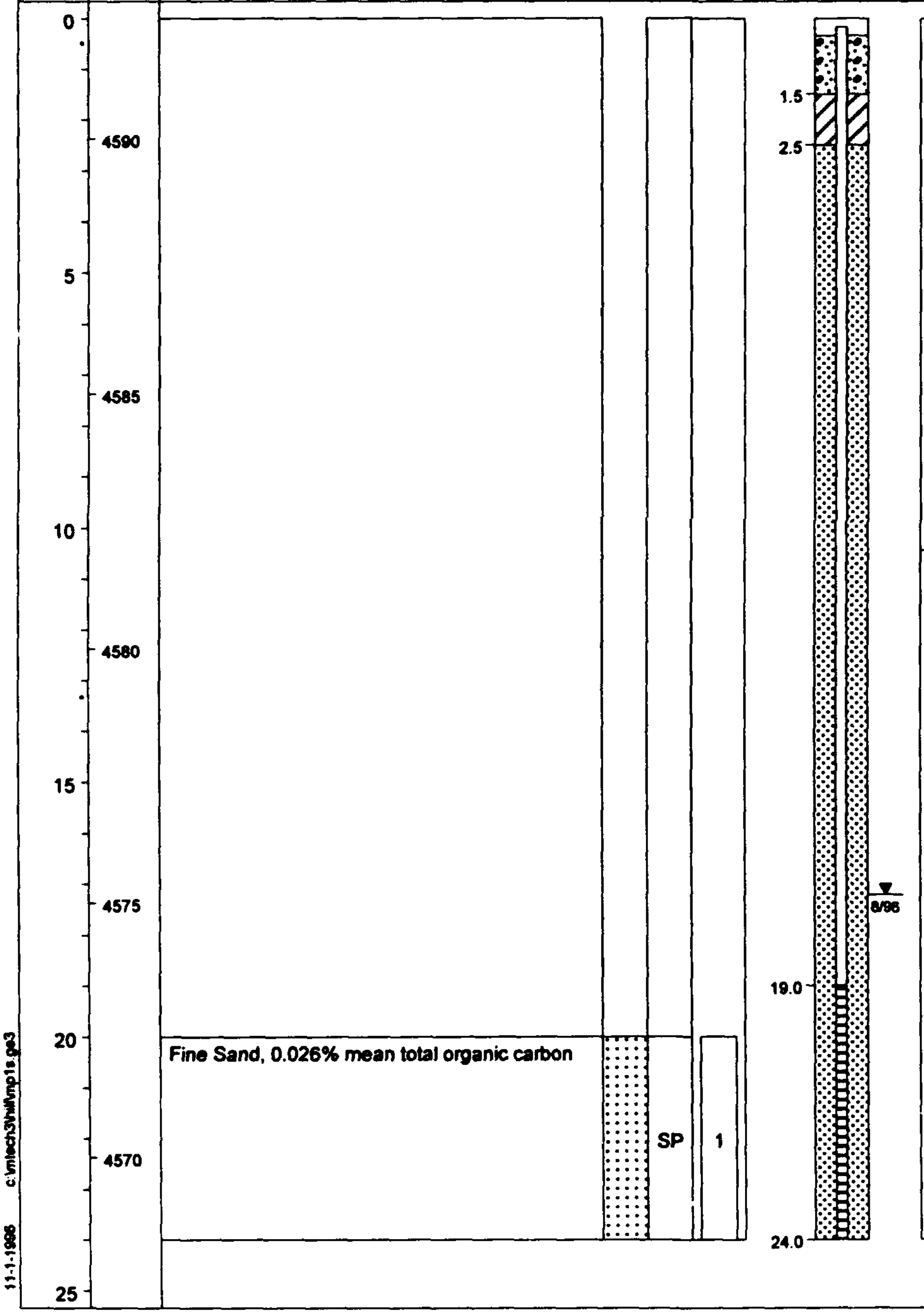
(Page 1 of 1)

Hill AFB
Operable Unit 5
RNA TS

Date Completed : 8/7/96
Drilling Method : Geoprobe
Sampling Method : Geoprobe
Company Rep. : R. Nagel
Drilling/Geoprobe Co : USEPA

Depth in feet	Surf. Elev. 4592.37	DESCRIPTION	GRAPHIC	USCS	Samples
20		Fine Sand, 0.026% mean total organic carbon	░	SP	1

MP 1
ELEV: 4592.37



Well Construction Information

Gr. Surface Elev. : 4592.37 ft msl
Top of PVC Elev. : 4592.06 ft msl
Surf. Completion : Flush mount
Borehole Diam. : 2 in

WELL CASING

Casing Material : PVC
PVC Diam. : 0.5 in
Joints : Threaded

WELL SCREEN

Screen Material : PVC
Screen Diameter : 0.5 in
Screen Openings : 0.010 in

MOUNTING : Concrete
: (0 to 1.5 ft bgs)
ANNULUS SEAL : Bentonite pellets
: (1.5 to 2.5 ft bgs)
FILTER PACK : 10-20 sand and nat. pack
: (2.5 to 24 ft bgs)

NOTES

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

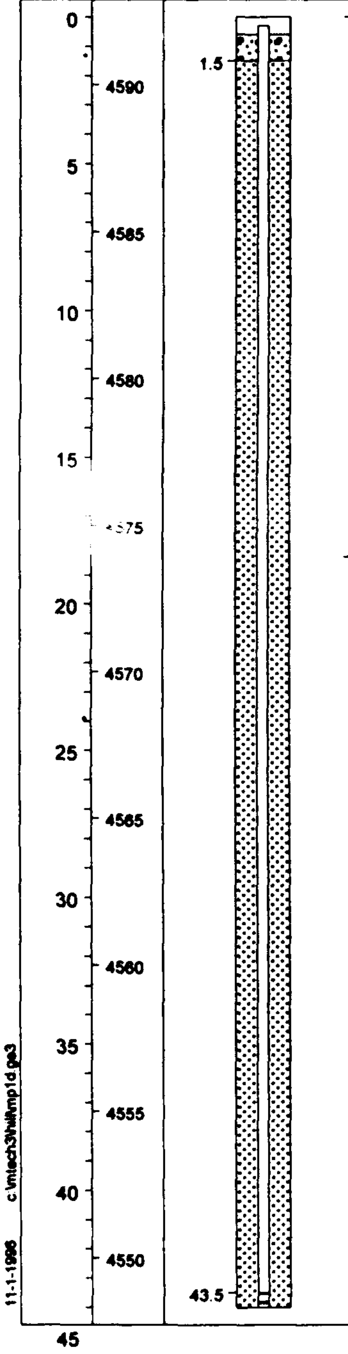
LOG OF BORING MP 1D

(Page 1 of 1)

Hill AFB
Operable Unit 5
RNA TS

Date Completed : 8/7/96
Drilling Method : Geoprobe
Sampling Method : Geoprobe
Company Rep. : R. Nagel
Drilling/Geoprobe Co : USEPA

Depth in feet	Surf. Elev. 4592.31	MP 1D ELEV: 4592.31	Well Construction Information



Gr. Surface Elev. : 4592.31 ft msl
Surf. Completion : Flush mount
Borehole Diam. : 2.0 in

WELL CASING

Casing Material : Teflon-lined : HDPE tubing
Tubing Diameter : 0.25 in

WELL SCREEN

Screen Material : Stainless Steel
Screen Diameter : 0.375 in
Screen Openings : 0.010 in

MOUNTING : Concrete : (0 to 1.5 ft bgs)
ANNULUS SEAL : Bentonite pellets : (8.7 to 12.7 ft bgs)
FILTER PACK : Natural sand pack : (1.5 to 8.7 ft bgs, : 12.7 to 44 ft bgs)

NOTES

The annulus seal is not shown on the diagram to the left. In actuality, it is located 7.2 feet below the concrete mounting in between the natural sand pack.

11-1-1996 c:\ntech3\hill\mp1d.ge3

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

LOG OF BORING MP 2S

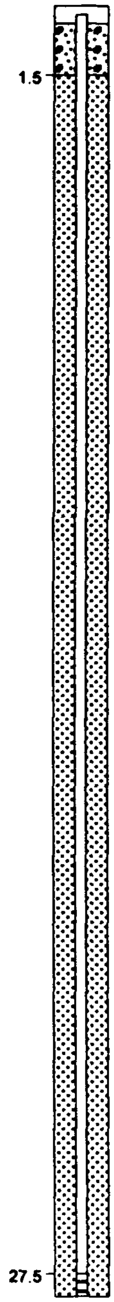
(Page 1 of 1)

Hill AFB
Operable Unit 5
RNA TS

Date Completed : 8/8/96
Drilling Method : Geoprobe
Sampling Method : Geoprobe
Company Rep. : R. Nagel
Drilling/Geoprobe Co : USEPA

Depth in feet	Surf. Elev. 4582.17	DESCRIPTION	GRAPHIC	USCS	Samples
0					
	4580				
5					
	4575				
10					
	4570				
15					
	4565				
20					
	4560				
25		Silty Sand to Fine Sand, 0.039% mean total organic carbon	▨	SM	1
	4555				

MP 2S
ELEV: 4582.17



Well Construction Information

Gr. Surface Elev. : 4582.17 ft msl
Surf. Completion : Flush mount
Borehole Diam. : 2.0 in

WELL CASING
Casing Material : Teflon-lined
: HDPE tubing
Tubing Diameter : 0.25 in

WELL SCREEN
Screen Material : Stainless Steel
Screen Diameter : 0.375 in
Screen Openings : 0.010 in

MOUNTING : Concrete
: (0 to 1.5 ft bgs)
FILTER PACK : Natural sand pack
: (1.5 to 28 ft bgs)

NOTES
There is no annulus seal in the borehole.

11-1-1996 c:\mtech3\hill\mp2s.ge3

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

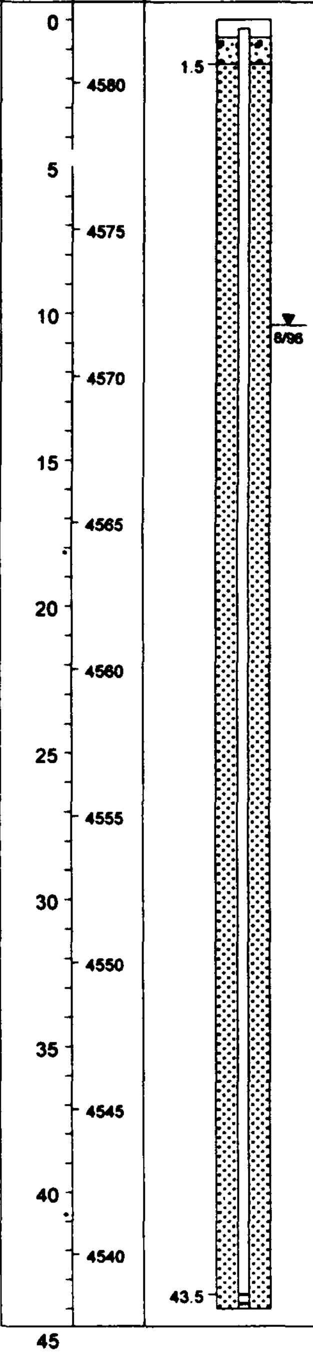
LOG OF BORING MP 2D

(Page 1 of 1)

Hill AFB
Operable Unit 5
RNA TS

Date Completed : 8/8/96
Drilling Method : Geoprobe
Sampling Method : Geoprobe
Company Rep. : R. Nagel
Drilling/Geoprobe Co : USEPA

Depth in feet	Surf. Elev. 4582.14	MP 2D ELEV: 4582.14	Well Construction Information



Gr. Surface Elev. : 4582.14 ft msl
Surf. Completion : Flush mount
Borehole Diam. : 2.0 in

WELL CASING
Casing Material : Teflon-lined
: HDPE tubing
Tubing Diameter : 0.25 in

WELL SCREEN
Screen Material : Stainless Steel
Screen Diameter : 0.375 in
Screen Openings : *0.010 in*

MOUNTING : Concrete
: (0 to 1.5 ft bgs)
FILTER PACK : Natural sand pack
: (1.5 to 44 ft bgs)

NOTES

There is no annulus seal in the borehole.

11-1-1996 c:\mtech3\hill\mp2d.gs3

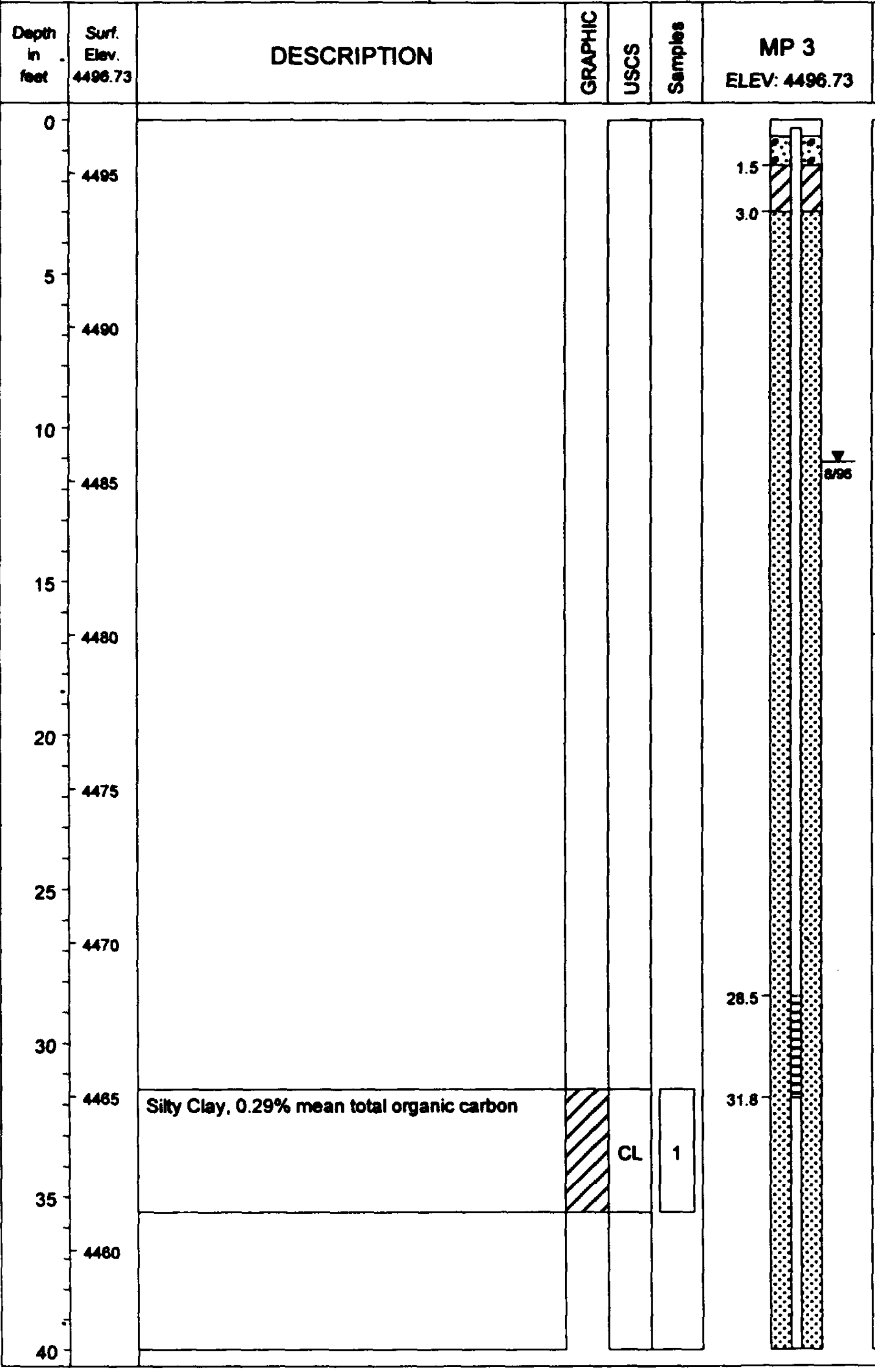
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

LOG OF BORING MP 3

(Page 1 of 1)

Hill AFB
Operable Unit 5
RNA TS

Date Completed : 8/10/96
Drilling Method : Geoprobe
Sampling Method : Geoprobe
Company Rep. : R. Nagel
Drilling/Geoprobe Co : USEPA



Silty Clay, 0.29% mean total organic carbon

Well Construction Information

Gr. Surface Elev. : 4496.73 ft msl
Top of PVC Elev. : 4496.37 ft msl
Surf. Completion : Flush mount
Borehole Diam. : 2 in

WELL CASING

Casing Material : PVC
PVC Diam. : 0.5 in
Joints : Threaded

WELL SCREEN

Screen Material : PVC
Screen Diameter : 0.5 in
Screen Openings : 0.010 in

MOUNTING : Concrete
: (0 to 1.5 ft bgs)
ANNULUS SEAL : Bentonite pellets
: (1.5 to 3 ft bgs)
FILTER PACK : 10-20 sand and nat. pack
: (3 to 40 ft bgs)

NOTES

11-1-1996 c:\mtech3\hill\mp3.ge3

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

LOG OF BORING MP 4

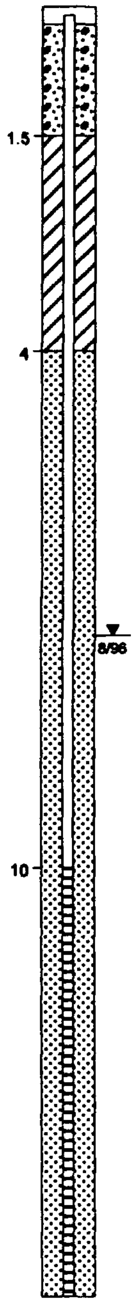
(Page 1 of 1)

Hill AFB
Operable Unit 5
RNA TS

Date Completed	: 8/9/96	Drilling/Geoprobe Co	: USEPA
Drilling Method	: Geoprobe		:
Sampling Method	: Geoprobe		:
Company Rep.	: R. Nagel		:

Depth in feet	Surf. Elev. 4445.09	DESCRIPTION	GRAPHIC	USCS	Samples
0	4445				
5	4440				
10	4435				
		Sandy, Clayey Silt 0.054% mean total organic carbon		ML	1
15					

MP 4
ELEV: 4445.09



Well Construction Information

Gr. Surface Elev. : 4445.09 ft msl
Top of PVC Elev. : 4444.92 ft msl
Surf. Completion : Flush Mount
Borehole Diam. : 2 in

WELL CASING
Casing Material : PVC
PVC Diam. : 0.5
Joints : Threaded

WELL SCREEN
Screen Material : PVC
Screen Diameter : 0.5 in
Screen Openings : 0.010 in

MOUNTING : Concrete
: (0 to 1.5 ft bgs)
ANNULUS SEAL : Bentonite pellets
: (1.5 to 4.0 ft bgs)
FILTER PACK : 10-20 sand and nat. pack
: (4 to 15 ft bgs)

NOTES

11-1-1996 c:\mtech3\hill\mp4.ge3

PARSONS
ENGINEERING SCIENCE, INC.
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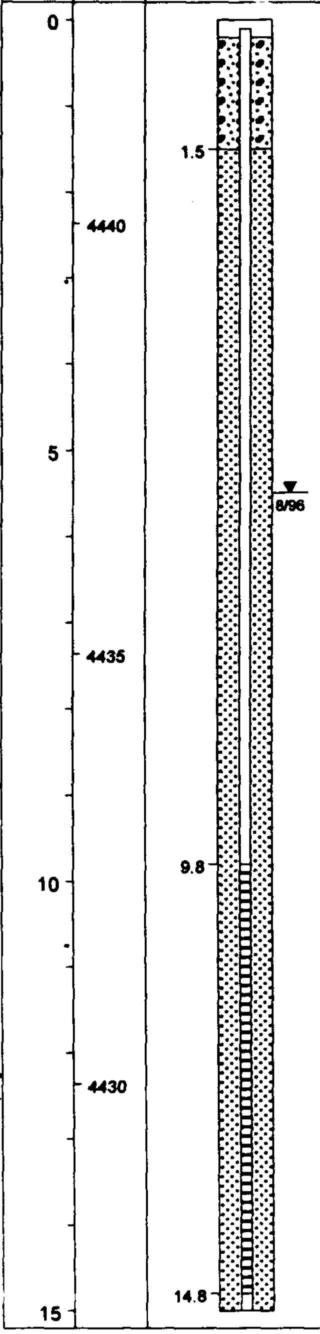
LOG OF BORING MP 5

(Page 1 of 1)

Hill AFB
Operable Unit 5
RNA TS

Date Completed : 8/9/96
Drilling Method : Geoprobe
Sampling Method : Geoprobe
Company Rep. : R. Nagel
Drilling/Geoprobe Co : USEPA

Depth in feet	Surf. Elev. 4442.36	MP 5 ELEV: 4442.36	Well Construction Information



Gr. Surface Elev. : 4442.36 ft msl
Top of PVC Elev. : 4442.14 ft msl
Surf. Completion : Flush mount
Borehole Diam. : 2 in
: heading

WELL CASING
Casing Material : PVC
PVC Diam. : 0.5 in
Joints : Threaded

WELL SCREEN
Screen Material : PVC
Screen Diameter : 0.5 in
Screen Openings : 0.010 in

MOUNTING : Concrete
: (0 to 1.5 ft bgs)
FILTER PACK : Natural sand pack
: (1.5 ft to 15 ft bgs)

NOTES
There is no annulus seal in the borehole.

11-1-1996 c:\mtech3\hill\mp5.ge3

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

LOG OF BORING MP 6

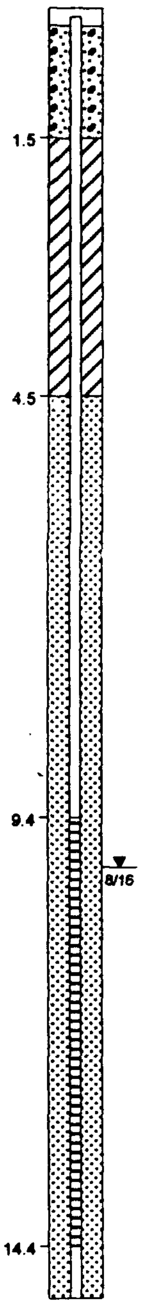
(Page 1 of 1)

Hill AFB
Operable Unit 5
RNA TS

Date Completed	: 8/9/96	Drilling/Geoprobe Co	: USEPA
Drilling Method	: Geoprobe		:
Sampling Method	: Geoprobe		:
Company Rep.	: R. Nagel		:

Depth in feet	Surf. Elev. 4437.01	DESCRIPTION	GRAPHIC	USCS	Samples
0					
	4435				
5					
	4430				
10					
		Sandy, Clayey Silt *0.045% mean total organic carbon*			
	4425			ML	1
15					

MP 6
ELEV: 4437.01



Well Construction Information

Gr. Surface Elev. : 4437.01 ft msl
Top of PVC Elev : 4436.83 ft msl
Surf. Completion : Flush mount
Borehole Diam. : 2 in

WELL CASING
Casing Material : PVC
PVC Diam. : 0.5 in
Joints : Threaded

WELL SCREEN
Screen Material : PVC
Screen Diameter : 0.5 in
Screen Openings : 0.010 in

MOUNTING : Concrete
: (0 to 1.5 ft bgs)
ANNULUS SEAL : Bentonite pellets
(1.5 ft to 4.5 ft bgs)
FILTER PACK : 10-20 sand and nat. pack
: (4.5 ft to 15 ft bgs)

NOTES

11-1-1996 c:\mtech3\hill\mp6.ge3

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

LOG OF BORING MP 7

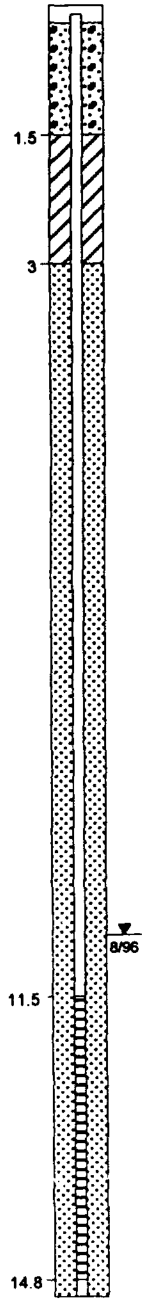
(Page 1 of 1)

Hill AFB
Operable Unit 5
RNA TS

Date Completed : 8/9/96
Drilling Method : Geoprobe
Sampling Method : Geoprobe
Company Rep. : R. Nagel
Drilling/Geoprobe Co : USEPA

Depth in feet	Surf. Elev. 4424.03	DESCRIPTION	GRAPHIC	USCS	Samples
0					
5	4420				
10	4415				
		Sandy, Clayey Silt 0.057% mean total organic carbon		ML	1
15	4410				

MP 7
ELEV: 4424.03



Well Construction Information

Gr. Surface Elev. : 4424.03 ft msl
Top of PVC Elev. : 4423.14 ft msl
Surf. Completion : Flush mount
Borehole Diam. : 2 in

WELL CASING
Casing Material : PVC
PVC Diam. : 0.5 in
Joints : Threaded

WELL SCREEN
Screen Material : PVC
Screen Diameter : 0.5 in
Screen Openings : 0.010 in

MOUNTING : Cement
: (0 to 1.5 ft bgs)
ANNULUS SEAL : Bentonite pellets
: (1.5 ft to 3 ft bgs)
FILTER PACK : 10-20 sand and nat. pack
: (3 ft to 15 ft bgs)

NOTES

11-1-1996 c:\mtech3\hill\mp7 ge3

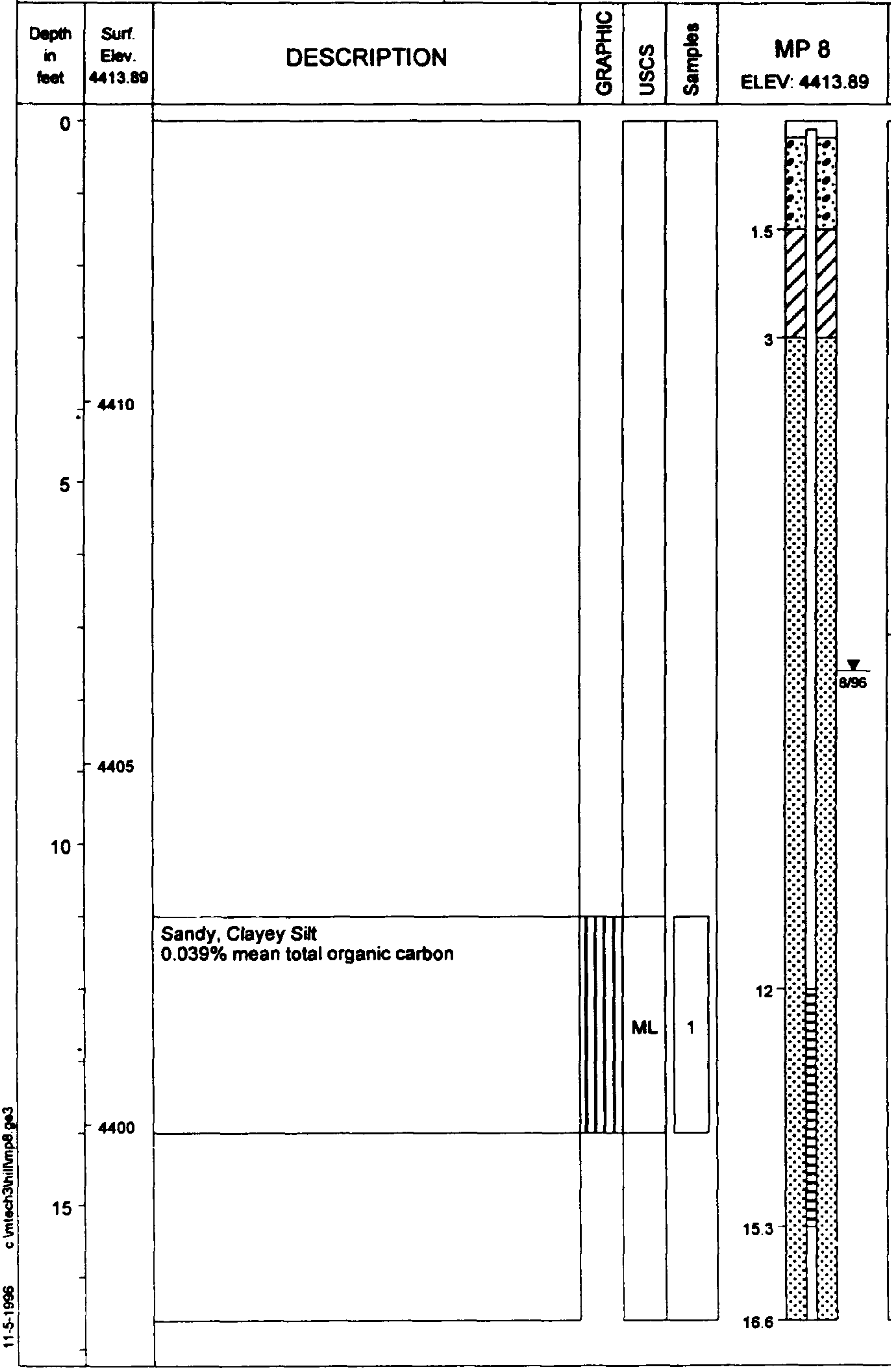
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

LOG OF BORING MP 8

(Page 1 of 1)

Hill AFB
Operable Unit 5
RNA TS

Date Completed : 8/9/96
Drilling Method : Geoprobe
Sampling Method : Geoprobe
Company Rep. : R. Nagel
Drilling/Geoprobe Co : USEPA



Sandy, Clayey Silt
0.039% mean total organic carbon

Well Construction Information

Gr. Surface Elev. : 4413.89 ft msl
Top of PVC Elev. : 4413.68 ft msl
Surf. Completion : Flush mount
Borehole Diam. : 2 in

WELL CASING
Casing Material : PVC
PVC Diam. : 0.5 in
Joints : Threaded

WELL SCREEN
Screen Material : PVC
Screen Diameter : 0.5 in
Screen Openings : 0.010 in

MOUNTING : Cement
: (0 to 1.5 ft bgs)
ANNULUS SEAL : Bentonite pellets
: (1.5 to 3 ft bgs)
FILTER PACK : 10-20 sand and nat. pack
: (3 to 16.6 ft bgs)

NOTES

c:\mtech3\hill\mp8.ge3
11-5-1996

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.02220
Location Hill AFB OU5, Ogden, Utah
Well Number mP 1 (shallow)

Job Name: AFCEE-RNA
by JH/RN/BH
Date: 8 | 11, 1996
Measurement Datum Top Uncut PVC

Pre-Development Information

Time (Start): 0810

Water Level: 18.10' Top Uncut PVC

Total Depth of Well: 20.4' Top Uncut PVC.

Water Characteristics

Color Very Cloudy Brown Clear [✓ Cloudy]
Odor: [✓ None] Weak Moderate Strong
Any Films or Immiscible Material None
pH NR Temperature(°C) NR
Specific Conductance(μS/cm) NR

→ Purged + Surged for 0.5 gallons to remove sediment + Muddy Water

Interim Water Characteristics

Casing Volume: 0.0235gal
Purge Volume = 0.24gal.

Gallons Removed 3.0

pH 7.44

Temperature (°C) 16.0

Specific Conductance(μS/cm) 580

Post-Development Information

Time (Finish): 0930

Water Level: NR

Total Depth of Well:

Approximate Volume Removed: 5 gallons

Water Characteristics

Color Slightly Cloudy - Clear Clear Cloudy
Odor: [✓ None] Weak Moderate Strong
Any Films or Immiscible Material None.
pH 7.45 Temperature(°C) 15.5
Specific Conductance(μS/cm) 590

Comments:

Time	Vol.	Temp.	pH	Ec	mV	DO
0815	0.5	15.0°C	7.44	570	142.7	3.78
0826	1.0	14.8	7.38	580	—	3.83
0835	2.00	15.0	7.47	590	—	4.56
0845	3.0	16.0	7.44	580	—	3.51
0910	4.0	16.0	7.46	580	170.9	4.02
0916	4.5	15.6	7.46	590	162.5	4.21
0926	5.0	15.5	7.45	590	156.0	4.09 (Clear)

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.02220
Job Name: AFCEE-RNA
Location Hill AFB OU5, Ogden, Utah
by JH/RN/BHD Date: 8/11, 1996
Well Number MP 1 D (Deep)
Measurement Datum Top inner PVC

Pre-Development Information

Time (Start): 0810

Water Level: NA

Total Depth of Well: NR
(Teflon Tubing to 6" SS Screen)

Water Characteristics

Color Muddy Brown Clear Cloudy
Odor: [✓ None] Weak Moderate Strong
Any Films or Immiscible Material None
pH NR Temperature(°C) NR
Specific Conductance(µS/cm) NR

Purged 0.5 gal. to remove sediment & muddy water

Interim Water Characteristics

Gallons Removed 2.0

pH 7.39

Temperature (°C) 15.9

Specific Conductance(µS/cm) 550

Post-Development Information

Time (Finish): 0930

Water Level: NA

Total Depth of Well: NA

Approximate Volume Removed: 5 gallons

Water Characteristics

Color Clear to Slightly Cloudy Clear Cloudy
Odor: [✓ None] Weak Moderate Strong
Any Films or Immiscible Material None
pH 7.36 Temperature(°C) 16.1
Specific Conductance(µS/cm) 540

Comments:

Time	Volume	Temp	pH	EC	mv	DO
0818	0.5 gal.	16.0°C	7.34	540	–	5.44 mg/L
0829	1.0	15.6	7.31	530	–	5.88
0838	2.0	15.9	7.39	550	–	6.04
0848	3.0	16.1	7.35	540	–	5.25
0908	4.0	16.4	7.35	530	179.5	5.36
0916	4.5	16.1	7.34	530	160.5	5.32
0926	5.0	16.1	7.36	540	160.2	5.33 (Clear)

Development
GROUNDWATER ~~SAMPLING~~ RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MP2
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/10, 1996 Not Sampled 8/10 a.m./p.m.
SAMPLE COLLECTED BY: [✓ RN]/JH/[✓ BH] of [✓ Parsons ES]
WEATHER: sunny 95°
DATUM FOR WATER DEPTH MEASUREMENT (Describe): —

45
1.5
31

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: NA
INNER PVC CASING CONDITION IS: NA
WATER DEPTH MEASUREMENT DATUM (IS [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR No
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [✓] EQUIPMENT CLEANED BEFORE USE WITH isopropyl / distilled water
Items Cleaned (List): probes

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH NA (24') FT. BELOW DATUM
Measured with: estimated from DTW of MW-126

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: slightly brown
Odor: None
Other Comments: —

4 [✓] WELL EVACUATION:
Method: Peristaltic (Began 245 pm)
Volume Removed: 8/10: 1600 mL
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - fell - no change)
Water odors: None
Other comments: slow, also air introduced into line affecting DO, etc.

Development Only
Not Sampled (BMH)

time	320	335	350	400	415	430
(mg/L) DO	3.21	2.68	2.50	2.45	2.16	2.12
pH	7.41	7.38	7.36	7.34	7.36	7.29
(°C) Temp	38.6	39.2	38.3	39.4	38.5	38.8
(mV) Redox	-100	-0.5	9.1	34.9	-20.5	-30.2

Note: This evacuation was a development as well (10 well volumes

2

Groundwater Sampling Record

Monitoring Well No. MP2 (Cont'd)

5 ☑ SAMPLE EXTRACTION METHOD:

☐ Bailer made of:
☒ Pump, type: Peristaltic
☐ Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 ☑ ON-SITE MEASUREMENTS: (final) Development

*Temp:	NR °C	Measured with:	YSI 55
pH:	7.29	Measured with:	Orion 250A
Conductivity:		Measured with:	–
Dissolved Oxygen:	2.12 (mg/L)	Measured with:	YSI 55
Redox Potential:	-30.2 (mV)	Measured with:	Orion 250A
Salinity:	–	Measured with:	–
Nitrate:	–	Measured with:	–
Sulfate:	–	Measured with:	–
Ferrous Iron:	–	Measured with:	–
Other:			

Note. Flow too slow to obtain accurate temperature

7 ☐ SAMPLE CONTAINERS (material, number, size): Not Sampled. Development only

8 ☐ ON-SITE SAMPLE TREATMENT: Development Only

☐ *Filtration:*

Method ______ Containers: ______
Method ______ Containers: ______
Method ______ Containers: ______

☐ Preservatives added:

Method ______ Containers: ______
Method ______ Containers: ______
Method ______ Containers: ______
Method ______ Containers: ______

9 ☐ CONTAINER HANDLING: Development only

☐ Container Sides Labeled
☐ Container Lids Taped
☐ Containers Placed in Ice Chest

10 ☐ OTHER COMMENTS: MP2 is installed with 6" implant screen and telfon lined 1/4" OD tubing to surface

~~EPA handled samples~~
~~No manbox yet~~ BmH

DEVELOPMENT

GROUNDWATER ~~SAMPLING~~ RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MP2D
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/10, 1996 Not Sampled 8/10 a.m./p.m.
SAMPLE COLLECTED BY: RN/JH/BH of Parsons ES
WEATHER: Sunny 95
DATUM FOR WATER DEPTH MEASUREMENT (Describe): NA (Monitoring Point)

MONITORING WELL CONDITION:
[ ] LOCKED: ☒ UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: NA
INNER PVC CASING CONDITION IS: NA
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR NO
[ ] MONITORING WELL REQUIRED REPAIR (describe): Needs wellhead completion.

Check-off

1 ✓ EQUIPMENT CLEANED BEFORE USE WITH isopropyl, distilled water
Items Cleaned (List): probes

2 ✓ PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH NA 24' FT. BELOW DATUM
Measured with: estimated from MW126

3 ✓ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: slightly brown
Odor: None
Other Comments: —

4 ✓ WELL EVACUATION:
Method: Peristaltic (began 2:45 pm) 3L/hr
Volume Removed: 9 Liters: 8/10
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - fell - no change)
Water odors: None
Other comments: Slow probably air in water line do water discharges

Development Only

Not Sampled 8/10

time	300	320	340	350	400	415	430
(mg/L) DO	168	1.00	0.71	0.58	0.66	0.49	0.61
pH	7.41	7.35	7.37	7.36	7.39	7.37	7.36
(°C) Temp	27.4	27.7	28.5	28.4	29.7	28.8	29.3
(mV Redox	138	-133	-0.2	96.0	-160.4	-155.3	-170.1

* Note: This evacuation was a development as well (10 well volumes

2D

Groundwater Sampling Record

Monitoring Well No. MP2D (Cont'd)

5 [ ] SAMPLE EXTRACTION METHOD:

Not Sampled 8/10

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS: (Final Development

* Temp: NR ° C Measured with: ~~[illegible]~~ YSI 55
pH: 7.36 Measured with: Orion 250A
Conductivity: — Measured with: —
Dissolved Oxygen: 0.61 (mg/L) Measured with: YSI 55
* Redox Potential: 77 (mV) Measured with: Orion 250A
Salinity: — Measured with: —
Nitrate: — Measured with: —
Sulfate: — Measured with: —
Ferrous Iron: — Measured with: —
Other:

* Flow too slow to accurately measure, Redox Probe shorting out erratic readings

7 [ ] SAMPLE CONTAINERS (material, number, size): Not Sampled 8/10. Development only

8 [ ] ON-SITE SAMPLE TREATMENT: Development only

[ ] Filtration:
Method Containers:
Method Containers:
Method Containers:

[ ] Preservatives added:
Method Containers:
Method Containers:
Method Containers:
Method Containers:

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: ~~EPA handled samples~~ Not Sampled 8/10 BMH

MP2D is installed with 6" implant screen and teflon-lined tubing (1/4" OD) to surface.

~~[illegible] No [illegible]~~r No manbox yet

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.02220
Job Name: AFCEE-RNA
Location Hill AFB OU5, Ogden, Utah
by JH/RN/BH
Date: 8/11, 1996
Well Number MP3
Measurement Datum Top Uncut PVC

Pre-Development Information

Time (Start): 1010

Water Level: 9.32' Top Uncut PVC
Total Depth of Well: 29.5' Top PVC w/ Probe

30' Constructed

Water Characteristics

Color Muddy-Cloudy Brown Clear Cloudy
Odor: [✓ None] Weak Moderate Strong
Any Films or Immiscible Material None
pH NR Temperature(°C) NR
Specific Conductance(µS/cm) NR

Casing Vol. = 0.21 gal.
Purge Vol. = 2.1 gal.

Interim Water Characteristics

Gallons Removed ~0.5 gallons → Used 1/2 gallon DI Water to surge + wash out sediment. ~~Well~~ continuously purged dry, would not recharge enough to maintain any flow. Cleared hole to T.D. Recovered ~1/2 gal. Muddy water. Did not recharge enough to keep pumping. Quit after 1/2 gallon.
pH NR
Temperature (°C) NR
Specific Conductance(µS/cm) NR

Post-Development Information

Time (Finish):

Water Level:
Total Depth of Well: Need to come back after well recharges.
Approximate Volume Removed:

Water Characteristics

Color Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material
pH Temperature(°C)
Specific Conductance(µS/cm)

Comments:

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.02220
Job Name: AFCEE-RNA
Location Hill AFB OU5, Ogden, Utah
by JH/RN/BHD 8/11 Date: ______, 1996
Well Number MP4
Measurement Datum Top Uncut PVC

Pre-Development Information
Time (Start): 1630

Water Level: Not Measurable
Total Depth of Well: NA

Water Characteristics

Color NA Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material ______
pH ______ Temperature(°C) ______
Specific Conductance(μS/cm) ______

Interim Water Characteristics

Gallons Removed ______

pH ______

Temperature (°C) ______

Specific Conductance(μS/cm) ______

NOTE: Monitoring Point MP4
has been vandalized by
some young neighborhood
boys (ages 6-8?). Could not
get tubing past 5-6'.
Attempted to wash out
w/ Pump & Distilled water.
Couldn't get past ~ 5-6'.

Post-Development Information
Time (Finish): ______

Water Level: ______
Total Depth of Well: ______

Approximate Volume Removed: ______

Water Characteristics

Color ______ Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material ______
pH ______ Temperature(°C) ______
Specific Conductance(μS/cm) ______

Comments:

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MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.02220
Job Name: AFCEE-RNA
Location Hill AFB OU5, Ogden, Utah
by JH/RN/BH
Date: 8/11, 1996
Well Number MP5
Measurement Datum Top uncut PVC

Pre-Development Information
Time (Start): 1200

Water Level: 5.20' TPVC
Total Depth of Well: 13.1' TPVC (Probe)
14.8' bgs (Construction)

Water Characteristics

Color Mucky Brown Clear Cloudy
Odor: [✓ None] Weak Moderate Strong
Any Films or Immiscible Material None
pH NR Temperature(°C) NR
Specific Conductance(μS/cm) NR

Interim Water Characteristics

Gallons Removed 1.5 gal.

pH 7.11

Temperature (°C) 18.5

Specific Conductance(μS/cm) 1150

Casing Vol. = 0.098 gal.
Purge Vol. (x10) = 1.0 gal.

Post-Development Information
Time (Finish): 1235

Water Level: ~5½'
Total Depth of Well: ~14'

Approximate Volume Removed: 3-3½ gal.

Water Characteristics

Color [✓ Clear] Cloudy
Odor: [✓ None] Weak Moderate Strong
Any Films or Immiscible Material None
pH 7.11 Temperature(°C) 18.6
Specific Conductance(μS/cm) 1150

Comments:

Time	Vol.	Temp.	pH	EC	mv	DO(1)	DO(2)
1210	0.5 gal.	→ Too muddy - Purged to clear sediment					
1215	1.0	18.7°C	7.08	1140	129	1.17	1.4
1220	1.5	18.5	7.11	1180	111.4	1.10	1.2
1225	2.0	18.5	7.10	1170	144.3	1.06	1.2
1235	3.0+	18.6	7.11	1150	138.4	1.03	1.3

DO(1) - YSI 55
DO(2) - Orion 840

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.02220 Job Name: AFCEE-RNA
Location Hill AFB OU5, Ogden, Utah by JH/RN/BH 8/11 Date: ______, 1996
Well Number MP6 Measurement Datum Top uncut PVC

Pre-Development Information Time (Start): 1320

Water Level: 9.30' TPVC Total Depth of Well: 11.5' TPVC (Probe)
14.4' bgs (Construction)

Water Characteristics

Color Muddy Brown Clear Cloudy
Odor: [✓ None] Weak Moderate Strong
Any Films or Immiscible Material None
pH NR Temperature(°C) NR
Specific Conductance(µS/cm) NR

Casing Volume = 0.052
Purge Vol. (x10) = 0.52 gal

Had to pump 0.5 gal. to remove sediment & muddy water.

Interim Water Characteristics

Gallons Removed 0.75

pH 7.38

Temperature (°C) 25.0 * Flow too slow to get accurate measurement

Specific Conductance(µS/cm) 1010

Post-Development Information Time (Finish): 1415

Water Level: ~ 13.5' Total Depth of Well: 14'

Approximate Volume Removed: 1.75 gallons

Water Characteristics

Color Slightly Cloudy Brown Clear Cloudy
Odor: [✓ None] Weak Moderate Strong
Any Films or Immiscible Material None
pH 7.40 Temperature(°C) 21.0*
Specific Conductance(µS/cm) 1270

Comments:

Time	Vol.	Temp*	pH	EC	mV	DO(1)* DO
1325	0.5gal.	26.8°C	7.51	~~143.5~~ 1010	143.5	4.05 #3
1340	0.75gal.	25.0	7.38	1170	122	3.70 #3
1355	1.0gal.	25.1	7.40	1200	127.1	4.06 #1
1405	1.25gal.	25.6	7.42	1270	162.8	4.18 #4
1408	1.50gal.	25.4	7.41	1280	156.2	3.95 #4
1415	1.75	21.0	7.40	1270	157.7	4.16 #4

Note: *Could not flow fast enough to obtain correct Temp. Reading.
*Some bubbling in sample affecting DO Readings
DO(1) → YSI 55 DO(2) → Orion 810

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729691.02220
Job Name: AFCEE-RNA
Location Hill AFB OU5, Ogden, Utah
by JH/RN/BH
Date: 8/11, 1996
Well Number MP7
Measurement Datum Top inner PVC

Pre-Development Information

Time (Start): 1435

Water Level: 8.80' Top inner PVC
Total Depth of Well: 12.70' Probe
14.8' Construction

Water Characteristics

Color Muddy Brown Clear Cloudy
Odor: [✓ None] Weak Moderate Strong
Any Films or Immiscible Material None
pH NR Temperature(°C) NR
Specific Conductance(µS/cm) NR

Interim Water Characteristics

Gallons Removed 1.5 gal.

pH 7.22

Temperature (°C) 16.8

Specific Conductance(µS/cm) 1180

Post-Development Information

Time (Finish): 1510

Water Level: ~9'
Total Depth of Well: ~14'

Approximate Volume Removed: 3.5 gal.

Water Characteristics

Color Clear - Sl. Cloudy Clear Cloudy
Odor: [✓ None] Weak Moderate Strong
Any Films or Immiscible Material None
pH 7.24 Temperature(°C) 16.9
Specific Conductance(µS/cm) 1170

Comments: Took ~0.5-0.75 gallons to pump out silt & muddy water, surged to clean screen

Casing Vol. = 0.021 gal
Purge Vol. = 0.21 gal. (10x)

Time	Vol.	pH	Temp.	mV	EC	DO(1)	DO(2)
1445	1.0 gal.	7.20	17.3°C	77.0	990	1.69 mg/L	1.9 mg/L
1450	1.5	7.22	16.8	77.5	1180	1.10	0.9
1455	2.0	7.24	16.9	75.8	1100	0.65	0.7
1500	2.5	7.24	16.9	73.1	1120	0.40	0.6
1505	3.0	7.25	16.9	76.6	1160	0.36	0.6
1510	3.5	7.24	16.9	73.8	1170	0.32	0.7

DO(1) - YSI 55
DO(2) - Orion 840

MONITORING POINT DEVELOPMENT RECORD

Job Number: 729080.05000
Job Name: AFCEE-RNA
Location Hill AFB OU5, Ogden, Utah
by JH/RN BMH
Date: 8/11, 1996
Well Number MP8
Measurement Datum Top Inner PVC

Pre-Development Information

Time (Start): 1540

Water Level: 7.05' TPVC
Total Depth of Well: 13.3' w/ Water level Indicator
15.3' bgs Construction

Water Characteristics

Color Very Muddy Brown Clear Cloudy
Odor: [✓ None] Weak Moderate Strong
Any Films or Immiscible Material None
pH NR Temperature(°C) NR
Specific Conductance(µS/cm) NR

Had to Pump 1-1½ gallons to purge sediment & muddy water before starting to clear. Start Metering at 2.0 gallons

Interim Water Characteristics

Gallons Removed 2.5

pH 7.40

Temperature (°C) 19.7

Specific Conductance(µS/cm) NR

Post-Development Information

Time (Finish): 1615

Water Level: NR
Total Depth of Well: 15.0'

Approximate Volume Removed: 4.0 gallons

Water Characteristics

Color Slightly Cloudy Brown Clear [✓ Cloudy]
Odor: [✓ None] Weak Moderate Strong
Any Films or Immiscible Material None
pH 7.41 Temperature(°C) 19.6
Specific Conductance(µS/cm) 950

Comments: Casing Volume =
Purge Vol. (x10) =

Time	Vol.	Temp	pH	EC	mv	DO(1)	DO(2)
1550	2.0	19.8°C	7.43	~~[illegible]~~	135.4	4.22 mg/L	4.1/Cloudy Brn
1557	2.5	19.7	7.40	—	118.1	4.35	4.4
1605	3.0	19.7	7.39	980	117.1	4.24	4.2 (Clear
1610	3.5	19.7	7.42	930	113.6	4.16	4.2
1614	4.0	19.6	7.41	950	111.3	4.08	4.0

DO(1) → 45555
DO(2) → orion 840

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GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MP1 (shallow)
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/12, 1996 1045 [✓ a.m.]/p.m.
SAMPLE COLLECTED BY: RN/JH of Parsons ES
WEATHER: DMH Clear, Sunny, Hot, 85°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe):
Not Measured – Tubing in Hole

MONITORING WELL CONDITION:
[ ] LOCKED: ☒ UNLOCKED
WELL NUMBER (IS - [✓ IS NOT]) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM ([✓ IS] - IS NOT) APPARENT
☒ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe): Labeled + Marked

Check-off
1 ☒ EQUIPMENT CLEANED BEFORE USE WITH New Peristaltic Tubing
Items Cleaned (List):

2 ☒ PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH NA FT. BELOW DATUM
Measured with:

3 ☒ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Slightly Cloudy
Odor: None
Other Comments:

4 ☒ WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 1.5+ gal.
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - fell - [✓ no change]) – Not measured
Water odors: None
Other comments:

Time	Vol.	Temp	pH	EC	DO
1033	0.5 gal.	17.9°C	7.21	440	4.06
1038	1.0 gal.	16.3	7.24	550	4.35
1043	1.5 gal.	16.2	7.24	550	4.42

Groundwater Sampling Record

Monitoring Well No. MP1 (Cont'd)

5 ☒ SAMPLE EXTRACTION METHOD:

☐ Bailer made of:
☑ Pump, type: Peristaltic
☐ Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 ☒ ON-SITE MEASUREMENTS:

Ferrous Iron: <0.1 mg/L
Manganese: <0.1 mg/L
Alkalinity: 250 mg/L
Carbon Dioxide: 30 mg/L
Phenols = 0.1 mg/L
Hydrogen Sulfide: <0.1

Temp: 16.2 ° C — Measured with: YSI 55
pH: 7.24 — Measured with: Orion 250A
Conductivity: 550 — Measured with: Oyster
Dissolved Oxygen: 4.06 — Measured with: YSI 55
Redox Potential: — — Measured with: —
Salinity: — — Measured with: —
Nitrate: — — Measured with: —
Sulfate: — — Measured with: —
Ferrous Iron: <0.1 — Measured with: Chemetrics
Other:

7 ☒ SAMPLE CONTAINERS (material, number, size): 4x VOAs
2x 125ml Plastic
1x 250ml. Plastic
2x Glass Syrum Jars

8 ☒ ON-SITE SAMPLE TREATMENT:

☒ None Filtration: Method Containers:
Method Containers:
Method Containers:

☒ Preservatives added: VOAs EPA Prepreserved
Glass Syrum Jars - 3 drops Sulfuric Acid
1x 125ml Plastic - 5 drops Sulfuric
Method Containers:
Method Containers:
Method Containers:
Method Containers:

9 ☒ CONTAINER HANDLING:

☒ Container Sides Labeled
☐ Container Lids Taped
☒ Containers Placed in Ice Chest

10 ☐ OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MP 1 D (Deep)
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/12/96, 1996 1005 [✓ a.m.]/p.m.
SAMPLE COLLECTED BY: RN/JH/[✓ BH] of Parsons ES
WEATHER: Clear, Sunny, Warm 80 85°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe):
NA → Thin Teflon Tubing

MONITORING WELL CONDITION:
☐ LOCKED: ☒ UNLOCKED
WELL NUMBER (IS - [✓ IS NOT]) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
☒ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR → Labeled
☐ MONITORING WELL REQUIRED REPAIR (d

Check-off
1 ☒ EQUIPMENT CLEANED BEFORE USE WITH New Peristaltic Tubing
Items Cleaned (List):

2 ☒ PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH NA FT. BELOW DATUM
Measured with:

3 ☒ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Slightly cloudy
Odor: None
Other Comments:

4 ☒ WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 1.5 gal.
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - fell - no change) NA
Water odors: None
Other comments:

Time	Vol.	pH	Temp	mV	EC	DO
0952	0.5 gal.	7.34	19.3°C	–	570	2.36
0956	1.0 gal.	7.34	17.4°C	–	590	2.37
1000	1.5 gal.	7.35	17.0°C	–	590	2.46

Groundwater Sampling Record

Monitoring Well No. MP 1D (Cont'd)

5 [X] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [X] ON-SITE MEASUREMENTS:

Ferrous Iron = <0.1 mg/l
Phenols = <0.1 mg/l
Alkalinity = 250 mg/l
Carbon Dioxide = 21 mg/l
Manganese = <0.1 mg/l
Hydrogen Sulfide = <0.1 mg/l

Temp: 17.0 ° C	Measured with: YSI 55
pH: 7.35	Measured with: Orion 290A
Conductivity: 590	Measured with: Oyster
Dissolved Oxygen: 2.36	Measured with: YSI 55
Redox Potential: —	Measured with: (Probe Broken)
Salinity: —	Measured with: —
Nitrate: —	Measured with: —
Sulfate: —	Measured with: —
Ferrous Iron: <0.1	Measured with: Chemetrics Kit

Other:

7 [X] SAMPLE CONTAINERS (material, number, size): 4x VOAs / 2x Jars (syrum)
2x 125 ml. Plastic
1x 250 ml Plastic

8 [X] ON-SITE SAMPLE TREATMENT:

[-] None Filtration:

Method	Containers:
Method	Containers:
Method	Containers:

[X] Preservatives added: VOAs - Prepreserved by EPA
Glass Syrum Jars - 3 drops Sulfuric Acid

Method 1x 125 ml. Plastic	Containers: 5 drops Sulfuric
Method	Containers:
Method	Containers:
Method	Containers:

9 [X] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped
[X] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MP2 / ~~MP2D~~ (number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/13 1996 1030 a.m./p.m.
SAMPLE COLLECTED BY: RN/JH/BH of Parsons ES
WEATHER: 80° Sunny
DATUM FOR WATER DEPTH MEASUREMENT (Describe): N/A implant w/tubing

MONITORING WELL CONDITION:
[ ] LOCKED: ☒ UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [✓ EQUIPMENT CLEANED BEFORE USE WITH Isopropyl / distilled water
Items Cleaned (List): probes

2 [✓ PRODUCT DEPTH none FT. BELOW DATUM
Measured with: –

WATER DEPTH ~24' FT. BELOW DATUM
Measured with: estimate from MW-126

3 [✓ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: cloudy - brown
Odor: none
Other Comments: –

4 [✓ WELL EVACUATION:
Method: Peristaltic (Began 1007-MP2)
Volume Removed: 2 Liters (MP2)
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

MP2	MP2D
28	44
-24	-24
4	20
/16	/16
1/4 gal	1 1/4 gallon

	1013	0023
pH	7.14	7.16
DO (mg/L)	2.43	2.14
temp (°C)	22.7	22.1
cond (µS/cm)	65×10	61×10

phenol <1 ppm
CO_2 = 40 ppm
Ferrous Iron (~~total~~ 2AM) = <0.1
Alkalinity = 25(
H_2S =
Mn =

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Groundwater Sampling Record

Monitoring Well No. MP2 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

Temp: ________ ° C — Measured with: YSI 55
pH: ________ — Measured with: Orion 250A
Conductivity: ________ (us/cm) — Measured with: Oyster
Dissolved Oxygen: ________ — Measured with: YSI 55
Redox Potential: — — Measured with: —
Salinity: ________ — Measured with:
Nitrate: ________ — Measured with:
Sulfate: ________ — Measured with:
Ferrous Iron: ________ — Measured with:
Other:

See Form

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs
2x 125 ml Plastic
2x 250 ml Plastic
2x Glass Syringe Jars

8 [✓] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: None
Method ________ Containers: ________
Method ________ Containers: ________
Method ________ Containers: ________

[X] Preservatives added:

Method Sulfuric Acid — Containers: 2x Glass Syringe Jars
Method ________ — Containers: 1x 125 ml Plastic
Method ________ — Containers: ________
Method ________ — Containers: ________

9 [✓] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped
[X] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Samples Handled by Parsons ES

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MP20
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/13/96, 1996 1220 a.m./p.m.
SAMPLE COLLECTED BY: [✓ RN]/JH/BH of Parsons ES
WEATHER: Sunny, '70's °F, Calm
DATUM FOR WATER DEPTH MEASUREMENT (Describe):

MONITORING WELL CONDITION:
[ ] LOCKED: [✓] UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: N/A
INNER PVC CASING CONDITION IS: N/A Tubing ok
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT N/A
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [ ] EQUIPMENT CLEANED BEFORE USE WITH
Items Cleaned (List):

2 [ ] PRODUCT DEPTH N/A FT. BELOW DATUM
Measured with:

WATER DEPTH N/A FT. BELOW DATUM
Measured with:

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: None
Other Comments:

4 [ ] WELL EVACUATION:
Method: Peristaltic pump
Volume Removed:
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - fell - no change)
Water odors None
Other comments:

Time	1115	1125	1136	1151	1205
pH	7.12	7.15	7.14	7.17	7.17
Temp (°C)	21.8	21.9	22.8	22.9	23.0
DO (mg/L)	1.02	1.00	0.51	0.42	0.50
EC (uS/cm)	57x10	56x10	56x10	50x10	50x10

Groundwater Sampling Record

Monitoring Well No. MP20 (Cont'd)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[ ] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

See page 1

Temp: ____ ° C Measured with:
pH: Measured with:
Conductivity: Measured with:
Dissolved Oxygen: Measured with:
Redox Potential: Measured with:
Salinity: Measured with:
Nitrate: Measured with:
Sulfate: Measured with:
Ferrous Iron: Measured with:
Other:

7 [ ] SAMPLE CONTAINERS (material, number, size): 4x VOCs
2x 125ml Plastic
2x 250ml Plastic
2x Glass Serum bottles

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: None
Method Containers:
Method Containers:
Method Containers:

[ ] Preservatives added:
Method Sulfuric Acid Containers: Serum bottle
Method Containers: 1x125ml plastic
Method Containers:
Method Containers:

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Samples Handled by Parsons ES

Hach Test

Alkalinity 250
phenol <1
Mn <1
H_2S <1
CO_2 25
Ferrous Iron 1.0

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MP3
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling: PM
DATE AND TIME OF SAMPLING: 8/13, 1996 845 am and 200 [✓ a.m.]/[✓ p.m]
SAMPLE COLLECTED BY: [✓ RN]/JH/BH of [✓ Parsons ES]
WEATHER: Sunny 70-75°
DATUM FOR WATER DEPTH MEASUREMENT (Describe): —

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [✓] EQUIPMENT CLEANED BEFORE USE WITH isopropyl / distilled water
Items Cleaned (List): probes

2 [✓] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

WATER DEPTH approx 5' FT. BELOW DATUM
Measured with: —

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: v cloudy - brown
Odor: none
Other Comments:

4 [✓] WELL EVACUATION:
Method: peristaltic (Began 720 am)
Volume Removed: ~~4.5~~ 4 gallons (3.75g)
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

36.5
-6.5
30.0
8
3.75

time	7:10	8:20	8:40
DO (mg/L)	2.63	2.28	2.26
pH	[illegible]	7.83	7.87
Temp (°C)	20.0	20.3	20.4
cond (mS/cm)	65×10	66×10	66×10
~~[illegible]~~			

Groundwater Sampling Record

Monitoring Well No. MP3 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

Temp:	20.4 °C	Measured with:	YSI 55
pH:	7.77	Measured with:	Orion 250A
Conductivity:	66×10 µS/cm	Measured with:	Oyster
Dissolved Oxygen:	2.26 mg/L	Measured with:	YSI 55
Redox Potential:	~~66~~	Measured with:	Orion 250A
Salinity:		Measured with:	
Nitrate:		Measured with:	
Sulfate:		Measured with:	
Ferrous Iron:		Measured with:	
Other:			

7 [✓] SAMPLE CONTAINERS (material, number, size): 4 x VOAs
2x Glass Serum Jars
2x 125 ml Plastic
1x 250 ml Plastic

8 [✓] ON-SITE SAMPLE TREATMENT:

[ ] Filtration:

Method		Containers:
Method		Containers:
Method		Containers:

[X] Preservatives added:

Method	H_2SO_4	Containers:	Serum Bottles + Fixed
Method		Containers:	
Method		Containers:	
Method		Containers:	

9 [✓] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped
[X] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Samples Handled by Parsons ES

Analysis at well head (ppm) (mg/L)

Iron (~~total~~ Ferrous) = ~~1.0 ppm~~ | 1.0 ppm
Phenols = ~~<1 ppm~~ | <1 ppm
H_2S = ~~<1 ppm~~ | <1 ppm
CO_2 = ~~28 ppm~~ | ppm
Alkalinity = ~~250 ppm~~ | 230 ppm

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MPS
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8\12\96, 1996 1215 a.m./[✓ pm]
SAMPLE COLLECTED BY: RN/JH/[✓ BH] of Parsons ES
WEATHER: Clear, Sunny, Hot 90-95°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Not Recorded, Don't have Water Level Indicator.

MONITORING WELL CONDITION:

[ ] LOCKED: ☒ UNLOCKED
WELL NUMBER (IS - [✓ IS NOT]) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
☒ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe): → Make Water Side PVC, Label Well

Check-off

1 ☒ EQUIPMENT CLEANED BEFORE USE WITH New Peristaltic Tubing
Items Cleaned (List):

2 ☒ PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH NR FT. BELOW DATUM
Measured with:

3 ☒ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: First Pint Cloudy Brown, then Slightly Cloudy
Odor: None
Other Comments:

4 ☒ WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 1.5 gal.
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - fell - no change) NR
Water odors: None
Other comments:

NOTE: Purged & Developed 8/11/96
Repurge for Sampling

Time	Vol	Temp	pH	EC	DO
1202	1/2 gal	18.9	7.08	1120	0.96
1208	1 gal	18.5	7.08	1150	0.94
1212	1 1/2 gal	18.4	7.07	1150	0.89

Groundwater Sampling Record

Monitoring Well No. MP5 (Cont'd)

5 [X] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [X] ON-SITE MEASUREMENTS:

Ferrous Iron = <0.1 mg/L
Phenols = <0.1
Manganese = <0.1 mg/L
Alkalinity = 275 mg/L
Carbon Dioxide = 55 mg/L
Hydrogen Sulfide = <0.1

Temp:	18.4 °C	Measured with: YSI 55
pH:	7.07	Measured with: Orion 230A
Conductivity:	1150	Measured with: Oyster
Dissolved Oxygen:	0.89	Measured with: YSI 55
Redox Potential:	—	Measured with: —
Salinity:	—	Measured with: —
Nitrate:	—	Measured with: —
Sulfate:	—	Measured with: —
Ferrous Iron:	<0.1 mg/L	Measured with: —
Other:		

7 [X] SAMPLE CONTAINERS (material, number, size): 4x VOAs / 2x Glass Syrup Jars / 1x 250 ml Plastic / 2x 125 ml Plastic

8 [X] ON-SITE SAMPLE TREATMENT:

[/] NA Filtration:

Method	Containers:
Method	Containers:
Method	Containers:

[X] Preservatives added: VOAs EPA Preserved
Glass Syrup Jars - Sulfuric Acid

Method	Containers:
Method	Containers:
Method	Containers:
Method	Containers:

9 [X] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped
[X] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Duplicate Sample MP-15 duplicate of MP5

MP15 (Slightly Cloudy)

Ferrous Iron = 0.1 mg/L
Phenols = <0.1 mg/L
Alkalinity = 350 mg/L

Manganese = <0.1 mg/L
Carbon Dioxide = 50 mg/L
Hydrogen Sulfide = <0.1 mg/L

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MP6
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/12 1996 500 a.m./[✓ p.m.] (1700)
SAMPLE COLLECTED BY: RM/JH/BH of [✓ Parsons ES]
WEATHER: sunny 100°
DATUM FOR WATER DEPTH MEASUREMENT (Describe): None - 0.5" diameter well

MONITORING WELL CONDITION:
[ ] LOCKED: [✓] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [✓] EQUIPMENT CLEANED BEFORE USE WITH Isopropyl / distilled water
Items Cleaned (List): probes

2 [✓] PRODUCT DEPTH none FT. BELOW DATUM
Measured with: –

WATER DEPTH – FT. BELOW DATUM
Measured with: –

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: very cloudy
Odor: none
Other Comments:

4 [✓] WELL EVACUATION:
Method: peristaltic
Volume Removed: developed 8/11/96 see development notes
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

Groundwater Sampling Record

Monitoring Well No. MP6 (Cont'd)

5 ☑ SAMPLE EXTRACTION METHOD:

☐ Bailer made of:
☒ Pump, type: Peristaltic
☐ Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 ☑ ON-SITE MEASUREMENTS: See 8/10 development record

Temp: ______ ° C Measured with: ______
pH: ______ Measured with: ______
Conductivity: ______ Measured with: ______
Dissolved Oxygen: ______ Measured with: ______
Redox Potential: ______ Measured with: ______
Salinity: ______ Measured with: ______
Nitrate: ______ Measured with: ______
Sulfate: ______ Measured with: ______
Ferrous Iron: ______ Measured with: ______
Other: ______

7 ☑ SAMPLE CONTAINERS (material, number, size): 4x VOAs
2x Glass Syrup Jar
2x 125 ml Plastic
1x 250 ml Plastic

8 ☑ ON-SITE SAMPLE TREATMENT:

☐ Filtration:
Method ______ Containers: ______
Method ______ Containers: ______
Method ______ Containers: ______

☑ Preservatives added:
Method H_2SO_4 Containers: ______
Method ______ Containers: ______
Method ______ Containers: ______
Method ______ Containers: ______

9 [ ] CONTAINER HANDLING:

☒ Container Sides Labeled
☐ Container Lids Taped
☒ Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Samples Handled by Parsons ES

Analysis done at well head (mg/L) ppm at 530pm
Iron(~~total~~ ferrous RAM) = <1 ppm
Phenols = <1 ppm
H_2S = <0.1 ppm
CO_2 = 220 mg/L
Alkalinity = 40 mg/L
BMH

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL [redacted] MP7 (770 West / 2300 North)
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/12, 1996 1330 a.m./[✓ p.m.]
SAMPLE COLLECTED BY: RN/JH/KH of Parsons ES
WEATHER: Clear, Sunny, Hot 95-98°c
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Not measured
Developed 8/11/96

MONITORING WELL CONDITION:
[ ] LOCKED: ☒ UNLOCKED
WELL NUMBER (IS - [✓ IS NOT]) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
☒ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe): PVC Marked

Check-off
1 ☒ EQUIPMENT CLEANED BEFORE USE WITH New Peristaltic Tubing
Items Cleaned (List):

2 ☒ PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH NR FT. BELOW DATUM
Measured with:

3 ☒ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Cloudy Brown
Odor: None
Other Comments:

4 ☒ WELL EVACUATION:
Method: Peristaltic Tubing
Volume Removed: 1.5+ gal.
Observations: Water (slightly - very) cloudy NR
Water level (rose - fell - no change) NR
Water odors: None
Other comments:

Time	Vol.	Temp	pH	EC	DO
1308	0.5 gal.	17.9	7.22	1210	0.32
1320	1.0 gal.	17.6	7.20	1220	0.27
1327	1.5+ gal.	17.7	7.20	1220	0.27

Groundwater Sampling Record

Monitoring Well No. [redacted] MP7 (Cont'd)

5 [X] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

Ferrous Iron = 0.1 mg/l
Manganese = <0.1 mg/l
Phenols = 0.1 mg/l
Alkalinity = 500 mg/l
Carbon Dioxide 70 mg/l
Hydrogen Sulfide = <0.1

Temp:	17.7 °C	Measured with:	YSI 55
pH:	7.20	Measured with:	Orion 250A
Conductivity:	1220	Measured with:	Oyster
Dissolved Oxygen:	0.27	Measured with:	YSI 55
Redox Potential:	—	Measured with:	—
Salinity:	—	Measured with:	—
Nitrate:	—	Measured with:	—
Sulfate:	—	Measured with:	—
Ferrous Iron:	0.1 mg/l	Measured with:	
Other:			

7 [X] SAMPLE CONTAINERS (material, number, size): 4x VOAs | 2x Glass Syme Jars
2x 125 mL Plastic
1x 250 mL Plastic

8 [ ] ON-SITE SAMPLE TREATMENT:

[X] None Filtration:

Method		Containers:	
Method		Containers:	
Method		Containers:	

[X] Preservatives added: VOAs EPA Prepreserved
Glass Sym Jars - 3 drops Sulfuric

Method		Containers:	
Method		Containers:	
Method		Containers:	
Method		Containers:	

9 [X] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped
[X] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:

Carbon Dioxide → CHEMetrics Kit K-1910 (10-100ppm)
Manganese → HACH Test Kit Model MN-5 (0-3 mg/l) (Cat. No. 1467-00)
Total Alkalinity → CHEMetrics Kit R-9815 (50-500ppm)
Phenols → CHEMetrics Kit K-8012
Hydrogen Sulfide → HACH Cat. No 25378-00
Ferrous Iron - CHEMetrics Kit K-6010

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MP8 (number)
NOTE: MP18 is a duplicate sample of MP8
REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/12, 1996 1435 a.m./p.m.
SAMPLE COLLECTED BY: RN/JH/[✓ BH] of Parsons ES
WEATHER: Clear, Sunny, Hot 95°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Not measured

MONITORING WELL CONDITION:
[ ] LOCKED: ☑ UNLOCKED
WELL NUMBER (IS - [✓ IS NOT]) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
☑ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe): Marked North Side Csc., Labeled well

Check-off
1 ☒ EQUIPMENT CLEANED BEFORE USE WITH New Peristaltic Tubing
Items Cleaned (List):

2 ☑ PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH NR FT. BELOW DATUM
Measured with:

3 ☑ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Cloudy Brown
Odor: None
Other Comments:

4 ☒ WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 1.5+ gal.
Observations: Water (slightly - very) cloudy Cloudy Brown
Water level (rose - [✓ fell] - no change)
Water odors: None.
Other comments:

Time	Vol.	Temp	pH	EC	DO
1412	0.5	20.1	7.33	1340	3.56
1422	1.0	22.2	7.33	1330	3.33
1432	1.5	21.0	7.33	1330	3.52

Groundwater Sampling Record

Monitoring Well No. MP8 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:

[✓] Pump, type: Peristaltic

[ ] Other, describe:

Sample obtained is [✓] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

Ferrous Iron = 0.2 mg/L
Phenols = 0.1 mg/L
Manganese = <0.1
Carbon Dioxide = 40 mg/L
Alkalinity ~~[illegible]~~ [illegible] = >500 mg/L
H_2S = <0.1 mg/L

Temp:	20.1 ° C	Measured with:	YSI 55
pH:	7.33	Measured with:	Orion 284
Conductivity:	1330	Measured with:	Extech Oyster
Dissolved Oxygen:	3.52	Measured with:	YSI 55
Redox Potential:	—	Measured with:	(Broken Probe)
Salinity:	—	Measured with:	—
Nitrate:	—	Measured with:	—
Sulfate:	—	Measured with:	—
Ferrous Iron:	0.2 mg/L	Measured with:	
Other:			

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs | 2x Glass Sym Jars
2x 125ml Plastic
1x 250ml Plastic

8 [✓] ON-SITE SAMPLE TREATMENT:

[–] None Filtration:

Method		Containers:	
Method		Containers:	
Method		Containers:	

[✓] Preservatives added: VOAs EPA preserved
Glass Jars - Sulfuric Acid

Method		Containers:	
Method		Containers:	
Method		Containers:	
Method		Containers:	

9 [✓] CONTAINER HANDLING:

[✓] Container Sides Labeled
[ ] Container Lids Taped
[✓] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Sample was cloudy, needed filtering for field tests

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW 122
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/8/96, 1996 1315 a.m/[✓ p.m.]
SAMPLE COLLECTED BY: RN/JH/[✓ BH] of Parsons ES
WEATHER: Clear, Sunny, Hot 90°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe):
WATER ⇒ 23.12 TPVC 30.02 TPVC ⇐ T.D.
23.26 TSteel 30.16 Top Steel

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):
levels taken from both top Steel & PVC Casing

Check-off
1 [X] EQUIPMENT CLEANED BEFORE USE WITH Alconox / Water Rinse / Isopropyl / DI water
Items Cleaned (List): Water level Indicator
Peristaltic Pump Tubing
Meter Probes (no isopropyl)
2 [X] PRODUCT DEPTH NM FT. BELOW DATUM
Measured with:

WATER DEPTH 23.12 TPVC / 23.26 Top Steel FT. BELOW DATUM
Measured with: Solinst

3 [X] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Cloudy Brown
Odor: None
Other Comments:

4 [X] WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 4.0 gal
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - [✓ fell] - no change) Slightly < 0.2'
Water odors: None
Other comments: Clear to Slightly Cloudy at 1.0 gal.

2" PVC Casing
Casing Volume: 1.12 gal.
Purge Volume = 3.4 gal.

Time	Vol.	pH	temp.	mV	EC	DO
1245	1.0	7.14	16.6	52.9	NR	5.66
1255	2.0	7.14	16.6	34.9	NR	5.10
1303	3.0	7.16	16.6	22.3	NR	5.23
1311	4.0	7.18	16.6	15.1	NR	5.02

Groundwater Sampling Record

Monitoring Well No. MW-22 (Cont'd)

5 [X] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [X] ON-SITE MEASUREMENTS:

Temp:	16.6 ° C	Measured with:	YSI 55
pH:	7.18	Measured with:	Orion 290A
Conductivity:	NR	Measured with:	NR
Dissolved Oxygen:	5.02	Measured with:	YSI 55
Redox Potential:	15.1	Measured with:	Orion 290A
Salinity:	—	Measured with:	—
Nitrate:	—	Measured with:	—
Sulfate:	—	Measured with:	—
Ferrous Iron:	—	Measured with:	—

Other:

7 [X] SAMPLE CONTAINERS (material, number, size): 4 VOAs / 2x 250ml Plastic
2x 125 ml Plastic / 2x Small Glass
Dissolved H_2 Sample

8 [X] ON-SITE SAMPLE TREATMENT:

[X] None Filtration:

Method		Containers:	
Method		Containers:	
Method		Containers:	

[X] Preservatives added: Standard → Sulfuric Acid
VOAs EPA Preserved

Method		Containers:	
Method		Containers:	
Method		Containers:	
Method		Containers:	

9 [X] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest
} EPA

10 [ ] OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW 124
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/7/96, 1996 ~~1408~~ a.m./[✓ p.m.]
SAMPLE COLLECTED BY: RN/JH/[✓ BH] of Parsons ES 1440 Smit
WEATHER: Clear, Sunny, Warm, 80's F
DATUM FOR WATER DEPTH MEASUREMENT (Describe):
Water: 14.21 Top PVC
T.D: 22.05 Top PVC

MONITORING WELL CONDITION:
[✓] LOCKED: [ ] UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: NA - Man box - good
INNER PVC CASING CONDITION IS: GOOD
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[✓] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):
Depth taken from top of PVC well casing on north side

Check-off
1 [✓] EQUIPMENT CLEANED BEFORE USE WITH Alconox & water ~~Water level indicator #17313 REG~~
Items Cleaned (List): Peristaltic tubing deconed, Waterlevel indicator

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 14.21 Top PVC FT. BELOW DATUM
Measured with: Solinst #17313

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: None
Other Comments:

4 [X] WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 4.2 gallons
Observations: Water (slightly - very) cloudy Clear
Water level (rose - fell - no change) No odor
Water odors: None
Other comments:

Casing Volume = 1.3
Purge Volume = 3.9

Time	Volume	pH	temp.	EC	mv	DO
1412	1.0 gal.	7.30	16.1 °C	NR	53.8	4.46 mg/L
1419	2.0	7.29	15.9	NR	56.5	4.39
1422	3.0	7.3	15.9	NR	61.5	4.32
1437	4.0	7.35	15.7	NR	64.8	4.37

pump on 1440

Groundwater Sampling Record

Monitoring Well No. MW 124 (Cont'd)

5 [X] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [X] ON-SITE MEASUREMENTS:

Temp: 15.7 ° C	Measured with: YSI 55
pH: 7.35	Measured with: Orion 250A
Conductivity: NR	Measured with: NR
Dissolved Oxygen: 4.32	Measured with: YSI 55
Redox Potential: 64.8	Measured with: Orion 250A
Salinity: –	Measured with: –
Nitrate: –	Measured with: –
Sulfate: –	Measured with: –
Ferrous Iron: –	Measured with: –
Other:	

7 [X] SAMPLE CONTAINERS (material, number, size): 4 VOAs / 2x 250ml Plastic
2 x 125ml Plastic / 2 x Small Glass

8 [X] ON-SITE SAMPLE TREATMENT:

[X] None Filtration:

Method	Containers:
Method	Containers:
Method	Containers:

[X] Preservatives added: 4 VOAs → Preserved by EPA
2 small glass → 3 drops Sulfuric Acid
1 fixed 125ml Plastic - 5 drops Sulfuric Acid.

Method	Containers:
Method	Containers:
Method	Containers:
Method	Containers:

9 [X] CONTAINER HANDLING:

[✓] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest
} EPA

10 [X] OTHER COMMENTS: Tested for Dissolved Hydrogen by Brian Newell
Samples picked up by EPA

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW125
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/8/96, 1996 1515 a.m./[✓ p.m.]
SAMPLE COLLECTED BY: RN/JH/[✓ BH] of Parsons ES
WEATHER: Clear, Sunny, Hot, 90°'s
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top PVC Casing
Water = 14.56 Top PVC 4" Well
T.D. = 27.0 Top PVC

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe): Top PVC North Side

Check-off

1 [X] EQUIPMENT CLEANED BEFORE USE WITH Alconox/Water Rinse/Isopropyl/DI Water
Items Cleaned (List): Water Level Indicator/Peristaltic Tubing
Meter Probes/Flowthrough Cell

2 [X] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 14.56' Top PVC FT. BELOW DATUM
Measured with: Solinst

3 [X] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: None
Other Comments:

4 [X] WELL EVACUATION:
Method: Combination Two-stage Pump/Peristaltic Pump
Volume Removed: 25.0 gal.
Observations: Water (slightly - very) cloudy Clear
Water level (rose - fell - no change) No Odor Fell ~ 2.0'
Water odors: None
Other comments:

Casing Volume = 8.1 gal.
Purge Volume = 24.3 gal.

Time	Vol.	pH	Temp	mV	EC	DO
1428	4.0	7.58	14.9	174.5	NR	0.27
1434	8.0	7.32	14.9	162.5	NR	0.93
1440	12.0	7.35	14.9	165.2	NR	0.86*
1445	16.0	7.38	14.7	166.1	NR	1.42
1455	20.0	7.55	15.1	166.9	NR	2.32 → Suchdar
1510	25.0	7.46	15.2	165.1	NR	2.12

Groundwater Sampling Record

Monitoring Well No. 125 (Cont'd)

5 [X] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [X] ON-SITE MEASUREMENTS:

Temp: 15.2 ° C	Measured with: YSI 55
pH: 7.46	Measured with: Orion 250A
Conductivity: NR	Measured with: NR
Dissolved Oxygen: 0.86	Measured with: YSI 55
Redox Potential: 165.1	Measured with: Orion 250A
Salinity: –	Measured with: –
Nitrate: –	Measured with: –
Sulfate: –	Measured with: –
Ferrous Iron: –	Measured with: –

Other:

7 [X] SAMPLE CONTAINERS (material, number, size): 4x VOAs / 2x 250ml Plastic / 2x 125ml Plastic / 2x Small glass
1x Hydrogen Sampler

8 [X] ON-SITE SAMPLE TREATMENT:

[X] None Filtration:

Method	Containers:
Method	Containers:
Method	Containers:

[X] Preservatives added: Standard Set (Sulfuric Acid)
VOAs Prepreserved by EPA

Method	Containers:
Method	Containers:
Method	Containers:
Method	Containers:

9 [X] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest } EPA

10 [ ] OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW126
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/8/96, 1996 1710 a.m./[✓ p.m.]
SAMPLE COLLECTED BY: RN/JH/[✓ BH] of Parsons ES
WEATHER: Sunny, Hot, 90's F
DATUM FOR WATER DEPTH MEASUREMENT (Describe):
Water = 25.30 TPVC
T.D = 41.0 TPVC

MONITORING WELL CONDITION:
[ ] LOCKED: ☒ UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe): Top of PVC - North Side

Check-off

1 ☑ EQUIPMENT CLEANED BEFORE USE WITH Alconox / Water / Distilled Water
Items Cleaned (List): Two Stage Purge Pump & Hose
Water level Indicator

2 ☑ PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 25.30' TPVC FT. BELOW DATUM
Measured with: Solinst

3 ☑ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Cloudy Yellowish Brown
Odor: None Slightly Cloudy after 10gal.
Other Comments:

4 ☑ WELL EVACUATION:
Method: Two-Stage Purge Pump
Volume Removed: 31 gallons
Observations: Water ([✓ slightly] - very) cloudy Slighty Cloudy
Water level (rose - [✓ fell] - no change) — Fell
Water odors: None
Other comments:

4" Well
Casing Volume = 10.2
Purge Volume = 30.7

Time	Vol.	pH	Temp	mv	DO	
1622	2.0 gal.	7.04	14.9	67.5	1.10	
1632	10.0 gal.	7.46	14.5	43.0	1.09	
1645	20.0 gal.	7.58	14.6	29.3	1.75	Clear
1700	30.0 gal.	7.8[illegible]	14.5	39.4	1.72	
1705	31.0 gal	7.62	14.5	31.6	1.70	

Groundwater Sampling Record

Monitoring Well No. MW1260 (Cont'd)

5 [X] SAMPLE EXTRACTION METHOD:

[X] Bailer made of: Polyethylene Disposable
[ ] Pump, type:
[ ] Other, describe:

Sample obtained is [X] GRAB [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

Temp:	14.5 °C	Measured with: YSI 55
pH:	7.62	Measured with: Orion 250A
Conductivity:	NR	Measured with: NR
Dissolved Oxygen:	1.70	Measured with: YSI 55
Redox Potential:	31.6	Measured with: Orion 250A
Salinity:	–	Measured with: –
Nitrate:	–	Measured with: –
Sulfate:	–	Measured with: –
Ferrous Iron:	–	Measured with: –

Other:

7 [X] SAMPLE CONTAINERS (material, number, size): 4 VOAs / 2x 250ml Plastic
2x 125 ml Plastic / 2x Small glass

8 [X] ON-SITE SAMPLE TREATMENT:

[X] None Filtration:

Method	Containers:
Method	Containers:
Method	Containers:

[X] Preservatives added: Standard → VOAs EPA Preserved
Glass Syum Jars - 3 drops sulfuric Acid

Method	Containers:
Method	Containers:
Method	Containers:
Method	Containers:

9 [X] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped } EPA
[ ] Containers Placed in Ice Chest }

10 [ ] OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW127
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/9/96, 1996 0900 [✓ a.m.]/p.m.
SAMPLE COLLECTED BY: RN/JH/[✓ BH] of Parsons ES
WEATHER: Clear, Sunny, Cool 60-65° F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top PVC Casing
16.18 TPVC
26.15 TPVC

MONITORING WELL CONDITION:

☐ LOCKED: ☒ UNLOCKED
WELL NUMBER (IS - [✓ IS NOT]) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM ([✓ IS] - IS NOT) APPARENT (Vague Mark)
☒ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR MARK ON NORTH SIDE
☐ MONITORING WELL REQUIRED REPAIR (describe):

4" Well w/ dedicated Pump (removed for Sampling)

Check-off

1 ☒ EQUIPMENT CLEANED BEFORE USE WITH
Items Cleaned (List): Alconox / Tap water → Two stage Pump & Tubing → Final DI water Rinse
Alconox / DI water / Isopropyl / DI water → Water Level Indicator / Peristaltic Tubing

2 ☒ PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 16.18' TPVC FT. BELOW DATUM
Measured with: Solinst

3 ☒ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear - Sl. Cloudy Brown
Odor: None
Other Comments:

4 ☒ WELL EVACUATION:
Method: Two Stage Pump to 20 gallons / Peristaltic to 24 gallons
Volume Removed: 24 gallons
Observations: Water (slightly - very) cloudy Clear to Slightly Cloudy
Water level (rose - [✓ fell] - no change)
Water odors: None
Other comments:

Casing Volume = 6.3 gal.
Purge Volume = 19.5 gal.

0741 → Pumped 6.0 gal.
0755 → Pumped 20.0 gal. → Set up Peristaltic Pump

Time	Vol.	pH	Temp.	MV	DO
0825	21.0	7.00	15.1	254.4	1.10
0835	22.0	7.12	14.9	243.8	2.48
0845	23.0	7.15	15.1	214.6	3.21
0850	23.5	7.19	15.3	217.9	3.31
0855	24.0	7.17	15.1	210.2	~~[illegible]~~ 2.90

Groundwater Sampling Record

Monitoring Well No. MW 127 (Cont'd)

5 [X] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [X] ON-SITE MEASUREMENTS:

Temp: 15.1 ° C — Measured with: YSI 55
pH: 7.17 — Measured with: Orion 250A
Conductivity: NR — Measured with: NR
Dissolved Oxygen: 2.48 — Measured with: YSI 55
Redox Potential: 210.2 — Measured with: Orion 250A
Salinity: – — Measured with: –
Nitrate: – — Measured with: –
Sulfate: – — Measured with: –
Ferrous Iron: – — Measured with: –
Other:

7 [X] SAMPLE CONTAINERS (material, number, size): 4x Voas / 2x 250 ml Plastic
2x 125 ml Plastic / 2x Syrum Glass Bottles
Dissolved H2 Bottle
PAHs - 1-Liter Amber / 250 ml Amber

8 [X] ON-SITE SAMPLE TREATMENT:

[X] None Filtration:
Method Containers:
Method Containers:
Method Containers:

[X] Preservatives added: EPA Preserved
3 drops Sulfuric acid in Glass Syrum Bottles
5 drops in Fixed 125 ml Plastic
Method Containers:
Method Containers:
Method Containers:
Method Containers:

9 [X] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped } EPA
[ ] Containers Placed in Ice Chest } EPA

10 [ ] OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW12B
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/9/96, 1996 1020 [✓ a.m.]/p.m.
SAMPLE COLLECTED BY: RN/JH/[✓ BH] of Parsons ES
WEATHER: Clear, Sunny, Warm; 75-80° F
DATUM FOR WATER DEPTH MEASUREMENT (Describe):
18.15 TPVC
51.0 TPVC

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM ([✓ IS] - IS NOT) APPARENT → Mark on North Side of PVC
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [X] EQUIPMENT CLEANED BEFORE USE WITH Alconox/Water Rinse/Distilled Rinse
Items Cleaned (List): Water level Indicator/Two-Stage Purge Pump
(Sample w/ Disposable Bailer)

2 [X] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 18.15 TOVC FT. BELOW DATUM
Measured with: Solinst

3 [X] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Slightly cloudy
Odor: None
Other Comments:

4 [X] WELL EVACUATION:
Method: Two-Stage Purge Pump
Volume Removed: 22 gal.
Observations: Water (slightly - very) cloudy Clear to slightly cloudy
Water level (rose [✓ fell] no change) → Pumped dry, slow to recharge
Water odors: None
Other comments:

Casing Volume = 21.4 gal.
Purge Volume = 64.3 gal.
Start Purge Pump @ 0805 → Pump ~ 18 gal. → Pumped Dry @ 0833 / water at 46.2'
0845 water @ 45.1' (very slowly rising) → can't pump below 45-47' 0945 → Rose to 42.6' (2.5' in one hour)

Time	Vol	pH	Temp	mV	DO
1000		7.54	16.7°C	148.4	1.65
1016	21.0 gal. 22.0	7.57	16.7	116.6	2.07

Sample w/ Disposable Bailer

Groundwater Sampling Record

Monitoring Well No. MW 12B (Cont'd)

5 [X] SAMPLE EXTRACTION METHOD:

[X] Bailer made of: Polyethylene Disposable Bailer
[ ] Pump, type:
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [X] ON-SITE MEASUREMENTS:

Temp: 16.7 ° C	Measured with: YSI 55
pH: 7.57	Measured with: Orion 250A
Conductivity: NR	Measured with: NR
Dissolved Oxygen: 1.65	Measured with: YSI 55
Redox Potential: 116.6	Measured with: Orion 250A
Salinity: –	Measured with: –
Nitrate: –	Measured with: –
Sulfate: –	Measured with: –
Ferrous Iron: –	Measured with: –

Other:

7 [X] SAMPLE CONTAINERS (material, number, size): 4x VOAs / 2x 250ml. Plastic
2x 125 ml Plastic / 2 glass syrum Jars

8 [X] ON-SITE SAMPLE TREATMENT:

[X] None Filtration:

Method Containers:
Method Containers:
Method Containers:

[X] Preservatives added: Standard + Added by EPA or Sulfuric Acid

Method Containers:
Method Containers:
Method Containers:
Method Containers:

9 [X] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped } EPA
[ ] Containers Placed in Ice Chest }

10 [ ] OTHER COMMENTS: Pumped Dry several Times → Very slow Recharge
(<2.5'/hr.)

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MP129
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/10/96, 1996 1605 a.m./[✓ p.m.]
SAMPLE COLLECTED BY: RN/JH/[✓ BH] of Parsons ES
WEATHER: Clear, Sunny, Hot, 90°s
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top of PVC Casing - North Side
Water @ 52.31 TPVC
TD @ 64.1 TPVC

MONITORING WELL CONDITION:
[ ] LOCKED: ☒ UNLOCKED
WELL NUMBER (IS - [✓ IS NOT]) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - IS [✓ NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):
Took levels from North Side PVC Casing

Check-off

1 [✓] EQUIPMENT CLEANED BEFORE USE WITH Alconox / Water / Isopropyl / Water
Items Cleaned (List): Teflon Bailer ; Two Stage Pump
Water level Indicator
(New bailing rope)

2 [X] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 52.31 Top PVC FT. BELOW DATUM
Measured with: Solinst

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Cloudy Reddish Brown
Odor: None
Other Comments:

4 [✓] WELL EVACUATION:
Method: Hand Bailed
Volume Removed: ~20 gallons
Observations: Water (slightly - [✓ very] cloudy) Reddish Brown
Water level (rose - fell - [✓ no change])
Water odors: None
Other comments:

Note: Tried to use two stage pump but would not pump below 52-53'. Hand Bailed for 90+ minutes, got ~20 gallons

Groundwater Sampling Record

Monitoring Well No. MW-29 (Cont'd)

5 [X] SAMPLE EXTRACTION METHOD:

[X] Bailer made of: Teflon
[ ] Pump, type:
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [X] ON-SITE MEASUREMENTS:

Temp:	16.5 ° C	Measured with: YSI 55
pH:	7.58	Measured with: Orion 250A
Conductivity:	NR	Measured with: NR
Dissolved Oxygen:	4.52	Measured with: YSI 55
Redox Potential:	39.6	Measured with: Orion 250A
Salinity:	–	Measured with: –
Nitrate:	–	Measured with: –
Sulfate:	–	Measured with: –
Ferrous Iron:	–	Measured with: –
Other:		

7 [X] SAMPLE CONTAINERS (number, size): 4x VOAs | 2x 250ml Plastic
2x 125 ml Plastic | 2x Glass Syn Jar

8 [X] ON-SITE SAMPLE TREATMENT:

[X] None Filtration:

Method	Containers:
Method	Containers:
Method	Containers:

[X] Preservatives added: VOAs prepreserved by EPA
Glass Syn Jar - Sulfuric Acid

Method	Containers:
Method	Containers:
Method	Containers:
Method	Containers:

9 [X] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped } EPA
[ ] Containers Placed in Ice Chest }

10 [ ] OTHER COMMENTS: Hand delivered to EPA Mobile Lab, last sample they would collect.

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW130
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/9/96, 1996 17 15 a.m./p.m. 4" Well
SAMPLE COLLECTED BY: RN/JH/[✓ BH] of Parsons ES
WEATHER: Water = 58.64' TPVC (Sunny, Hot)
DATUM FOR WATER DEPTH MEASUREMENT (Describe):
T.D = 65.5 Top PVC Water @ 58.64' Top PVC
6.86' Sat. watercolumn

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER (IS - [✓ IS NOT]) APPARENT
STEEL CASING CONDITION IS: Fair
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):
levels taken North Side PVC
Cleaned up flush mount → it probably leaks

Check-off
1 [X] EQUIPMENT CLEANED BEFORE USE WITH Alconox / Distilled Water
Items Cleaned (List): Teflon Bailer / Water Level Indicator

2 [X] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 58.64' Top PVC FT. BELOW DATUM
Measured with: Solinst

3 [X] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Very Cloudy Reddish Brown
Odor: None
Other Comments:

4 [X] WELL EVACUATION:
Method: Hand Bailed
Volume Removed: 13.5 gallons
Observations: Water (slightly [✓ very]) cloudy
Water level (rose [✓ fell] no change) → Fell up to 2' but recharged every 5-10 minutes
Water odors: None
Other comments:

Casing Volume = 4.5 gal.
Purge Volume = 13.4 gal.

Time	Vol.	pH	Temp.	EC	mV	DO
1600	4.0 gal.	7.86	15.2	NR	143.2	5.01
1620	8.0 gal.	7.81	15.3	NR	145.9	4.95
1648	12.0	7.75	15.2	NR	140.1	4.90
1705	13.5	7.71	15.0	NR	136.9	5.07

Groundwater Sampling Record

Monitoring Well No. MW130 (Cont'd)

5 [X] SAMPLE EXTRACTION METHOD:

[X] Bailer made of: Teflon
[ ] Pump, type:
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [X] ON-SITE MEASUREMENTS:

Temp: 15.0 ° C — Measured with: YSI 55
pH: 7.74 — Measured with: Orion 250A
Conductivity: NR — Measured with: NR
Dissolved Oxygen: 4.90 — Measured with: YSI 55
Redox Potential: 136.9 — Measured with: Orion 250A
Salinity: – — Measured with: –
Nitrate: – — Measured with: –
Sulfate: – — Measured with: –
Ferrous Iron: – — Measured with: –
Other:

7 [X] SAMPLE CONTAINERS (material, number, size): 4x VOAs / 2x 250ml Plastic / 2x 125 ml Plastic / 2x glass syringes

8 [X] ON-SITE SAMPLE TREATMENT:

[X] None Filtration:
Method Containers:
Method Containers:
Method Containers:

[X] Preservatives added: VOAs - EPA Preserved
Method Syringe Jars Containers: 3 drops sulfuric
Method 125 ml plastic Containers: 5 drops sulfuric
Method Containers:
Method Containers:

9 [X] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped } EPA
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL Mw 133
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/7/96, 1996 1320 a.m./[✓ p.m.]
SAMPLE COLLECTED BY: RN/JH/[✓ BH] of Parsons ES
WEATHER: Clear, Sunny, Hot 85° F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top PVC - North Side
Top Water: 29.20
T.D: 34.80

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT - North Side
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [X] EQUIPMENT CLEANED BEFORE USE WITH Alconox / Distilled water
Items Cleaned (List): Two-stage Pump & Tubing; Meter Probes; + bucket flow through cell

2 [X] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 29.20' FT. BELOW DATUM
Measured with: Solinst

3 [X] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Very Muddy Reddish brown
Odor: None
Other Comments:

4 [X] WELL EVACUATION:
Method: Two-stage Pump
Volume Removed: 8.5 gal.
Observations: Water (slightly - [✓ very]) cloudy Very Murky Reddish Brown
Water level (rose - [✓ fell] - no change) → Pumped dry, slow to recover
Water odors: None
Other comments:

Casing Volume = 3.66 gal.
Purge Volume = 11.0 gal.

Time	Vol.	pH	Temp	EC	mv	DO
1235	4.0	7.05	15.4°C	NR	167.2	3.80
Bailed dry at 4.5 gal. / Water at 32.5' at 1239						
1255	7.0	6.96	15.5°C	NR	-31.0	3.98
Bailed Dry at 7.0 gallons						
1305	8.5	6.87	15.5°C	NR	-21.0	4.27
Dry at 8.5 - Quit Purging						

Groundwater Sampling Record

Monitoring Well No. MW 133 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[✓] Bailer made of: Polyethylene
[ ] Pump, type:
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

Temp:	15.5 °C	Measured with:	YSI 55
pH:	6.87	Measured with:	Orion 250A
Conductivity:	NR	Measured with:	–
Dissolved Oxygen:	3.80 mg/L	Measured with:	YSI 55
Redox Potential:	-21.0	Measured with:	Orion 250A
Salinity:	–	Measured with:	–
Nitrate:	–	Measured with:	–
Sulfate:	–	Measured with:	–
Ferrous Iron:	–	Measured with:	–

Other:

7 [✓] SAMPLE CONTAINERS (material, number, size): 4 VOAs | 2x 250 ml Plastic
2x 125 ml Plastic
2 small Glass

8 [✓] ON-SITE SAMPLE TREATMENT:

[✓] None Filtration:

Method		Containers:	
Method		Containers:	
Method		Containers:	

[✓] Preservatives added: Standard Sample Set
VOAs EPA Preserved
Sulfuric Acid for Glass Syn Jars

Method		Containers:	
Method		Containers:	
Method		Containers:	
Method		Containers:	

9 [✓] CONTAINER HANDLING:

[✓] Container Sides Labeled
[ ] Container Lids Taped } EPA
[ ] Containers Placed in Ice Chest }

10 [ ] OTHER COMMENTS: ~~[illegible]~~ (BMH) Samples Picked up by EPA

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-134
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/7, 1996 1030 [✓ a.m.]/p.m.
SAMPLE COLLECTED BY: [✓ RN/JH/BH] of [✓ Parsons ES]
WEATHER: Sunny 60°-65°
DATUM FOR WATER DEPTH MEASUREMENT (Describe):

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS [✓ IS NOT]) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS [✓ IS NOT]) APPARENT
[X] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR DATUM + well number
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [✓] EQUIPMENT CLEANED BEFORE USE WITH Isopropyl + distilled water
Items Cleaned (List): probes, peristaltic tubing

2 [✓] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

25.5
16.9
8.6
4.3

WATER DEPTH 16.91' TOC FT. BELOW DATUM
Measured with: ~~Solinst~~ water level indicator

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments: —

4 [✓] WELL EVACUATION:
Method: Peristaltic pump (Begin 922)
Volume Removed: 5 gallons
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

time	930	9:45	1000	10:15	1030
(mg/L) DO	5.1	4.7	4.9	5.0	5.0
pH	7.11	6.98	7.01	6.94	6.94
(°C) Temp	17.3	17.3	17.2	17.2	17.3
(µS/cm) cond	91×10	92×10	93×10	93×10	94×10
(mV) redox	118.7	212.2	206.1	218.2	216.0

Groundwater Sampling Record

Monitoring Well No. MW134 (Cont'd)

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS: (Final)

Temp:	17.3 °C	Measured with: Orion 840
pH:	6.94	Measured with: Orion 250A
Conductivity:	9610 (µS/cm)	Measured with: Oyster
Dissolved Oxygen:	5.0 (mg/L)	Measured with: Orion 840
Redox Potential:	216.0 (mV)	Measured with: Orion 250A
Salinity:		Measured with:
Nitrate:		Measured with:
Sulfate:		Measured with:
Ferrous Iron:		Measured with:

Other: Lowest DO Reading = 4.7 mg/L

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs
2x Glass Syrup Jar
2x 125 ml Quality
2x 250 ml Plastic

8 [✓] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: None

	Method	Containers:
	Method	Containers:
	Method	Containers:

[✓] Preservatives added:

Method Sulfuric Acid	Containers: 2x Glass Syrup Jar
Method	Containers: 1x 125 ml Plastic
Method	Containers:
Method	Containers:

9 [✓] CONTAINER HANDLING:

[✓] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Samples handled by EPA

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-35
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/16/96, 1996 1330 a.m./p.m.
SAMPLE COLLECTED BY: RN/JH/[✓ BH] of Parsons ES
WEATHER: Clear, Sunny, Hot 90's
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top PVC - North Side
Water Level = 10.22 TPVC
T.D. = 30.3 TPVC

MONITORING WELL CONDITION:
[ ] LOCKED: ☒ UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe): North Side PVC
2" Well w/ dedicated Pump

Check-off
1 ☒ EQUIPMENT CLEANED BEFORE USE WITH Alconox / Water / Isopropyl / Distilled H2O
Items Cleaned (List): New Peristaltic Tubing & Hose
Water level Indicator

2 ☒ *PRODUCT DEPTH* FT. BELOW DATUM
Measured with: NA

WATER DEPTH 10.22' Top PVC FT. BELOW DATUM
Measured with: Solinst

3 ☒ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear-Sl Cloudy
Odor: None
Other Comments:

4 ☒ WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 10 gallons
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - [✓ fell] - no change) → Less than 2' change
Water odors: None
Other comments:

Casing Volume = 3.27 gal.
Purge Volume = 9.8 gal.

Time	Vol.	pH	Temp	mv	DO
1250	3.0	7.43	16.4°C	-98.2	0.34 mg/L
1310	6.0	7.43	16.0	-113.7	0.28
1325	9.0	7.44	15.9	-134.4	0.28
1330	10.0	7.44	16.5	-143.3	0.41

Groundwater Sampling Record

Monitoring Well No. MW 135 (Cont'd)

5 ☒ SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
☒ Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 ☒ ON-SITE MEASUREMENTS:

Temp: 15.9 ° C — Measured with: YSI 55
pH: 7.44 — Measured with: Orion 250A
Conductivity: NR — Measured with: NR
Dissolved Oxygen: 0.28 — Measured with: YSI 55
Redox Potential: -143.3 — Measured with: Orion 250A
Salinity: – — Measured with: –
Nitrate: – — Measured with: –
Sulfate: – — Measured with: –
Ferrous Iron: – — Measured with: –
Other:

7 ☒ SAMPLE CONTAINERS (material, number, size):

8 ☒ ON-SITE SAMPLE TREATMENT:

☒ None Filtration:
Method — Containers:
Method — Containers:
Method — Containers:

☒ Preservatives added: VOAs - EPA Preserved

Method Syringe Sys — Containers: 3 drops Sulfuric Acid
Method 1x 125ml — Containers: 5 drops Sulfuric
Method — Containers:
Method — Containers:

9 ☒ CONTAINER HANDLING:

☒ Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

} EPA

10 [ ] OTHER COMMENTS: Collected Dissolved H_2 Samples

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-136
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/8, 1996 0850 [✓ a.m.]/p.m.
SAMPLE COLLECTED BY: RN/[✓ JH]/BH of Parsons ES
WEATHER: Clear, breezy, 10-20mph, Cool (~60°F)
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [✓] EQUIPMENT CLEANED BEFORE USE WITH Alconox Solution, DI H2O
Items Cleaned (List): Water level meter

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 7.86' TOC FT. BELOW DATUM
Measured with: Solinst water level indicator

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: none
Other Comments:

4 [✓] WELL EVACUATION:
Method: Peristaltic pump Start 0753
Volume Removed: 5 gal
Observations: Water (slightly - very) cloudy Clear
Water level (rose - [✓ fell] - no change)
Water odors: None
Other comments: New Silicone Tubing on pump

Purge volume = 5 gal
(3 casing volumes)

	0820	0835	0850
DO	3.3	3.8*	3.9
Redox	172	161	160
pH	7.55	7.50	7.53
Temp	19.3	19.2	19.2
Cond	95×10	92×10	92×10

*YSI DO meter reads 3.6 mg/L

Groundwater Sampling Record

Monitoring Well No. MW-136 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

Temp:	19.2 °C	Measured with: Orion 840
pH:	7.53	Measured with: Orion 250
Conductivity:	920	Measured with: Oyster
Dissolved Oxygen:	3.3 mg/l (Lowest Reading)	Measured with: Orion 840
Redox Potential:	100	Measured with: Orion 250
Salinity:		Measured with:
Nitrate:		Measured with:
Sulfate:		Measured with:
Ferrous Iron:		Measured with:

Other:

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs
2x Glass Syrum Jars
2x 250ml Plastic
2x 125ml. Plastic

8 [✓] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: None

Method		Containers:
Method		Containers:
Method		Containers:

[✓] Preservatives added:

Method	Sulfuric Acid	Containers: 2x Glass Syrum Jars,
Method		Containers: 1x 125 ml. Plast.
Method		Containers:
Method		Containers:

9 [✓] CONTAINER HANDLING:

[✓] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA Handled Samples

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-177 (number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/9, 1996 1225 a.m. [✓ p.m.]
SAMPLE COLLECTED BY: RN/JH/BH of Parsons ES
WEATHER: Sunny, hot (~90°F), calm
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM ([✓ IS] - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [✓] EQUIPMENT CLEANED BEFORE USE WITH Alconox Solution, DI H2O
Items Cleaned (List): Water level probe

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 6.06' TOC FT. BELOW DATUM
Measured with: Solinst Water level meter

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear to sl. cloudy
Odor: None
Other Comments:

4 [✓] WELL EVACUATION:
Method: Peristaltic Pump (Start 1136)
Volume Removed: 5 gal
Observations: Water (slightly - very) cloudy
Water level (rose - [✓ fell] - no change)
Water odors: None
Other comments: No effervescence as in MW-138

3 casing Volumes = 5 gal

DO (mg/L)	Redox (mV)	Temp (oC)	pH	Cond (mS/cm)	Time	Vol (gal)
1.0/0.12	106	19.6	6.71	104x10	1150	1/2 gal
1.5/1.17	111	19.6	6.89	102x10	1205	2 gal
1.7/1.4	111	19.7	6.84	104x10	1215	4 gal

Groundwater Sampling Record

Monitoring Well No. MW-137 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[✓] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

See previous page

Temp: 19.7 ° C	Measured with: Orion 840
pH: 6.84	Measured with: Orion 250A
Conductivity: 1040	Measured with: Oyster
Dissolved Oxygen: 1.7 mg/L	Measured with: Orion 840
Redox Potential: 111	Measured with: Orion 250A
Salinity:	Measured with:
Nitrate:	Measured with:
Sulfate:	Measured with:
Ferrous Iron:	Measured with:
Other:	

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs
2x Glass Syrup Jars
2x 125 ml Plastic
2x 250 ml Plastic

8 [✓] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: None

Method	Containers:
Method	Containers:
Method	Containers:

[✓] Preservatives added:

Method Sulfuric Acid	Containers: 2x Glass Syrup Jars
Method	Containers: 1x 125 ml Plastic
Method	Containers:
Method	Containers:

9 [✓] CONTAINER HANDLING:

[✓] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Duplicate = MW-137a (all parameters)
EPA Handed Samples

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-138 (number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/9, 1996 1050 [✓ a.m.]/p.m.
SAMPLE COLLECTED BY: RN/[✓ JH]/BH of Parsons ES
WEATHER: Clear, warm (~70°F), breezy
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[ ] LOCKED: ☒ UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM ([✓ IS] - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [✓] EQUIPMENT CLEANED BEFORE USE WITH Alconox Solution, DI H2O
Items Cleaned (List): Water level probe

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 6.28' bgl FT. BELOW DATUM
Measured with: Solinst water level meter

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: none
Other Comments:

4 [✓] WELL EVACUATION:
Method: Peristaltic pump (start 0805)
Volume Removed: 17 gal
Observations: Water (slightly - very) cloudy
Water level (rose - [✓ fell] - no change)
Water odors:
Other comments:

3 casing volume = 17 gal

1030 7.35 ~~JRH 73~~ 16.0 730 -122 0.6/0.14* 16 gal

	pH	Temp (°C)	Cond (µS/cm)	Redox (mV)	DO (mg/L)	Approx. Vol
0831	7.29	16.1	750	-56	0.9/0.62*	5 gal
0904	7.24	15.9	740	-108.5	0.9/0.19*	~~Ac 7 gal~~ 6 gal
0910	7.70	16.0	~~760~~ 730	-87.9	0.5/0.17*	7 gal
0925	~~7.15~~ JRH 7.78	15.8	750	-125	0.5/0.16*	9 gal
1012	7.40	16.3	760	~~-98~~ JRH -118	0.7/0.18*	14 gal

* [illegible] Parsons YSI meter

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Page 1 of 2

Groundwater Sampling Record

Monitoring Well No. MW-138 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[✓] Pump, type: peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

See previous page

Temp: 16.0 ° C	Measured with: Orion 840
pH: 7.35	Measured with: Orion 230
Conductivity: 730	Measured with: Oyster
Dissolved Oxygen: 0.10 mg/L	Measured with: Orion 840
Redox Potential: -122	Measured with: Orion 250
Salinity:	Measured with:
Nitrate:	Measured with:
Sulfate:	Measured with:
Ferrous Iron:	Measured with:
Other:	

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs
2x Glass Syringe Jar
2x 125 ml Plastic
2x 250 ml Plastic

8 [✓] ON-SITE SAMPLE TREATMENT:

[ ] Filtration:

Method	Containers:
Method	Containers:
Method	Containers:

[✓] Preservatives added:

Method Sulfuric Acid	Containers: 2x Glass Syringe Jars,
Method	Containers: 1x 125 ml Plastic
Method	Containers:
Method	Containers:

9 [✓] CONTAINER HANDLING:

[✓] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest
} EPA

10 [ ] OTHER COMMENTS: Water has some effervescence - hard to get bubble-free VOC samples. Note: Collected VFA Sample on 8/10/96 @ ~ 0930 am. When removing well cap, there was a burst of air from the well.

GROUNDWATER SAMPLING RECORD

17.15' Toc = T.D.

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-139
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: Aug 6, 1996 1045 a.m./p.m.
SAMPLE COLLECTED BY [✓ RN/JH/BH] of Parsons ES
WEATHER: Clear, Warm, 70's (°F)
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top of Casing

MONITORING WELL CONDITION:
- [✓] LOCKED: [ ] UNLOCKED
- WELL NUMBER (IS - [✓ IS NOT]) APPARENT
- STEEL CASING CONDITION IS: Good
- INNER PVC CASING CONDITION IS: Good
- WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
- [ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR → Well labeled
- [ ] MONITORING WELL REQUIRED REPAIR (describe): Lots of salt deposits at wellhead

Check-off

1 [✓] EQUIPMENT CLEANED BEFORE USE WITH Soap Solution, DI H_2O, isopropyl rinse
Items Cleaned (List): Waterlevel meter

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 6.99' Toc FT. BELOW DATUM
Measured with: Solinst waterlevel indicator

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: None
Other Comments:

4 [✓] WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 5 gallons
Observations: Water (slightly - very) cloudy Clear to sl cloudy
Water level (rose - [✓ fell] - no change)
Water odors: None
Other comments: H_2O @ 14.6' Toc @ ~1015; 13.8' Toc @ 1027

3 casing volumes = 4.9 gal

	~1/4 gal 0957	~3 gal 1027	~3.5 gal
pH	7.07	7.27	7.44
DO(mg/L)	1.01	1.2	3.2
Temp(°C)	18.5	17.7	18.5
EC(uS/cm)	108×10	100×10	91×10
redox(mv)	69	40	[illegible]84

1:00 ✓ Check on DO reading against EPA DO meter - EPA's reads 0.7mg/L - ours read 0.92

Groundwater Sampling Record

Monitoring Well No. MW139 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS: (Final)

Temp: 18.5 °C	Measured with: Orion 840
pH: 7.49	Measured with: Orion 250A
Conductivity: 910 µS/cm	Measured with: Oyster
Check → Dissolved Oxygen: 3.2 mg/L	Measured with: Orion 840
Redox Potential: 84	Measured with: Orion 250A
Salinity:	Measured with:
Nitrate:	Measured with:
Sulfate:	Measured with:
Ferrous Iron:	Measured with:

Other:

7 [✓] SAMPLE CONTAINERS (material, number, size): 4 x VOAs / 2 x Glass Syrup Jars
2 x 250 ml Plastic / 2 x 125 ml. Plastic

8 [✓] ON-SITE SAMPLE TREATMENT:

[✓] None Filtration:

Method	Containers:
Method	Containers:
Method	Containers:

[✓ Preservatives added:

Method Glass Syrup Jars	Containers: Sulfuric Acid
Method 1 x 125 ml. Plastic	Containers: "
Method	Containers:
Method	Containers:

9 [✓] CONTAINER HANDLING:

☒ Container Sides Labeled
☐ Container Lids Taped
☐ Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: EPA handled samples
Had to shut off pump @ ~1026 to allow well to recharge

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU2
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-40
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/8, 1996 1700 a.m./[✓ p.m]
SAMPLE COLLECTED BY: RN/JH/BH of Parsons ES
WEATHER:
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top of pump cap - dedicated pump in well - could not remove.

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS:
INNER PVC CASING CONDITION IS:
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [✓] EQUIPMENT CLEANED BEFORE USE WITH Alconox / Isopropyl / Distilled H2O
Items Cleaned (List): Water level Indicator

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 6.78' TOC FT. BELOW DATUM
Measured with: Solinst

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance:
Odor:
Other Comments:

4 [✓] WELL EVACUATION:
Method: Peristaltic Pump (Start 1620)
Volume Removed: 4.5 gal.
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors:
Other comments:

	1630 (~1.5 gal)	1655 (~3.5 gal)	1705 (4.5 gal)
DO (mg/L)	2.5/1.8*	3.9/3.8**	3.8/3.7*
Redox (mV)	166	151	92
pH	7.34	7.64	7.50
Temp (°C)	19.9	19.3	19.3
Cond (uS/Cm)	8710	8810	9210

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* EPA Orig. Meter / Parsons YSI meter

200 [illegible] Titration Field Kit = 0.3 mg/L

[illegible]

Groundwater Sampling Record

Monitoring Well No. MW 140 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[✓] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

Temp: 19.3 °C	Measured with: YSI 55
pH: 7.50	Measured with: Orion 250A
Conductivity: 920	Measured with: Oyster
Dissolved Oxygen: 3.7 mg/L	Measured with: YSI 55
Redox Potential: 92	Measured with: Orion 250A
Salinity:	Measured with:
Nitrate:	Measured with:
Sulfate:	Measured with:
Ferrous Iron:	Measured with:

Other:

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs
2x Glass Syrup Jars
2x 125 ml Plastic
2x 250 ml Plastic

8 [✓] ON-SITE SAMPLE TREATMENT:

[ ] *Filtration:* None

	Method	Containers:
	Method	Containers:
	Method	Containers:

[✓] Preservatives added:

Method Sulfuric Acid	Containers: 2x Glass Syrup Jars
Method	Containers: 1x 125 ml Plastic
Method	Containers:
Method	Containers:

9 [✓] CONTAINER HANDLING:

[✓] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Samples Handled by EPA

DO recalibration, continued

Oxygenated H_2O. EPA meter 6.2 - should be 6.4
Spring Water 5.6 - " " 6.4

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-141
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/7/96, 1996 0810 [✓ a.m.]/p.m.
SAMPLE COLLECTED BY: RN/JH/[✓ BH] of Parsons ES
WEATHER: Clear, Cool, Breezy, 60°F - Warming to 70° F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top of PVC
Top Water = 8.56 TPVC
T.D = 18.50' TPVC

MONITORING WELL CONDITION:

[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - [✓ IS NOT]) APPARENT
STEEL CASING CONDITION IS: Good - Intact
INNER PVC CASING CONDITION IS: Good → has dedicated Pump - Removed for sampling
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe): Taken on North Side

Check-off

1 [X] EQUIPMENT CLEANED BEFORE USE WITH Alconox Wash / Water Rinse /
Items Cleaned (List): Isopropyl Rinse / DI Water Rinse / Dry
Water level indicator; Peristaltic Tubing

2 [X] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 8.56' FT. BELOW DATUM
Measured with: Water level Indicator

3 [X] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: None
Other Comments:

4 [X] WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 5.0 gal.
Observations: Water (slightly - very) cloudy - Clear
Water level (rose - fell - no change) - Fell
Water odors: None
Other comments:

Casing Volume = 1.63 gal.
Purge Volume = 5.0 gal.

Time	Vol.	pH	Temp.	EC	mv	D.O
0735	1.0 gal.	7.43	16.82	NR	153.7	1.16
0740	2.0	7.51	17.4	NR	143.3	1.54
0747	3.0	7.39	17.9	NR	139.8	1.65
0755	4.0	7.39	18.4	NR	140.0	1.54
0805	5.0	7.41	18.2	NR	141.0	1.51

Groundwater Sampling Record

Monitoring Well No. MW-141 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

Temp:	18.2 °C	Measured with: YSI 55
pH:	7.41	Measured with: Orion 250A
Conductivity:	NR	Measured with: NR
Dissolved Oxygen:	1.51	Measured with: YSI 55
Redox Potential:	141.0	Measured with: Orion 250A
Salinity:	–	Measured with: –
Nitrate:	–	Measured with: –
Sulfate:	–	Measured with: –
Ferrous Iron:	–	Measured with: –
Other:		

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs / 2x 250 ml. Plastic
2x 125 ml plastic
2x 50 ml Glass Jars

8 [✓] ON-SITE SAMPLE TREATMENT:

[✓] None Filtration: Method ____ Containers: ____
Method ____ Containers: ____
Method ____ Containers: ____

[✓] Preservatives added: VOAs Pretreated by EPA
Small Glass Jars – 3 drops Sulfuric Acid
Method Fixed 125 ml plastic – 5 drops Sulfuric Acid Containers:
Method ____ Containers: ____
Method ____ Containers: ____
Method ____ Containers: ____

9 [✓] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped } EPA
[ ] Containers Placed in Ice Chest }

10 [ ] OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-142
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/8, 1996 1340 a.m. [✓ p.m.]
SAMPLE COLLECTED BY: RN/[✓ JH]/BH of Parsons ES
WEATHER: Sunny, hot (~90°F), calm
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [✓] EQUIPMENT CLEANED BEFORE USE WITH Alconox / Isopropyl / Distilled H2O
Items Cleaned (List): Water Level Indicator

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 12.05' TOC FT. BELOW DATUM
Measured with: Solinst Water Level meter

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: None
Other Comments:

4 [✓] WELL EVACUATION:
Method: Peristaltic Pump (Start 1237)
Volume Removed: 4 gal
Observations: Water (slightly - very) cloudy Clear
Water level (rose - fell - no change)
Water odors:
Other comments: New Silicon tubing

urge Vol - 4 gal

Time	Temp	Vol	Mv	pH	DO	Cond
1250	18.9	0.5 gal	160	7.78	2.1/1.4*	103x10
1305	18.5	2 gal	157	7.71	1.9/1.4*	110x10
1320	18.4	3 gal	140	7.42	2.0/1.04	112x10
1340	18.3	4 gal	154	7.41	1.9/1.46	110x10

* EPA DO meter / Parsons YSI meter

Groundwater Sampling Record

Monitoring Well No. MW142 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[✓] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

Temp:	18.3 °C	Measured with:	YSI 55
pH:	7.41	Measured with:	Orion 250A
Conductivity:	1110	Measured with:	Oyster
Dissolved Oxygen:	1.4 mg/L	Measured with:	YSI 55
Redox Potential:	154	Measured with:	Orion 290A
Salinity:		Measured with:	
Nitrate:		Measured with:	
Sulfate:		Measured with:	
Ferrous Iron:		Measured with:	

Other:

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs
2x Glass Syrup Jars
2x 250ml Plastic
2x 125ml Plastic

8 [✓] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: None

Method		Containers:	
Method		Containers:	
Method		Containers:	

[✓] Preservatives added:

Method	Sulfuric Acid	Containers:	2x Glass Syrup Jar
Method		Containers:	1x 125ml Plastic
Method		Containers:	
Method		Containers:	

9 [✓] CONTAINER HANDLING:

[✓] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Samples Handled by EPA

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-143
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 1434, 1996 8 August a.m./[✓ p.m.] 1996
SAMPLE COLLECTED BY: RN/[✓ IH]/BH of Parsons ES
WEATHER: Sunny, temp ~ 90° F, Humidity <20%
DATUM FOR WATER DEPTH MEASUREMENT (Describe): North side of PVC Casing.

MONITORING WELL CONDITION:
[ ] LOCKED: ☒ UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: Manbox (Al) Good
INNER PVC CASING CONDITION IS: Excellent - Dedicated pump
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[-] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 ☒ EQUIPMENT CLEANED BEFORE USE WITH Alconox & water
Items Cleaned (List): Water level indicator

2 ☒ PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 11.14' (total depth 21') FT. BELOW DATUM
Measured with: Water level. indicator #101-100-R3 Solinst # 18034

3 ☒ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: None
Other Comments:

4 ☒ WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 5 gal.
Observations: Water (slightly - very) cloudy NR
Water level (rose - fell - no change) NR
Water odors: None
Other comments:

Time	Volume	Temp	Conductivity	pH	Mv	DO	Surge volume
1450	1 gal	17.6	1270	7.63	170.7	1.3/0.77	5 gal
1459	2 gal	17.2	1160	7.6	158.9	1.8/0.80	
1508	3 gal	17.0	1220	7.53	153.1	2.1/0.87	
1516	4 gal	17.1	1140	7.45	141.3	1.8/0.89	
1527	5 gal	17.1	1220	7.55	136.2	2.0/0.97	

Groundwater Sampling Record

Monitoring Well No. MW-143 **(Cont'd)**

5 [X] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [X] ON-SITE MEASUREMENTS:

Temp:	17.1 °C	Measured with: YSI 55
pH:	7.55	Measured with: Orion 250A
Conductivity:	1220	Measured with: Extech Oyster
Dissolved Oxygen:	0.97	Measured with: YSI 55
Redox Potential:	136.2	Measured with: Orion 250A
Salinity:	–	Measured with: –
Nitrate:	–	Measured with: –
Sulfate:	–	Measured with: –
Ferrous Iron:	–	Measured with: –

Other:

7 [X] SAMPLE CONTAINERS (material, number, size): 4 x VOAs / 2 x 250ml Plastic
2 x 125ml Plastic / 2 x glass synm jars

8 [X] ON-SITE SAMPLE TREATMENT:

[ ] None Filtration:
Method Containers:
Method Containers:
Method Containers:

[X] Preservatives added: VOAs prepreserved
Glass Symn. Jars / 1 x 125 ml Plastic – Sulfuric Acid
Method Containers:
Method Containers:
Method Containers:
Method Containers:

9 [X] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped } EPA
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Samples handled by EPA

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-144
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 1440, 1996 8/7/96 a.m./[✓ p.m.]
SAMPLE COLLECTED BY: RN/JH/BH of Parsons ES
WEATHER: Clear, Sl. breeze (5-10 mph), hot (high 90's °F)
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:

[X] LOCKED: [ ] UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [✓] EQUIPMENT CLEANED BEFORE USE WITH Alconox Solution, DI H2O
Items Cleaned (List): Water level probe, Silicone tubing

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 10.76' TOC FT. BELOW DATUM
Measured with: Solinst water level indicator

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: None
Other Comments:

4 [✓] WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: Start 1335 hrs
Observations: Water (slightly - very) cloudy
Water level (rose - [✓ fell] - no change)
Water odors: None
Other comments:

3 casing volumes = 4.5 gal

		(~2.5 gal)	(~4 gal)	
	Start 1345 (~1 gal)	1402	1415	Purged 4.5 gal
DO (mg/L)	~~7.2~~ 4.1	3.9	3.8	
Redox (mV)	160	148	142	
pH	~~7.14~~ 6.98	7.26	7.26	
Temp (°C)	17.5	17.3	17.3	
Cond (mS/cm)	93×10	103×10	78×10	

Groundwater Sampling Record

Monitoring Well No. 144 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[✓] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS: See previous page

Temp: 17.3 ° C — Measured with: TSI 55 / Orion 840
pH: 7.26 — Measured with: Orion 250A
Conductivity: 980 — Measured with: Extech Oyster
Dissolved Oxygen: 3.8 mg/L — Measured with: Orion 840
Redox Potential: 142 — Measured with: Orion 250A
Salinity: — Measured with:
Nitrate: — Measured with:
Sulfate: — Measured with:
Ferrous Iron: — Measured with:
Other:

7 [✓] SAMPLE CONTAINERS (material, number, size): 4 x VOAs
2 x Glass Syrup Jars
2 x 125 ml. Plastic
2 x 250ml. Plastic

8 [✓] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: None
Method — Containers:
Method — Containers:
Method — Containers:

[✓] Preservatives added:

Method Sulfuric Acid — Containers: 2 x Glass Syrup Jars,
Method — Containers: 1 x 125 ml Plastic
Method — Containers:
Method — Containers:

9 [✓] CONTAINER HANDLING:

[✓] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Samples handled by ECA
Standing H2O in well box to top of PVC pipe — sponged out.

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-145
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/7/96, 1996 1645 a.m./p.m.
SAMPLE COLLECTED BY: RN/JH/BH of Parsons ES
WEATHER: Clear, Calm, high 80's (°F)
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:

- [X] LOCKED: [ ] UNLOCKED
- WELL NUMBER ([✓ IS] - IS NOT) APPARENT
- STEEL CASING CONDITION IS: Good
- INNER PVC CASING CONDITION IS: Good
- WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
- [ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
- [ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 [✓] EQUIPMENT CLEANED BEFORE USE WITH Alconox Solution, DI H_2O
Items Cleaned (List): Waterlevel probe, silicone tubing

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 11.78' TOC FT. BELOW DATUM
Measured with:

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: None
Other Comments: Standing H_2O in well box to top of PVC pipe - sponged out

4 [✓] WELL EVACUATION:
Method: Peristaltic Pump (Start 1550)
Volume Removed:
Observations: Water (slightly - very) cloudy Clear
Water level (rose - fell - no change)
Water odors: None
Other comments:

3 Casing Volumes = 5 gal.

	(~1/2 gal)	(~3 gal)	(5 gal)
	1558	1620	1640
DO (mg/L)	3.8	5.7*	6.1*
Redox (mV)	165	180	185
pH	7.21	7.15	7.17
Temp (°C)	18.7	18.5	18.7
Cond (µS/cm)	118 x10	112 x10	104 x10

* checked against YSI meter

Groundwater Sampling Record

Monitoring Well No. MW-145 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[✓] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

Temp: 18.7 ° C — Measured with: Orion 840
pH: 7.17 — Measured with: Orion 250
Conductivity: 1040 — Measured with: Oyster
Dissolved Oxygen: 3.8 (lowest) — Measured with: Orion 840
Redox Potential: 185 — Measured with: Orion 250
Salinity: — Measured with:
Nitrate: — Measured with:
Sulfate: — Measured with:
Ferrous Iron: — Measured with:
Other:

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs
2x Glass Syrup Jars
2x 125 ml. Plastic
2x 250 ml. Plastic

8 [✓] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: None
Method — Containers:
Method — Containers:
Method — Containers:

[✓] Preservatives added:

Method Sulfuric Acid — Containers: 2x Glass Syrup Jars,
Method — Containers: 1x 125 ml. Plastic
Method — Containers:
Method — Containers:

9 [✓] CONTAINER HANDLING:

[✓] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Samples Handled by EPA

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-146
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: August 6, 1996 1330 a.m./[✓ p.m.]
SAMPLE COLLECTED BY: RN/JH/BH of Parsons ES
WEATHER: Clear, Sunny, Warm 75-80° F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top of PVC - Not marked, taken on North Side

MONITORING WELL CONDITION:
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good - Intact
INNER PVC CASING CONDITION IS: Good - Intact
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[X] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR - North Side PVC
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [X] EQUIPMENT CLEANED BEFORE USE WITH Alconox Wash / DI Water Rinse /
Items Cleaned (List): Isopropyl Rinse / DI Rinse

2 [X] PRODUCT DEPTH None FT. BELOW DATUM
Measured with:

WATER DEPTH 3.38' below TPVC FT. BELOW DATUM
Measured with: Solinst Water Level Indicator

3 [X] WATER-CONDITION BEFORE WELL EVACUATION (Describe): → First Purge
Appearance: Clear
Odor: None
Other Comments:

4 [X] WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 6.0 gallons
Observations: Water (slightly - very) cloudy → Clear
Water level (rose - fell - no change) → Fell very slightly
Water odors: None
Other comments:

Notes: T.D = 15.40'
2" PVC
Casing Volume = 1.96 gal.
Purge Volume = 6.0 gal.

Time	Vol.	pH	EC	Temp	mv.	D.O.
1227	1.0 gal.	6.17	NR	18.9°C	185.0	3.61
1240	2.0	NR	NR	18.9°C	155.5	5.05
1247	3.0	7.45	1160	19.0°C	175	5.25
1303	4.0	7.55	1030	18.8°C	152	5.45
1313	5.0	7.63	1090	19.0	168	4.2
1325	6.0	7.58	1060	19.0	160	4.2

Note: No Conductivity Meter to start, borrowed one to finish

NOTE: Switched out DO meters, last readings w/ Orion Model 840

Groundwater Sampling Record

Monitoring Well No. MW-1416 (Cont'd)

5 [X] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic Pump
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [X] ON-SITE MEASUREMENTS:

Temp: 19.0 ° C — Measured with: YSI 55
pH: 7.58 — Measured with: Orion 250A
Conductivity: 1060 — Measured with: Oyster
Dissolved Oxygen: 4.2 mg/L — Measured with: YSI 55 / Orion 840
Redox Potential: 160 — Measured with: Orion 250A
Salinity: NR — Measured with:
Nitrate: NR — Measured with:
Sulfate: NR — Measured with:
Ferrous Iron: NR — Measured with:
Other:

7 [X] SAMPLE CONTAINERS (material, number, size): 4 VOAs / 2 200ml. Plastic
2 125ml Plastic / 2 small glass

8 [X] ON-SITE SAMPLE TREATMENT:

[ ] None Filtration:
Method — Containers:
Method — Containers:
Method — Containers:

[X] Preservatives added: (Standard for Analyses) VOAs prepreserved by EPA

Method Glass Syringe Jars — Containers: 3 drops Sulfuric
Method — Containers:
Method — Containers:
Method — Containers:

9 [X] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest } Handled by US EPA

10 [ ] OTHER COMMENTS: H2O (Level) following Sample Collection = 3.81' TOC

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-147
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/8, 1996 1120 a.m./p.m.
SAMPLE COLLECTED BY: RN/JH/BH of Parsons ES
WEATHER: Sunny, Warm (~80°F), Sl. breeze 5-10 mph
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [✓] EQUIPMENT CLEANED BEFORE USE WITH Alconox Solution + DI rinse
Items Cleaned (List): Water level probe

2 [✓] PRODUCT DEPTH N/A FT. BELOW DATUM
Measured with:

WATER DEPTH 5.57' TOC FT. BELOW DATUM
Measured with:

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: None
Other Comments:

4 [✓] WELL EVACUATION:
Method: Peristaltic Pump (Start 1040)
Volume Removed: 5 gal
Observations: Water (slightly - very) cloudy clear
Water level (rose - fell - no change)
Water odors: None
Other comments: New silicone tubing

3 casing volumes = 5 gal

	1050	1105	1115
D.O. (mg/L)	3.7	3.6	3.4
Redox (mV)	162	170	169
pH	7.50	7.46	7.49
Temp (°C)	18.6	18.6	18.8
Cond (mS/cm)	95×10	102×10	102×10

Groundwater Sampling Record

Monitoring Well No. 147 **(Cont'd)**

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[✓] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

Temp:	18.6 °C	Measured with: Orion 840
pH:	~~[illegible]~~ 7.49	Measured with: Orion 250
Conductivity:	1020	Measured with: Oyster
Dissolved Oxygen:	3.4 mg/L	Measured with: Orion 840
Redox Potential:	169	Measured with: Orion 250
Salinity:		Measured with:
Nitrate:		Measured with:
Sulfate:		Measured with:
Ferrous Iron:		Measured with:
Other:		

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs
2x Glass Syrup Jars
2x 125 ml. Plastic
2x 250 ml. Plastic

8 [✓] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: None

Method	Containers:
Method	Containers:
Method	Containers:

[✓] Preservatives added:

Method Sulfuric Acid	Containers: 2x Glass Syrup Jars
Method	Containers: 1x 125 ml. Plastic
Method	Containers:
Method	Containers:

9 [✓] CONTAINER HANDLING:

[✓] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Samples Handled by EPA

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW148
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/6/96, 1996 940 [✓ a.m.]/p.m.
SAMPLE COLLECTED BY: RN/JH/[✓ BH] of Parsons ES
WEATHER: Clear, Breezy, Warm 60-65°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top of PVC / Top of Steel Casing
Water at 50.88 Top PVC / 51.00 Top steel
T.D. at 61.40 Top PVC

MONITORING WELL CONDITION:
[ ] LOCKED: ☒ UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe): Taken at both Top PVC + Steel Casing (2" stickup well)

Check-off

1 [X] EQUIPMENT CLEANED BEFORE USE WITH Alconox/Distilled Water
Items Cleaned (List): Teflon Bailer / Water level Indicator Meter Probes + Beaker

2 [X] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 50.88' Top PVC FT. BELOW DATUM
Measured with:

3 [X] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear to Slightly Cloudy
Odor: None
Other Comments:

4 [X] WELL EVACUATION:
Method: Hand Bailed
Volume Removed: 5.3 gallons
Observations: Water (slightly - very) cloudy Slightly Cloudy
Water level (rose - fell - no change) Fell - Bailed Dry at 3.25/4.25 gal.
Water odors: None
Other comments:

Casing Volume = 1.71 gal.

Purge Volume = 5.2 gal

Time	Vol	pH	Temp	mV	DO	
0735	1.75	7.65	14.4°C	158.1	5.25 mg/L	Clear-slightly Cloudy
0750	3.50	7.67	14.1	107.2	5.75	Bailed to 61.5' at 3.25 gal.
0810	5.25	7.64	14.2	101.3	5.50	

Groundwater Sampling Record

Monitoring Well No. MW14B (Cont'd)

5 [X] SAMPLE EXTRACTION METHOD:

[X] Bailer made of: Teflon
[ ] Pump, type:
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [X] ON-SITE MEASUREMENTS:

Temp:	14.2 °C	Measured with:	YSI 55
pH:	7.64	Measured with:	Orion 250A
Conductivity:	NR	Measured with:	NR
Dissolved Oxygen:	5.25	Measured with:	YSI 55
Redox Potential:	101.3	Measured with:	Orion 250A
Salinity:	–	Measured with:	–
Nitrate:	–	Measured with:	–
Sulfate:	–	Measured with:	–
Ferrous Iron:	–	Measured with:	–
Other:			

7 [X] SAMPLE CONTAINERS (material, number, size): 4x VOAs / 2x 250ml Plastic
2x 125 ml Plastic / 2x Syrum Glass Jars

8 [X] ON-SITE SAMPLE TREATMENT:

None Filtration:

Method		Containers:	
Method		Containers:	
Method		Containers:	

[X] Preservatives added: VOAs - EPA Preserved

Method	Syrum Jars	Containers:	3 drops Sulfuric
Method	125 ml Plastic (1)	Containers:	5 drops Sulfuric
Method		Containers:	
Method		Containers:	

9 [X] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest } EPA

10 [ ] OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW 149
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/5/96, 1996 0920 [✓ a.m.]/p.m.
SAMPLE COLLECTED BY: RN/JH/[✓ RH] of Parsons ES
WEATHER: Clear, Sunny Warm 60-70°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe):
Water @ 44.26' To Top of Steel Protective Casing
43.72' to Top of PVC TD = 60.54 / 60.0

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[X] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):
Water levels taken to both Top
of Steel Casing + PVC Casing

Check-off

1 [X] EQUIPMENT CLEANED BEFORE USE WITH Alconox / Water / Isopropyl / Distilled H2O
Items Cleaned (List): Water level Indicator / Two Stage
Pump + Tubing
(Sampled w/ disposable bailer)

2 [X] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 44.26' To Top of Steel Casing FT. BELOW DATUM
Measured with: Solinst

3 [X] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear - slightly Cloudy
Odor: None
Other Comments:

4 [X] WELL EVACUATION:
Method: Two stage Pump
Volume Removed: 8 gallons
Observations: Water (slightly - very) cloudy Slightly Cloudy - Clear
Water level (rose - [✓ fell] - no change) Pumped dry at ~5.0 gallons,
Water odors: None Couldn't Pump below ~50+ fee
Other comments:

Casing Volume = 2.65 gal.
Purge Volume = 8.0 gal.

Time	Vol.	pH	Temp	mV	DO	EC	
0757	2.0 gal.	7.19	15.6°C	190.5	4.56 mg/L	NR	
0830	3.0	7.40	16.3°C	179.7	—	—	} Bubbling in
0845	5.0	7.55	16.4°	173.3	—	—	
0900	7.0	7.50	16.2°	186.5	4.58	—	
0910	8.0	7.48	16.1°	184.9	5.48	—	

Groundwater Sampling Record

Monitoring Well No. MW 149 (Cont'd)

5 ☒ SAMPLE EXTRACTION METHOD:

☒ Bailer made of: Polyethylene Disposable
[ ] Pump, type:
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 ☒ ON-SITE MEASUREMENTS:

Temp: 16.1 ° C — Measured with: YSI 55
pH: 7.48 — Measured with: Orion 250A
Conductivity: NR — Measured with: NR
Dissolved Oxygen: 4.56 — Measured with: YSI 55
Redox Potential: 189.9 — Measured with: Orion 250A
Salinity: – — Measured with: –
Nitrate: – — Measured with: –
Sulfate: – — Measured with: –
Ferrous Iron: – — Measured with:
Other:

7 ☒ SAMPLE CONTAINERS (material, number, size): 4x VOAs / 2x 250ml Plastic / 2x Syrum Jars / 2x 125ml Plastic

8 ☒ ON-SITE SAMPLE TREATMENT:

☒ None Filtration:
Method Containers:
Method Containers:
Method Containers:

☒ Preservatives added: VOAs – EPA preserved

Method Syrum Jars Containers: 3 drops Sulfuric
Method Fixed Inorganic Containers: 5 drops soln
Method Containers:
Method Containers:

9 ☒ CONTAINER HANDLING:

☒ Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

} EPA

10 [ ] OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW 150
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 081996, 1996 1430 a.m./p.m.
SAMPLE COLLECTED BY: RN/JH/[✓ BH] of Parsons ES
WEATHER: Clear Sunny, Hot, 90's
DATUM FOR WATER DEPTH MEASUREMENT (Describe):
Water 38.32 / 38.51 TPVC / Steel
T.D 57.35 TPVC

MONITORING WELL CONDITION:
[ ] LOCKED: ☒ UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe): Levels taken at both PVC + Steel

Check-off
1 ☒ EQUIPMENT CLEANED BEFORE USE WITH Alconox / Water
Items Cleaned (List): PVC Purge Bailer / Water Level Indicator

2 ☒ PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 38.32 Top PVC / 38.51 Top Steel FT. BELOW DATUM
Measured with: Solinst

3 ☒ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Slightly cloudy
Odor: None
Other Comments:

4 ☒ WELL EVACUATION:
Method: Hand Bailed
Volume Removed: 9.5 gal.
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - [✓ fell] - no change) Bailed to <3' every 2+ gallons
Water odors: None
Other comments:

Casing Volume = 3.1 gal.
Purge Volume = 9.3 gal.

Time	Vol.	pH	Temp	mV	DO
1325	40	7.59	14.7	98.3	4.52
1338	6.0	7.69	14.9	96.7	5.00
1350	8.0	7.53	14.9	97	4.89
1400	9.5	7.48	14.9	93.1	4.57

Groundwater Sampling Record

Monitoring Well No. MW150 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[✓] Bailer made of: Disposable Polyethylene Bailer
[ ] Pump, type.
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

Temp:	14.9 °C	Measured with:	YSI 55
pH:	7.48	Measured with:	Orion 250A
Conductivity:	NR	Measured with:	NR
Dissolved Oxygen:	4.52	Measured with:	YSI 55
Redox Potential:	93.1	Measured with:	Orion 250A
Salinity:	-	Measured with:	-
Nitrate:	-	Measured with:	-
Sulfate:	-	Measured with:	-
Ferrous Iron:	-	Measured with:	-

Other:

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs / 2x 250ml. Plastic / 2x 125 ml Plastic / 2x Sryum Glass Jars

8 [✓] ON-SITE SAMPLE TREATMENT:

[✓] None Filtration:

Method		Containers:	
Method		Containers:	
Method		Containers:	

[✓] Preservatives added: VOAs - EPA Preserved

Method	Sryum Glass	Containers:	3 chops Sulfuric
Method	125 ml. plastic	Containers:	5 chops Sulfuric
Method		Containers:	
Method		Containers:	

9 [✓] CONTAINER HANDLING:

[✓] Container Sides Labeled
[ ] Container Lids Taped } EPA
[ ] Containers Placed in Ice Chest }

10 [ ] OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW151
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/9/96, 1996 [redacted] a.m./[✓ p.m.]
SAMPLE COLLECTED BY: RN/JH/BH of Parsons ES 1410 ([illegible])
WEATHER: Clear, Sunny, Hot 85-90°
DATUM FOR WATER DEPTH MEASUREMENT (Describe):
2" pvc well

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER ([✓ IS] IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):
Water = 46.45 pvc 46.515 Steel
T.D. = 62.28 pvc 63.40 Steel

Check-off
1 [X] EQUIPMENT CLEANED BEFORE USE WITH Alconox / Water / Distilled Water
Items Cleaned (List): Water level Indicator / ~~Pvc~~ bailer
Teflon

2 [X] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 46.45 TPVC / 46.51 Top Steel FT. BELOW DATUM
Measured with: Solinst

3 [X] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Slighty Cloudy - Cloudy Yellowish Brown
Odor: None
Other Comments:

4 [X] WELL EVACUATION:
Method: Hand Bailed
Volume Removed: 8 gallons
Observations: Water (slightly - very) cloudy → Moderately Cloudy Brown
Water level (rose [✓ fell] no change) → Bailed to <2'
Water odors: None
Other comments:

2.58 gal. Casing Volume
7.75 gal. Purge Volume

Time	Vol.	pH	Temp	mV	DO	EC
1155	2.0	8.2	16.4	102.1	3.01	NR
1240	4.0	7.77	15.4	89.3	3.28	NR
1251	6.0	7.60	14.5	90.7	3.22	NR
1301	7.0	7.59	14.9	91.7	3.16	NR
1315	8.0	7.53	14.8	92.3	3.15	NR

1205 Bailed Dry @ 3+ gallons (<1 foot)

Bailed dry (<1 foot) at 7.0 gal

Groundwater Sampling Record

Monitoring Well No. MW151 (Cont'd)

5 ☒ SAMPLE EXTRACTION METHOD:

☒ Bailer made of: Teflon Bailer
☐ Pump, type:
☐ Other, describe:

Sample obtained is ☒ GRAB; ☐ COMPOSITE SAMPLE

6 ☒ ON-SITE MEASUREMENTS:

Temp:	14.8 °C	Measured with: YSI 55
pH:	7.53	Measured with: Orion 250A
Conductivity:	NR	Measured with: NR
Dissolved Oxygen:	3.15	Measured with: YSI 55
Redox Potential:	92.3	Measured with: Orion 250A
Salinity:	–	Measured with: –
Nitrate:	–	Measured with: –
Sulfate:	–	Measured with: –
Ferrous Iron:	–	Measured with: –
Other:		

7 ☒ SAMPLE CONTAINERS (material, number, size): 4x VOAs / 2x 250ml Plastic / 2x Syrum Glass Jars / 2x 125ml Plastic

8 ☒ ON-SITE SAMPLE TREATMENT:

☒ None *Filtration:*

Method	*Containers:*
Method	Containers:
Method	Containers:

☒ Preservatives added: VOAs – EPA Preserved

Method Syrum Jars	Containers: 3 drops Sulfuric Acid
Method 125ml Plastic	Containers: 5 drops " "
Method	Containers:
Method	Containers:

9 ☒ CONTAINER HANDLING:

☒ *Container Sides Labeled*
☐ Container Lids Taped } EPA
☐ Containers Placed in Ice Chest }

10 ☐ OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW153
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/13, 1996 1020 [✓ a.m.]/p.m.
SAMPLE COLLECTED BY: RN/[✓ JH]/BH of Parsons ES
WEATHER: Sunny, warm, highs 90-100°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): NR

MONITORING WELL CONDITION:
[ ] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT NR
STEEL CASING CONDITION IS:
INNER PVC CASING CONDITION IS:
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1[✓] EQUIPMENT CLEANED BEFORE USE WITH Alconox Wash / Water Rinse
Items Cleaned (List): Two Stage Pump & hose
Water level Indicator

2[✓] PRODUCT DEPTH NR FT. BELOW DATUM
Measured with:

WATER DEPTH NR FT. BELOW DATUM
Measured with:

3[✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: NR
Odor:
Other Comments:

4[✓] WELL EVACUATION:
Method: Two-Stage Pump
Volume Removed: 15 gal.
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change) NR
Water odors: NR
Other comments:

Time	Vol.	pH	Temp	redox	DO
0940	1 gal.	7.67	15.0	139	5.87
0945	5	7.83	14.3	137	5.60
095	10	7.83	14.3	132	5.45

Final DO = 5.39 mg/L at 15 gal. @ 14.2°C

Groundwater Sampling Record

Monitoring Well No. 153 (Cont'd)

5 ☒ SAMPLE EXTRACTION METHOD:

☒ Bailer made of: Polyethylene Disposable
☐ Pump, type:
☐ Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 ☑ ON-SITE MEASUREMENTS:

Temp:	14.2 ° C	Measured with: YSI 55
pH:	7.83	Measured with: Orion 250A
Conductivity:	NR	Measured with: –
Dissolved Oxygen:	5.39	Measured with: YSI 55
Redox Potential:	132	Measured with: Orion 250A
Salinity:	–	Measured with:
Nitrate:	–	Measured with:
Sulfate:	–	Measured with:
Ferrous Iron:	–	Measured with:
Other:		

H_2S = <0.1 mg/L
CO_2 = 35 mg/L
Phenols = < 0.1 ppm
Iron = 0.3 mg/L
Manganese = <0.1 mg/L
Alkalinity = 70 mg/L

7 ☒ SAMPLE CONTAINERS (material, number, size): Standard Set

8 ☑ ON-SITE SAMPLE TREATMENT:

☐ Filtration: Method ____ Containers: ____
Method ____ Containers: ____
Method ____ Containers: ____

☐ Preservatives added: Standard

Method ____ Containers: ____
Method ____ Containers: ____
Method ____ Containers: ____
Method ____ Containers: ____

9 ☑ CONTAINER HANDLING:

☑ Container Sides Labeled
☐ Container Lids Taped
☑ Containers Placed in Ice Chest

10 ☐ OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-54
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/10/96, 1996 1045 [✓ a.m.]/p.m.
SAMPLE COLLECTED BY: RN/JH/BB of Parsons ES
WEATHER: Clear, Sunny, Hot 80-85°
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top of PVC
Water @ 15.54 TPVC
T.D. @ 23.05' TPVC

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER ([✓ IS] IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe): Note Sample
Had Dedicated Pump → removed, let sit
10 minutes for water level to stabilize

Check-off
1 [X] EQUIPMENT CLEANED BEFORE USE WITH Alconox / Distilled Water / Isopropyl / Distilled Water
Items Cleaned (List): Water level indicator / Peristaltic Tubing

2 [X] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 15.54 TPVC FT. BELOW DATUM
Measured with: Solinst

3 [X] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: None
Other Comments:

4 [X] WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 4.0 gal.
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - fell - [✓ no change])
Water odors: None
Other comments:

Casing Vol. = 0.8 gal. (1.5" PVC)
Purge Vol. = 2.4 gal.

Time	Vol.	Temp	pH	mV	DO	
0900	1.0 gal.	14.5	7.23	157.1	1.18	
0920	2.0	14.3	7.16	123	0.60	Clear - sl. cloudy
0430	3.0	14.2	7.13	115	0.70	
1028	4.0	14.3	7.10	82.9	0.45	
1035	4.5	14.2	7.11	83.0	0.47	

Groundwater Sampling Record

Monitoring Well No. MW154 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[✓] Pump, type: Peristaltic Pump
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

Temp:	14.2 ° C	Measured with:	YSI 55
pH:	7.11	Measured with:	Orion 250A
Conductivity:	NR	Measured with:	NR
Dissolved Oxygen:	0.45	Measured with:	YSI ~~[illegible]~~ 55
Redox Potential:	83.0	Measured with:	Orion 250A
Salinity:	–	Measured with:	–
Nitrate:	–	Measured with:	–
Sulfate:	–	Measured with:	–
Ferrous Iron:	–	Measured with:	–
Other:			

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs / 2x 250ml Plastic
2x 125ml Plastic / 2x glass Syrum jars
1x H_2 Sample

8 [✓] ON-SITE SAMPLE TREATMENT:

HNa *Filtration:*

Method		Containers:	
Method		Containers:	
Method		Containers:	

H Preservatives added: VOAs EPA Preserved

Method	(2x) Syrum Jars	Containers:	3 drops Sulfuric Acid
Method	(1x) 125ml Plastic	Containers:	5 drops " "
Method		Containers:	
Method		Containers:	

9 [✓] CONTAINER HANDLING:

[✓] Container Sides Labeled
[ ] Container Lids Taped } EPA
[ ] Containers Placed in Ice Chest }

10 [ ] OTHER COMMENTS: Took Dissolved H_2 Sample

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW155
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8\16\96, 1996 1105 [✓ a.m.]/p.m.
SAMPLE COLLECTED BY: RN/JH~~/BH~~ of Parsons ES
WEATHER: Clear, Sunny, Hot 85-90°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top PVC - North Side
Water = 15.95' Top PVC
T.D. = 57.50' Top PVC

MONITORING WELL CONDITION:
[ ] LOCKED: ☒ UNLOCKED
WELL NUMBER (IS - [✓ IS NOT]) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe): North Side PVC

Check-off
1 ☒ EQUIPMENT CLEANED BEFORE USE WITH Alconox/Water/Isopropyl/Distilled Water
Items Cleaned (List): Water level Indicator + Tape
Teflon Bailer
Two Stage Pump + Tubing

2 ☒ PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 15.95' Top PVC FT. BELOW DATUM
Measured with: Solinst

3 ☒ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Cloudy Brown
Odor: None
Other Comments:

4 ☒ WELL EVACUATION:
Method: Two-Stage Pump
Volume Removed: 21 gallons
Observations: Water (slightly - [✓ very]) cloudy Brown
Water level (rose - [✓ fell] - no change) → fell to within 5.0' of bo at max. pump.
Water odors: None
Other comments: Let Recharge While Sampling MW148

Casing Vol. = 6.77 gal.
Purge Vol. = 20.3 gal.

Time	Vol.	temp	pH	mv	DO	
0915	5.0 gal.	14.7	7.39	136	1.76	Clear - slightly Cloudy Brn.
0925	10.0	14.2	7.34	115	0.72	Cloudy Brown
0935	15.0	14.1	7.20	70.6	0.84	"
1005	20.0	14.1	7.28	69.0	0.64	"
1007	21.0	14.1	7.26	69.4	0.61	"

Groundwater Sampling Record

Monitoring Well No. MW-55 (Cont'd)

5 [X] SAMPLE EXTRACTION METHOD:

[X] Bailer made of: Teflon
[ ] Pump, type:
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [X] ON-SITE MEASUREMENTS:

Temp:	14.1 °C	Measured with: YSI 55
pH:	7.26	Measured with: Orion 250A
Conductivity:	NR	Measured with: NR
Dissolved Oxygen:	0.61	Measured with: YSI 55
Redox Potential:	69.4	Measured with: Orion 250A
Salinity:	–	Measured with: –
Nitrate:	–	Measured with: –
Sulfate:	–	Measured with: –
Ferrous Iron:	–	Measured with: –
Other:		

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs / 2x 250 ml Plastic
2x 125 ml Plastic / 2x glass syrum jars

8 [✓] ON-SITE SAMPLE TREATMENT:

[✓] None Filtration:
Method Containers:
Method Containers:
Method Containers:

[✓] Preservatives added: VOAs - EPA Preserved

Method 2x glass Syrum Jar Containers: 3 drops Sulfuric
Method 1x 125 ml Plastic Containers: 5 drops Sulfuric
Method Containers:
Method Containers:

9 [✓] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped } EPD
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-158
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/6/96, 1996 1245 a.m./p.m.
SAMPLE COLLECTED BY: [✓ RN]/JH/BH of Parsons ES
WEATHER: Sunny, breezy, 80°
DATUM FOR WATER DEPTH MEASUREMENT (Describe):

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER ([✓ IS] IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS [✓ IS NOT]) APPARENT ~~[illegible]~~
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [✓] EQUIPMENT CLEANED BEFORE USE WITH isopropyl/alconox/distilled water
Items Cleaned (List): probes/water level indicator/

2 [✓] PRODUCT DEPTH None FT. BELOW DATUM
Measured with: –

WATER DEPTH 8.0' and rising (see note) FT. BELOW DATUM
Measured with: Solinst water level indicator

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: None
Other Comments: –

4 [✓] WELL EVACUATION:
Method: Peristaltic (began 1140)
Volume Removed:
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - fell - no change) NR
Water odors: None
Other comments:

*Note removed dedicated pump prior to taking 1st water level

	11:50	11:59	12:08	12:20	12:28	12:35
DO (mg/L)	3.1	3.0	2.9	2.7	2.8	2.8
pH	7.70	7.56	7.45	7.30	7.41	7.30
cond (µS/cm)	87×10	89×10	87×10	83×10	84×10	83×10
redox (mV)	136	176	166	190	183	185
Temp (°C)	15.8	15.7	16.3	17.3	16.6	16.7

Groundwater Sampling Record

Monitoring Well No. MW158 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS: (Final)

Temp:	16.7 °C	Measured with: Orion 840
pH:	7.30	Measured with: Orion 250A
Conductivity:	830 (uS/cm)	Measured with: Oyster
Dissolved Oxygen:	2.8 (mg/L)	Measured with: Orion 840
Redox Potential:	185 (mV)	Measured with: Orion 250A
Salinity:		Measured with:
Nitrate:		Measured with:
Sulfate:		Measured with:
Ferrous Iron:		Measured with:

Other:

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs / 2x Glass Syrup Jars
2x 250ml Plastic / 2x 125ml Plastic

8 [✓] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: None
Method Containers:
Method Containers:
Method Containers:

[✓] Preservatives added: Glass Syrup Jar & 1x 125ml Plastic -> Sulfuric Acid

Method Containers:
Method Containers:
Method Containers:
Method Containers:

9 [✓] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: samples handled by EPA

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-159
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: Aug 9, 1996 1450 a.m. [✓ p.m.]
SAMPLE COLLECTED BY: RN/[✓ JH]/BH of Parsons ES
WEATHER: Sunny, hot (90's), calm
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC (top of pump cap)
Dedicated pump in well - could not remove

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER (IS - [✓ IS NOT]) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [✓] EQUIPMENT CLEANED BEFORE USE WITH Alconox Solution, DI H2O
Items Cleaned (List): water level probe

2 [-] PRODUCT DEPTH ______ FT. BELOW DATUM
Measured with:

WATER DEPTH 8.36 ft TOC FT. BELOW DATUM
Measured with:

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear to sl. cloudy
Odor: none
Other Comments:

4 [✓] WELL EVACUATION:
Method: Peristaltic pump (start 1325)
Volume Removed: 4.5 gal
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors:
Other comments: Recalibrated meters prior to this purging

3 casing volumes = 5 gal

Time	Vol.	DO	Redox	pH	Temp	Cond
1350	1.5 gal	2.1/2.2*	128	7.47	25.0	120x10
1415	2.5 gal	2.5/2.0*	123	7.23	23.8	117x10
1435	3.5 gal	2.0/1.6*	113	7.65	23.6	120x10
1447	4 gal	2.1/1.7*	111	7.47	23.7	118x10

* EPA Orionmeter / Parsons YSI meter

Groundwater Sampling Record

Monitoring Well No. MW-159 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS: See Previous Page

Temp:	23.7 °C	Measured with: Orion 840
pH:	7.47	Measured with: Orion 250
Conductivity:	1180	Measured with: Oyster
Dissolved Oxygen:	2.1	Measured with: Orion 840
Redox Potential:	111	Measured with: Orion 250
Salinity:		Measured with:
Nitrate:		Measured with:
Sulfate:		Measured with:
Ferrous Iron:		Measured with:
Other:		

7 [✓] SAMPLE CONTAINERS (material, number, size): 2 40-ml VOA vials (Cl VOCs); 2 40ml VOA vials (Aromatic VOCs); 2 125-ml plastic (Inorganics); 2 250-ml plastic (field lab tests); 2 Serum bottles (dissolved gases + TOC)

8 [✓] ON-SITE SAMPLE TREATMENT: JRH

[ ] Filtration: Method ~~VOCs - chlorinated~~ Containers:
Method Containers:
Method Containers:

[✓] Preservatives added:

Method Inorganics Containers: 125ml plastic (Sulfuric Acid)
Method Dissolved gases + TOC Containers: Glass Serum bottles (" ")
Method Containers:
Method Containers:

9 [✓] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Dedicated pump in well - can't remove. can't get pump tubing down past pump so need to pump at low rate to avoid pumping level below tubing inlet.

Collected field blank at this well 0415-FB1 (filled 4 VOA vials with grocery store distilled water)

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW 160
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/7/96, 1996 0930 [✓ a.m.]/p.m.
SAMPLE COLLECTED BY: RN/JH/[✓ BH] of Parsons ES
WEATHER: Clear, Sunny, Warm 70°F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top PVC
Water: 11.86' TPVC
T.D.: 20.45 TPVC

MONITORING WELL CONDITION:

[X] LOCKED: [ ] UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe): Top North Side of PVC
Had to cut off lock, left unlocked

Check-off

1 [X] EQUIPMENT CLEANED BEFORE USE WITH Alconox/Water/Isopropyl/DI water
Items Cleaned (List): Water level Indicator/Peristaltic Pump Tubing/
Meter Probes (no isopropyl)

2 [X] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 11.86' TPVC FT. BELOW DATUM
Measured with: Solinst

3 [X] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Cloudy - Yellowish Brown
Odor: None
Other Comments: Cleared w/1/2 gallon

4 [X] WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 5.0 gal.
Observations: Water (slightly - very) cloudy - Clear
Water level (rose - fell - no change)
Water odors: None
Other comments:

Casing Volume = 1.41 gal.
Purge Volume = 4.5 gal.

Time	Vol.	pH	Temp.	EC	mv	DO
0910	1.0 gal.	6.96	15.2°C	NR	180.2	2.88
0918	2.0	6.97	15.4	NR	141.3	3.27
0926	3.0	7.03	15.5	NR	156.3	3.55
0935	4.0	7.01	15.5	NR	148.6	3.44
0944	5.0	7.09	15.6	NR	151.5	3.30

Groundwater Sampling Record

Monitoring Well No. MW 160 (Cont'd)

5 ☒ SAMPLE EXTRACTION METHOD:

☐ Bailer made of:
☒ Pump, type: Peristaltic
☐ Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 ☒ ON-SITE MEASUREMENTS:

Temp:	15.6 °C	Measured with: YSI 55
pH:	7.09	Measured with: Orion 250 A
Conductivity:	NR	Measured with: NR
Dissolved Oxygen:	3.27	Measured with: YSI 55
Redox Potential:	151.5	Measured with: Orion 250A
Salinity:	–	Measured with: –
Nitrate:	–	Measured with: –
Sulfate:	–	Measured with: –
Ferrous Iron:	–	Measured with: –

Other:

7 ☒ SAMPLE CONTAINERS (material, number, size): 4x VOAs / 2x 250 ml. Plastic
2x 125 ml Plastic / 2x 50ml Glass

8 ☒ ON-SITE SAMPLE TREATMENT:

☒ None Filtration:

Method	Containers:
Method	Containers:
Method	Containers:

☒ Preservatives added:

VOAs → EPA Preserved
2x 50ml Glass - 3 drops sulfuric acid
1x 125ml Plastic - Fixed w/ 5 drops sulfuric acid.

Method	Containers:
Method	Containers:
Method	Containers:
Method	Containers:

9 ☒ CONTAINER HANDLING:

☒ Container Sides Labeled
☐ Container Lids Taped
☐ Containers Placed in Ice Chest

} EPA - Hand Pickup at Site

10 ☒ OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW61
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/6, 1996 505 a.m./[✓ p.m.]
SAMPLE COLLECTED BY: [✓ RN]/JH/BH of [✓ Parsons ES]
WEATHER: Sunny, breezy 85°
DATUM FOR WATER DEPTH MEASUREMENT (Describe):

MONITORING WELL CONDITION:
[ ] LOCKED: ☒ UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [✓] EQUIPMENT CLEANED BEFORE USE WITH Isopropyl alcohol/distilled water
Items Cleaned (List): probes/water interface probe

2 [✓] PRODUCT DEPTH none FT. BELOW DATUM
Measured with: –

WATER DEPTH 10.55 FT. BELOW DATUM
Measured with: Solinst water level indicator

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: none
Other Comments: –

4 [✓] WELL EVACUATION:
Method: peristaltic (Began 4:07)
Volume Removed: 5 gallons
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments: –

	4:15	4:25	4:40	4:51	5:01
DO (mg/L)	3.2	2.7	2.7	2.5	2.5
Temp (°C)	18.0	18.2	18.1	17.8	17.9
cond (uS/cm)	100×10	105×10	110 ×10	109×10	107×10
redox (mV)	202.2	211.7	206.8	217.1	208.2
pH	7.44	7.39	7.38	7.26	7.25

Groundwater Sampling Record

Monitoring Well No. MW-601 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS: (Final)

Temp: 17.9 °C	Measured with: Orion 840
pH: 7.25	Measured with: Orion 250A
Conductivity: 107x10 μS/cm	Measured with: Oyster
Dissolved Oxygen: 25 mg/L	Measured with: Orion 840
Redox Potential: 208.2 mV	Measured with: Orion 250A
Salinity:	Measured with:
Nitrate:	Measured with:
Sulfate:	Measured with:
Ferrous Iron:	Measured with:

Other:

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs
2x Glass Syrum Jars
2x 250m. Plastic
2x

8 [✓] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: None

	Method	Containers:
	Method	Containers:
	Method	Containers:

[✓] Preservatives added:

Method Sulfuric Acid	Containers: Glass Syrum Jars
Method " "	Containers: 125 ml. Plastic
Method	Containers:
Method	Containers:

9 [✓] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: samples handled by EPA

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-162
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: Aug 7 1996 830 [✓ a.m.]/p.m.
SAMPLE COLLECTED BY: [✓ RN]/[✓ JH]/BH of [✓ Parsons ES]
WEATHER: 55° Sunny
DATUM FOR WATER DEPTH MEASUREMENT (Describe):

MONITORING WELL CONDITION:
[✓] LOCKED: [ ] UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM ([✓ IS] - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [✓] EQUIPMENT CLEANED BEFORE USE WITH isopropyl alcohol/distilled water
Items Cleaned (List): probes, peristaltic tubing

2 [✓] PRODUCT DEPTH none FT. BELOW DATUM
Measured with: –

WATER DEPTH 10.88' TOC FT. BELOW DATUM
Measured with: Solinst water level indicator

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Clear
Odor: none
Other Comments:

4 [✓] WELL EVACUATION:
Method: Peristaltic Pump (730 began)
Volume Removed: 6 gallons
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

time	740	750	8:04	8:21
DO (mg/L)	4.4	4.2	4.4	4.1
pH	7.27	7.15	7.10	7.10
cond (mS/cm)	138×10	141×10	139×10	136×10
redox (mv)	140.8	151.3	151.0	167.7
Temp (°C)	16.0	15.8	15.6	15.7

*calibrated pH, DO meters prior to purging.

Groundwater Sampling Record

Monitoring Well No. MW162 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS: (Final)

Temp: 15.7 °C	Measured with: Orion 840
pH: 7.10	Measured with: Orion 250
Conductivity: 136x10 (uS/cm)	Measured with: Oyster
Dissolved Oxygen: 4.1 (mg/L)	Measured with: Orion 840
Redox Potential: 167.7 (mV)	Measured with: Orion 250
Salinity:	Measured with:
Nitrate:	Measured with:
Sulfate:	Measured with:
Ferrous Iron:	Measured with:

Other:

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs
2x Glass Syrum Jars
2x 125 ml. Plastic
2x 250 ml. [illegible]

8 [✓] ON-SITE SAMPLE TREATMENT:

[ ] Filtration:

Method	Containers:
Method	Containers:
Method	Containers:

[✓] Preservatives added:

Method Sulfuric Acid	Containers: Glass Syrum Jars,
Method	Containers: 1x 125 ml Plastic
Method	Containers:
Method	Containers:

9 [✓] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Samples handled by EPA

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-163
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/10, 1996 1110 [✓ a.m.]/p.m.
SAMPLE COLLECTED BY: RN/[✓ JH]/BH of Parsons ES
WEATHER: Clear, Sunny, Warm (70's °F), Calm
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top of pump cap

MONITORING WELL CONDITION:
[ ] LOCKED: ☒ UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [✓] EQUIPMENT CLEANED BEFORE USE WITH Alconox Solution, DI H2O
Items Cleaned (List): Water level probe

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 7.96' from top of Pump cap FT. BELOW DATUM
Measured with:

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Sl. to mod. cloudy
Odor: None
Other Comments:

4 [✓] WELL EVACUATION:
Method: Peristaltic Pump (Start 0810)
Volume Removed: 5 gal
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - [✓ fell] - no change) Slightly
Water odors: None
Other comments:

3 casing Volumes = 5 gal

(gal) Vol	Time	(mg/L) DO	(mv) Redox	pH	(°C) Temp	(mS/cm) Cond
1 gal	~~0825~~ 1025 JRH	0.4/0.8*	95	7.72	15.4	114 x10
2.5 gal	1040	0.3/0.8*	82	7.59	15.2	112 x10
4.5 gal	1100	0.3/0.8*	84	7.65	15.1	meter battery went dead

* Parsons YSI meter | EPA Orion Meter

Groundwater Sampling Record

Monitoring Well No. MW-163 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[✓] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

Temp: 15.1 ° C — Measured with: Orion 840
pH: 7.65 — Measured with: Orion 230
Conductivity: 1120 — Measured with: Oyster
Dissolved Oxygen: 0.8 — Measured with: Orion 840
Redox Potential: 84 — Measured with: Orion 250
Salinity: — Measured with:
Nitrate: — Measured with:
Sulfate: — Measured with:
Ferrous Iron: — Measured with:
Other:

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs
2x Glass Syrup Jars
2x 125 ml Plastic
2x 250 ml Plastic

8 [✓] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: None
Method — Containers:
Method — Containers:
Method — Containers:

[✓] Preservatives added:

Method Sulfuric Acid — Containers: 2x Glass Syrup Jars
Method — Containers: 1x 125 ml Plastic
Method — Containers:
Method — Containers:

9 [✓] CONTAINER HANDLING:

[✓] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Dedicated pump in well – removed for this sampling
→ SAMPLES handled by EPA

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW164
(number)

REASON FOR SAMPLING: [X] *Regular Sampling;* [ ] *Special Sampling;*
DATE AND TIME OF SAMPLING: 8/7, 1996 1210 a.m./[✓ p.m.]
SAMPLE COLLECTED BY: [✓ RN]/JH/BH of Parsons ES
WEATHER: 80° Sunny
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[✓] LOCKED: [ ] UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[✓] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [✓] EQUIPMENT CLEANED BEFORE USE WITH isopropanol / distilled water
Items Cleaned (List): probes

2 [✓] PRODUCT DEPTH — FT. BELOW DATUM
Measured with: —

19
-10.2
8.8/2 = 4.4 gallons

WATER DEPTH 10.20' (TOC) FT. BELOW DATUM
Measured with: Solinst water level indicator

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments: —

4 [✓] WELL EVACUATION:
Method: Peristaltic pump (Began 1106)
Volume Removed: gallons
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

time	1115	1130	1140	1150	1200
DO (mg/L)	3.0	4.6	4.7	4.9	4.8
pH	7.41	7.46	7.56	7.51	7.49
Temp (°C)	15.7	16.8	17.2	16.7	16.8
redox (mV)	137.0	126.9	123.0	133.3	137.4
cond (µS/cm)	105×10	90×10	91×10	98×10	98×10

Groundwater Sampling Record

Monitoring Well No. MW164 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS: (Final)

Temp:	16.8 °C	Measured with:	Orion 840
pH:	7.48	Measured with:	Orion 250A
Conductivity:	98 x 10 (uS/cm)	Measured with:	Oyster
Dissolved Oxygen:	4.8 (mg/L)	Measured with:	Orion 840
Redox Potential:	~~0~~137.4 (mV)	Measured with:	Orion 250A
Salinity:		Measured with:	
Nitrate:		Measured with:	
Sulfate:		Measured with:	
Ferrous Iron:		Measured with:	

Other: Lowest DO = 3.0 mg/L

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs
2x Glass Syrup Jars
2x 125 ml. Plastic
2x 250 ml. Plastic

8 [✓] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: None

Method		Containers:	
Method		Containers:	
Method		Containers:	

[✓] Preservatives added:

Method	Sulfuric Acid	Containers:	2x Glass Syrup Jars
Method		Containers:	1x 125 ml Plastic
Method		Containers:	
Method		Containers:	

9 [✓] CONTAINER HANDLING:

[✓] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Samples handled by EPA

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW165
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 7 August, 1996 1620 a.m. [✓ p.m.]
SAMPLE COLLECTED BY: RN/JH/[✓ RH] of Parsons ES [illegible]
WEATHER: Clear, Sunny, Hot 85° F
DATUM FOR WATER DEPTH MEASUREMENT (Describe):
Water @ 8.88' TPVC
T.D. = 19.11 TPVC

MONITORING WELL CONDITION:
[ ] LOCKED: ☒ UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: NA / Manbox (AL) good cond.
INNER PVC CASING CONDITION IS: Excellent
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT - measured to north side of PVC
[0] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off

1 ☒ EQUIPMENT CLEANED BEFORE USE WITH Water level indicator - Alconox & Distilled H_2O
Items Cleaned (List): Peristaltic pump tubing - Alconox & water (distilled)

2 ☒ PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 8.88' TPVC FT. BELOW DATUM
Measured with: Solinst Water level Indicator

3 ☒ WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Slightly cloudy
Odor: No
Other Comments:

4 ☒ WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 5.0 gal.
Observations: Water (slightly - very) cloudy Slightly cloudy
Water level (rose - fell - no change) Fell slightly
Water odors: None
Other comments: -

Time	Vol	Temp	pH	EC	Mv	DO
1546	1 gal	17.6	7.48	NR	132.7	0.84
1556	2 gal	17.8	7.47	NR	116.1	0.79
1602	3 gal	17.8	7.40	NR	108.9	0.74
1610	4.0 gal.	17.8	7.46	NR	98.7	0.70
1618	5.0	17.9	7.40	NR	94.5	0.70

[illegible]
casing volume: 1.7 g
purge volume: 5.0 g

Groundwater Sampling Record

Monitoring Well No. MW105 (Cont'd)

5 [X] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [X] ON-SITE MEASUREMENTS:

Temp:	17.9 °C	Measured with:	YSI 55
pH:	7.40	Measured with:	Orion 250A
Conductivity:	NR	Measured with:	NM
Dissolved Oxygen:	0.20	Measured with:	YSI 55
Redox Potential:	94.5	Measured with:	Orion 250A
Salinity:	—	Measured with:	—
Nitrate:	—	Measured with:	—
Sulfate:	—	Measured with:	—
Ferrous Iron:	—	Measured with:	—

Other:

7 [X] SAMPLE CONTAINERS (material, number, size): 4x VOAs / 2x 250ml Plastic
2x 125ml Plastic / 2x Glass Vials
Collected

8 [X] ON-SITE SAMPLE TREATMENT:

[X] None Filtration:

Method		Containers:	
Method		Containers:	
Method		Containers:	

[X] Preservatives added: Standard Set - VOAs EPA Preserved
- Glass Syringe Jars - Sulfuric Acid (3-4 drops)

Method		Containers:	
Method		Containers:	
Method		Containers:	
Method		Containers:	

9 [X] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped } EPA
[ ] Containers Placed in Ice Chest }

10 [X] OTHER COMMENTS: Samples Delivered to Bldg 860 Lab by Anita Gomes

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-167
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/6/96, 1996 1545 a.m./p.m.
SAMPLE COLLECTED BY: RN/JH/[✓ BH] of Parsons ES
WEATHER: Clear, Sunny, Warm, 80° F
DATUM FOR WATER DEPTH MEASUREMENT (Describe): Top of PVC - North Side
Water @ 6.21' TPVC
T.D. @ 15.24' TPVC

MONITORING WELL CONDITION:
[ ] LOCKED: ☒ UNLOCKED
WELL NUMBER (IS - [✓ IS NOT]) APPARENT
STEEL CASING CONDITION IS: Good - Intact
INNER PVC CASING CONDITION IS: Fair - Intact but dented around cap
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT -Taken North Side
☒ DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 ☒ EQUIPMENT CLEANED BEFORE USE WITH Alconox / Water Rinse / Isopropyl Rinse / DI
Items Cleaned (List): Peristaltic Tubing / Water Level Indicator Tape /
Flow Through Cell

2 ☒ PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 6.21' Top PVC FT. BELOW DATUM
Measured with: Solinst Water Level Indicator

3 ☒ WATER-CONDITION BEFORE WELL EVACUATION (Describe): (First Purge Water)
Appearance: Clear - sl. Cloudy
Odor: None
Other Comments: Cleared within 1/2 gallon Purging

4 ☒ WELL EVACUATION:
Method: Peristaltic Pump
Volume Removed: 5.0 gal.
Observations: Water (slightly - very) cloudy Clear
Water level (rose - fell - no change) Fell Slightly
Water odors: None
Other comments:

Casing Volume = 1.5 gal.

Time	Vol.	pH	Temp	EC	mV	DO
1515	1.0 gal.	7.79	20.5	1070	197	0.8
1522	2.0	7.10	20.9	1050	116	0.9
1529	3.0	7.14	21.0	1050.	120.2	1.0
1534	4.0	7.19	21.0	1040	114.0	1.0
1540	5.0	7.21	20.9	1040	119	

Groundwater Sampling Record

Monitoring Well No. MW-167 (Cont'd)

5 [X] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[X] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [X] ON-SITE MEASUREMENTS:

Temp:	20.9 °C	Measured with: Orion 840
pH:	7.21	Measured with: Extech oyster / Orion 250A
Conductivity:	1040 uS/cm	Measured with: Extech Oyster
Dissolved Oxygen:	1.6	Measured with: Orion 840
Redox Potential:	119	Measured with: Orion 250A
Salinity:	NA	Measured with: –
Nitrate:	NA	Measured with: –
Sulfate:	NA	Measured with: –
Ferrous Iron:	NA	Measured with: –
Other:		

7 [X] SAMPLE CONTAINERS (material, number, size): 4 VOAs / 2 250ml Plastic / 2 - 125 ml. Plastic / 2 small glass

8 [X] ON-SITE SAMPLE TREATMENT:

[ ] None Filtration:
Method ____ Containers: ____
Method ____ Containers: ____
Method ____ Containers: ____

[X] Preservatives added: → Added by EPA lab to VOAs
→ Added 3 drops Sulfuric Acid to small glass, 5 drops to fixed Iron (125ml plastic
Method ____ Containers: ____
Method ____ Containers: ____
Method ____ Containers: ____
Method ____ Containers: ____

9 [X] CONTAINER HANDLING:

[X] Container Sides Labeled
[ ] Container Lids Taped } EPA
[ ] Containers Placed in Ice Chest } EPA

10 [ ] OTHER COMMENTS: Water level = 6.50' TOP PVC After Purge + Sample

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-16
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/16, 1996 1615 a.m/[✓ p.m]
SAMPLE COLLECTED BY: RN/[✓ JH]/BH of Parsons ES
WEATHER: Sunny, hot (upper 90's) calm
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS[illegible] Good
WATER DEPTH MEASUREMENT DA[illegible] [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY S[illegible]E COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [✓] EQUIPMENT CLEANED BEFORE USE WITH Alconox / Isopropyl / Distilled H2O
Items Cleaned (List): Water level Indicator

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 7.40' TOC FT. BELOW DATUM
Measured with:

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Sl. Cloudy
Odor: none
Other Comments:

4 [✓] WELL EVACUATION:
Method: Peristaltic Pump (Start 1538)
Volume Removed: 4 gal
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - [✓ fell] - no change)
Water odors:
Other comments:

Well depth measured at 16' bgs
Purge volume = 4 gal

Time	Vol (gal)	DO (mg/L)	Redox (mV)	pH	Temp (°C)	Co
1545	~~2.4~~ 1 gal	2.0/1.9*	118	7.48	21.9	m
1555	2 gal	1.8/1.8*	103	7.34	21.4	h
1610	3.5 gal	1.8/1.6*	98	7.38	21.8	k

* EPA Orion meter / Parsons YSI meter

Groundwater Sampling Record

Monitoring Well No. MW-16 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[✓] Pump, type: peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS: See Previous Page

Temp:	21.8 ° C	Measured with:	Orion 840
pH:	7.38	Measured with:	Orion 250A
Conductivity:	NR	Measured with:	Oyster
Dissolved Oxygen:	1.8	Measured with:	Orion 840
Redox Potential:	98	Measured with:	Orion 250 A
Salinity:		Measured with:	
Nitrate:		Measured with:	
Sulfate:		Measured with:	
Ferrous Iron:		Measured with:	

Other:

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs
2x Glass Screw Jars
2x 125 ml Plastic
2x 250 ml Plastic

8 [✓] ON-SITE SAMPLE TREATMENT:

[ ] Filtration:		Method	Containers:
None		Method	Containers:
		Method	Containers:

[✓] Preservatives added:

Method Sulfuric Acid	Containers:
Method	Containers:
Method	Containers:
Method	Containers:

9 [✓] CONTAINER HANDLING:

[✓] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Samples handled by EPA

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL MW-169
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/10, 1996 0845 [✓ a.m.] ~~p.m.~~
SAMPLE COLLECTED BY: RN/[✓ JH]/BH of Parsons ES
WEATHER: Sunny, hot (90's), sl breeze ~10 mph
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION
[X] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - [✓ IS NOT]) APPARENT
STEEL CASING CONDITION IS: Manhole cover partly cracked off
INNER PVC CASING CONDITION IS: Good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [✓] EQUIPMENT CLEANED BEFORE USE WITH Alconox Solution, DI H_2O
Items Cleaned (List): Waterlevel probe

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 7.90' TOC FT. BELOW DATUM
Measured with: Solinst water level meter

Measured B.o.W. @ 16' bgs

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Sl. cloudy
Odor: None
Other Comments:

4 [✓] WELL EVACUATION:
Method: Peristaltic Pump (Start 1610)
Volume Removed:
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - [✓ fell] - no change)
Water odors: None
Other comments: Purged dry after 2 gal. Recharge v. slow

Purge Volume = 4 gal

Time	(gal) Vol.	(mg/L) DO	(mV) Redox	pH	(uS/cm) Cond	(°C) Temp
1620	1 gal	~~2.1~~ 3.2/2.8* 2.9/2.5*	137	7.55	116x10	17.8

Sampled on 8/10/96

* Orion meter / YSI meter

Groundwater Sampling Record

Monitoring Well No. MW-169 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[✓] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

Temp:	17.8 ° C	Measured with:	Orion 840
pH:	7.55	Measured with:	Orion 250
Conductivity:	1160	Measured with:	Oyster
Dissolved Oxygen:	2.9	Measured with:	Orion 840
Redox Potential:	137	Measured with:	Orion 250
Salinity:		Measured with:	
Nitrate:		Measured with:	
Sulfate:		Measured with:	
Ferrous Iron:		Measured with:	

Other:

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs
2x Glass Serum Jars
2x 250 ml Plastic
2x 125 ml Plastic

8 [✓] ON-SITE SAMPLE TREATMENT:

[ ] Filtration: None

Method		Containers:	
Method		Containers:	
Method		Containers:	

[✓] Preservatives added:

Method	Sulfuric Acid	Containers:	
Method		Containers:	
Method		Containers:	
Method		Containers:	

9 [✓] CONTAINER HANDLING:

[✓] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Sample collected 8/10/96 - well had fully recovered. Purged slowly for ~5 min prior to sample collection. Samples handled by EPA

GROUNDWATER SAMPLING RECORD

Screen Top 45.5' bgs
" Bottom 55.5' bgs

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL TA0-4
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/12, 1996 ~~[illegible]~~ a.m./p.m. ~~[illegible]~~ 1 pm
SAMPLE COLLECTED BY: [✓ RN/JH/BH of Parsons ES]
WEATHER: Sunny hot ~90°F at 1:00 pm
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
☒ LOCKED: [ ] UNLOCKED
WELL NUMBER ([✓ IS] - IS NOT) APPARENT
STEEL CASING CONDITION IS: good
INNER PVC CASING CONDITION IS: good
WATER DEPTH MEASUREMENT DATUM (IS - [✓ IS NOT]) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe): No

Check-off
1 [✓] EQUIPMENT CLEANED BEFORE USE WITH isopropyl/distilled water
Items Cleaned (List): probes, bailer

2 [✓] PRODUCT DEPTH none FT. BELOW DATUM
Measured with: —

WATER DEPTH 21.75 FT. BELOW DATUM
Measured with: Solinst water level indicator

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: clear
Odor: none
Other Comments:

4 [✓] WELL EVACUATION:
Method: ~~Bailing~~ 2-stage pump (begin 1050)
Volume Removed: 85 gallons
Observations: Water ([✓ slightly] - very) cloudy
Water level (rose - fell - no change)
Water odors: none
Other comments:

time	1055	1105	1115	1125	1135	1145
DO (mg/L)	2.64	0.44	0.32	0.19	0.16	0.15
pH	6.05	5.72	5.69	5.59	5.49	5.60
temp (°C)	16.4	15.8	15.6	15.4	15.5	15.5
redox (mV)	10.0	-120.6	-143.9	-109.3	-49.3	-51.5

DO (mg/L)	0.15	0.18
pH	5.79	~~[illegible]~~ 5.00
Temp (°C)	15.5	15.5
redox (mV)	-82.7	-48.1
time	1155	1215

.167
4
.668
4
2.672
35
13360
8016
93.820

55.50
− 21.75
33.75 × 2
67.5

22.5
4
80

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Page 1 of 2

Groundwater Sampling Record

Monitoring Well No. TAD 4 (Cont'd)

5 ☒ SAMPLE EXTRACTION METHOD:

☒ Bailer made of: Teflon
☐ Pump, type:
☐ Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 ☑ ON-SITE MEASUREMENTS:

1410
Ferrous Iron = 1.0 mg/L
Manganese = <0.1
Phenols = 0.1 mg/L
Alkalinity = 250
Carbon Dioxide = 25
Hydrogen Sulfide <0.1

Temp: 15.5 ° C — Measured with: ~~Orion 250A~~ / TSI 55
pH: 5.80 — Measured with: Orion 250A
Conductivity: — — Measured with: —
Dissolved Oxygen: 0.18 (mg/L) — Measured with: TSI 55
Redox Potential: -48.1 (mV) — Measured with: Orion 250A
Salinity: — Measured with:
Nitrate: — Measured with:
Sulfate: — Measured with:
Ferrous Iron: — Measured with:
Other:

7 ☑ SAMPLE CONTAINERS (material, number, size): Vials / Glass Jars / 125ml Plastic
1x 250ml Plastic

8 ☑ ON-SITE SAMPLE TREATMENT:

☑ None Filtration: Method ____ Containers: ____
Method ____ Containers: ____
Method ____ Containers: ____

☑ Preservatives added: Standard

Method ____ Containers: ____
Method ____ Containers: ____
Method ____ Containers: ____
Method ____ Containers: ____

9 ☑ CONTAINER HANDLING:

☒ Container Sides Labeled
☐ Container Lids Taped
☒ Containers Placed in Ice Chest

10 ☐ OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

Sampling Location Hill AFB - OU5
Sampling Dates 8/5/96-8/16/96

GROUND WATER SAMPLING RECORD - MONITORING WELL TAD-6
(number)

REASON FOR SAMPLING: [X] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: 8/10, 1996 1435 a.m./[✓ p.m.]
SAMPLE COLLECTED BY: RN/[✓ JH]/BH of Parsons ES
WEATHER: Sunny, hot (90's), Calm
DATUM FOR WATER DEPTH MEASUREMENT (Describe): TOC

MONITORING WELL CONDITION:
[ ] LOCKED: [X] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: Good
INNER PVC CASING CONDITION IS: Good (Stainless Steel well, 4")
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe):

Check-off
1 [✓] EQUIPMENT CLEANED BEFORE USE WITH PVC bailer - (Alconox solution, DI H2O,
Items Cleaned (List): Isopropyl ~~ethno~~ alcohol, DI H2O); Water level probe - Alconox Solution, DI H2O. JRH

2 [✓] PRODUCT DEPTH NA FT. BELOW DATUM
Measured with:

WATER DEPTH 4.9' TOC FT. BELOW DATUM
Measured with: Solinst Water level Meter

3 [✓] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: Sl. Cloudy
Odor: None
Other Comments:

4 [✓] WELL EVACUATION:
Method: PVC bailer + Peristaltic Pump
Volume Removed: 17 gal (See next page)
Observations: Water (slightly - very) cloudy Clear to Sl. Cloudy
Water level (rose - [✓ fell] - no change)
Water odors: None
Other comments:

3 casing ~ Volume 21 gal

Time	(gal) Vol	(mg/L) DO	(mV) Redox	pH	(uS/cm) Cond	(°C) Temp
1400	14 gal	2.9/2.6 *	97	7.95	meter not operating	19.3
1410	15 gal	3.2/~~2.8~~ gal	75	7.95		19.2
1420	16 gal	3.8/~~3.4~~ 2.9				
1430	17 gal	4.0/3.7				

* (EPA Orion meter / Parsons / YSI meter)

Groundwater Sampling Record

Monitoring Well No. TA1-6 (Cont'd)

5 [✓] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of:
[✓] Pump, type: Peristaltic
[ ] Other, describe:

Sample obtained is [X] GRAB; [ ] COMPOSITE SAMPLE

6 [✓] ON-SITE MEASUREMENTS:

Temp: 19.2 ° C	Measured with:	Orion 840
pH: 7.95	Measured with:	Orion 250A
Conductivity: NR	Measured with:	—
Dissolved Oxygen: 2.9 (lowest)	Measured with:	Orion 840
Redox Potential: 75	Measured with:	Orion 250A
Salinity:	Measured with:	
Nitrate:	Measured with:	
Sulfate:	Measured with:	
Ferrous Iron:	Measured with:	
Other:		

7 [✓] SAMPLE CONTAINERS (material, number, size): 4x VOAs
2x Glass Sigma Jars
2x 250 ml Plastic
2x 125 ml Plastic

8 [✓] ON-SITE SAMPLE TREATMENT:

[ ]	Filtration:	Method	Containers:
	None	Method	Containers:
		Method	Containers:

[✓] Preservatives added:

Method Sulfuric Acid	Containers: 2x Glass Sigma / 1x 125 ml Plastic
Method	Containers:
Method	Containers:
Method	Containers:

9 [✓] CONTAINER HANDLING:

[✓] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: Well purged nearly dry twice w/ bailer, Then purged last 4 gal w/ peristaltic pump to obtain meter readings.
Samples handled by EPA

Clinton Area

File: 66-AX96.CR5

POINT	NORTHING	EASTING	ELEVATION	NOTE
1	297516.7499	1854026.6463	4493.0121	WP N/W OLD/26
20	296125.0284	1854010.1447	4496.7308	TOP CNTR LID MP3
21	296125.0914	1854010.1423	4496.3710	PVC MARK
22	295695.6837	1854009.7955	4497.4141	RADIAN MW
23	297023.3204	1852208.1399	4442.3597	TOP CNTR LID MP5
24	297023.4353	1852208.1418	4442.1388	PVC MARK MP5
25	298111.5095	1852392.7471	4444.2817	GRND @ SPRING
26	296994.2846	1852030.1399	4440.1061	OLD WP N/W
27	295852.8982	1852157.3455	4445.0949	TOP CNTR LID MP4
28	295852.8988	1852157.4097	4444.9183	PVC MARK
29	296207.4580	1851656.2631	4437.0099	TOP CNTR LID MP6
30	296207.5266	1851656.1707	4436.8261	PVC MARK
31	296986.0633	1850574.3793	4412.9981	INT MON2300N900W
32	297048.7118	1851213.6101	4424.0276	TOP CNTR LID MP7
33	297048.8820	1851213.6700	4423.1362	PVC MARK
34	296514.4392	1850546.5222	4413.8867	TOP CNTR LID MP8
35	296514.5498	1850546.5838	4413.6800	PVC MARK
40	296998.0752	1851732.6028	4435.2641	TBC
41	296998.4074	1851629.6043	4433.2228	TBC
42	296957.4170	1851631.7180	4433.1465	BCR
43	296951.9703	1851646.0291	4433.6414	TBC+POC
44	296932.1993	1851656.2127	4433.9535	BCR
45	296887.7199	1851655.9606	4434.0468	TBC
46	296888.0402	1851696.9133	4434.4011	TBC
47	296930.9555	1851697.0606	4434.2032	BCR
48	296949.1415	1851704.7810	4434.2738	TBC+POC
49	296957.0743	1851724.7405	4434.9896	BCR

On HAFB (Rail Yd Area)

File: 66X-96.CR5

POINT	NORTHING	EASTING	ELEVATION	NOTE
1	297003.4110	1855991.9850	4598.1800	WP N/W
2	296631.0830	1855921.0920	4588.2400	MON73-7 BASE PT
21	295940.9499	1855729.8164	4580.7138	RADIAN MW
22	295954.6678	1855730.8538	4580.5756	RADIAN MW
23	296448.8196	1855830.6507	4581.8256	MW 126
24	296252.4000	1855830.8557	4582.1688	MP 2
25	296252.4312	1855830.8489	4581.4476	MP 2 LOW PVC
26	296252.2541	1855830.6537	4581.8346	MP 2 HIGH PVC
28	296251.5404	1855830.6941	4582.1356	MP 2D
29	296251.5126	1855830.6822	4581.4445	MP 2D LOW PVC
30	296251.4504	1855830.3820	4581.8851	MP 2D HIGH PVC
31	295835.9177	1856102.9377	4594.0953	NE COR BLDG
32	295741.2926	1856102.1478	4593.0289	SE COR BLDG 1723
33	295661.7027	1856082.7231	4592.0345	NE COR BLDG 1710
34	295613.4148	1856156.6793	4592.3688	MP 1
35	295613.4480	1856156.6778	4592.0598	TOP PVC MP 1
36	295609.5824	1856157.2117	4592.3085	MP 1D
37	295609.5349	1856157.1891	4591.7733	N EDGE PVC MP 1D

APPENDIX C

LABORATORY ANALYTICAL DATA

Ref: 96-SH89/vg

August 30, 1996

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift

Dear Don:

Attached are TOC results for 8 Hill soils submitted August 13, 1996 under Service Request #SF-2-227. Sample analysis was begun August 16, 1996 and completed August 29, 1996 using RSKSOP-102 and RSKSOP-120.

Blanks, duplicates, and AQC samples were analyzed along with your samples, as appropriate, for quality control. If you have any questions concerning this data, please feel free to ask me.

Sincerely,

Sharon Hightower

Sharon Hightower

xc: R.L. Cosby
G.B. Smith
J.L. Seeley

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

KAMPBELL HILL SOILS SF-2-227

SAMPLE	SOIL FILTRATE % O.C.	SOLIDS % O.C.	TOTAL SOIL % TOC	MEAN %TOC	STD DEV
MP-1,1-1	<.00004	.024	.024	.026	
1-2	.001	.026	.027		
MP-2,1-1	<.00004	.040	.040	.039	
1-2	.003	.034	.037		
MP-2, BIS 24-28					
1-1	.002	.027	.029	.040	.009
1-2	.002	.043	.045		
1-3	.012	.033	.045		
MP-3,1-1	.012	.281	.293	.290	
1-2	.019	.267	.286		
MP-4,1-1	.006	.047	.053	.054	
1-2	.007	.048	.055		
MP-6,1-1	.005	.041	.046	.045	
1-2	.002	.041	.043		
MP-7,1-1	.006	.050	.056	.057	
1-2	.011	.047	.058		
MP-8,1-1	.003	.036	.039	.039	
1-2	.002	.036	.038		

WPO35-II 38.1
LECO SOIL Q.C. .911

WPO35-II Std. t.v.=40.1
Leco soil std. t.v.=.88+/-.04

HILL AIR FORCE BASE
FIELD DATA

Sample	Date	Redox mV	pH	Cond umho/cm	Carbon Dioxide mg/l	Total Alkalinity mg/l CaCo$_3$	Ferrous Iron mg/l	Maganese mg/l	Phenol mg/l
MW-139	8-6-96	195	7.3	1040	128	388	<.05	.3	.4
MW-158	8-6-96	226	7.2	1027	96	300	<.05	<.2	<.1
MW-146	8-6-96	218	7.3	1277	132	262	<.05		
MW-167	8-6-96	223	7.4	1226	180	444	<.05	<.2	.6
MW-161	8-6-96	239	7.5	1345	204	487	<.05	<.2	<.1
MW-141	8-7-96	279	7.9	1164	142	456	<.05	<.2	.2
MW-162	8-7-96	289	7.4	1749	236	420	<.05	<.2	0.4
MW-134	8-7-96	300	7.2	1173	228	433	<.05	<.2	0.1
MW-160	8-7-96	301	7.5	941	96	321	<.05	<.2	0.2
MW-133	8-7-96	253	7.1	2850	302	269	<.05	<.2	0.6
MW-164	8-7-96	267	7.5	1260	156	475	<.05	<.2	0 [illegible]
MW-124	8-7-96	273	7.4	820	178	199	<.05	<.2	0.3
MW-144	8-7-96	269	7.3	1162	190	320	<.05	<.2	0.1
MW-165	8-7-96	270	7.7	1046	200	386	<.05	<.2	<0.1
MW-145	8-7-96	252	7.4	1254	186	287	<.05	<.2	0.4
MW-136	8-8-96	280	7.3	1076	176	230	<.05	<.2	0.1
MW-149	8-8-96	275	7.6	689	94	241	<.05	<.2	0.1
MW-147	8-8-96	286	7.5	1243	186	484	<.05	<.2	1.0
MW-147A	8-8-96	285	7.6	1240	182	495	<.05	<.2	1.0
MW-122	8-8-96	286	7.1	1120	148	270	<.05	<.2	0.2
MW-142	8-8-96	281	7.3	1286	222	435	<.05	<.2	0.2
MW-125	8-8-96	297	7.5	605	110	255	<.05	<.2	0.1
MW-143	8-8-96	278	7.4	1407	170	512	<.05	<.2	1.0
MW-126	8-8-96	250	7.7	646	158	217	<.05	<.2	<0.1
MW-140	8-8-96	270	7.6	1148	142	389	<.05	<.2	0.1

Ref: 96\LB63

August 19, 1996

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection and Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift SV

Dear Don:

Please find attached the analytical results for Service Request SF-2-227 requesting the analysis of Hill AFB groundwater samples to be analyzed by purge-and-trap/GC-FID:PID for Benzene, Toluene, Ethylbenzene, p-, m-, & o-Xylene, 1,3,5-, 1,2,4-, & 1,2,3-Trimethylbenzene, and Total Fuel Carbon. We obtained the 57 groundwater samples, in duplicate, in capped, 40 mL VOA autosampler vials August 13-14, 1996, and they were analyzed August 15-16, 1996. The samples were acquired and processed using the Millennium data system. A 4 place (1-1000 ppb) external standard curve was used to quantitate sample concentration for the compounds of interest.

RSKSOP-133, "Simultaneous Analysis of Aromatics and Total Fuel Carbon by Dual Column-Dual Detector for Ground Water Samples" was used for these analyses. Autosampling was performed using a Dynatech Precision autosampler system in line with a Tekmar LSC 2000 concentrator.

Sincerely,

Lisa R. Black

Lisa R. Black

xc: R.L. Cosby
G.B. Smith
J.T. Wilson
J.L. Seeley SV

ManTech Environmental Research Services Corporation
R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

Printed [illegible]/96 SF-2-227 Hill AFB GW Samp[illegible] Dr. Don Kampbell Units = ng/mL Anal[illegible] Black

SampleName	BENZENE	TOLUENE	ETHYLBENZENE	p-XYLENE	m-XYLENE	o-XYLENE	1,3,5-TMB	1,2,4-TMB	1,2,3-TMB	Fuel Carbon
QC, OBSERVED, PPB	25.3	25.2	28.4	26.7	24.9	25.8	25.8	27.1	26.0	N/A
QC, TRUE VALUE, PPB	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	N/A
100 PPB	98.0	96.5	101	97.6	92.3	99.1	99.2	102	102	N/A
GC LAB BLANK, PPB	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A
MW 122	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 124	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 125	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 126	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 127	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 127 Duplicate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-128	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-129	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 130	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 133	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 134	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1 PPB	1.0	0.9	0.9	0.9	1.0	1.0	0.9	1.1	1.0	N/A
MW 135	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 136	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 137	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 137A	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 138	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 139	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 140	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 141	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 142	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 143	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 144	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 144 Duplicate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10 PPB	9.3	9.0	9.5	9.7	9.1	9.3	9.5	9.7	10.1	N/A
MW 145	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 146	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 147	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 147A	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 148	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 149	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 150	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 151	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 151 Duplicate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 154	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 155	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
QC, OBSERVED, PPB	46.9	46.4	52.6	46.6	47.8	48.6	48.3	50.8	49.5	N/A
QC, TRUE VALUE, PPB	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	N/A

Printed 8/19/96 SF-2-227 Hill AFB GW Samples for Dr. Don Kampbell Units = ng/mL Analyst: L. Black

SampleName	BENZENE	TOLUENE	ETHYLBENZENE	p-XYLENE	m-XYLENE	o-XYLENE	1,3,5-TMB	1,2,4-TMB	1,2,3-TMB	Fuel Carbon
MW 158	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 159	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 160	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 161	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 162	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 163	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 163 Duplicate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 164	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 165	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 167	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW 168	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
100 PPB	99.5	96.8	101	96.2	99.3	101	99.2	103	104	N/A
MW 169	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
OUS-FB1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TAD-6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-1D	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-1D Duplicate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-2D	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1 PPB	1.1	1.0	1.0	1.0	0.9	1.0	1.0	1.2	1.1	N/A
MP-7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-15	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-18	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-153	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TAD-4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TAD-4 Duplicate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
QC, OBSERVED, PPB	47.9	48.6	55.8	49.7	47.3	51.8	53.7	56.6	54.5	N/A
QC, TRUE VALUE, PPB	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	N/A

ND = None Detected; N/A = Not Analyzed

Table 1. Quantitation Report for S.R. # SF-2-227 from Hill.

Concentration = ppb

Compound	MW122	MW124	MW125	MW126	MW127	MW128	MW129	MW130	MW133	MW134
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHENE	---	ND	ND	ND	---	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	***	***	***	***	***	***	***	***	***	***
T-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHANE	3.4	ND	ND	ND	---	ND	ND	ND	ND	ND
C-1,2-DICHLOROETHENE	1.1	ND	---	ND	1.9	---	ND	ND	ND	ND
CHLOROFORM	---	ND	---	2.2	1.0	ND	---	ND	ND	ND
1,1,1-TRICHLOROETHANE	16.1	ND	---	ND	20.3	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	1.3	ND	7.4	1.0	186	12.7	55.8	ND	1.5	ND
1,1,2-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE	---	---	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

	MW135	MW136	MW136 Field Dup	MW137	137A	MW 138	MW 139	MW 140	MW 141	MW142
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHENE	ND	---	---	2.1	2.0	1.9	ND	ND	ND	ND
METHYLENE CHLORIDE	***	***	***	***	***	***	***	***	***	***
T-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHANE	ND	ND	ND	2.6	2.7	---	ND	ND	ND	ND
C-1,2-DICHLOROETHENE	ND	ND	ND	13.9	14.5	1.2	ND	---	ND	ND
CHLOROFORM	ND	---	---	---	---	ND	ND	ND	ND	ND
1,1,1-TRICHLOROETHANE	ND	1.8	1.9	15.8	15.7	3.3	ND	---	ND	---
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	1.7	19.9	21.1	228	240	355	3.7	37.1	5.1	19.6
1,1,2-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	253	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROBENZENE	---	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND = None Detected --- = Below Calibration Limit(1.0 ppb) Dup = Duplicate *** = Below Calibration Limit(5.0 ppb)

Table 2. Quantitation Report for S.R. # SF-2-227 from Hill.

Concentration = ppb

Compound	MW143	MW144	MW144 Field Dup	MW 145	MW 146	MW 147	MW 147 Lab Dup	MW 147A	MW148	MW149
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHENE	ND	ND	ND	ND	---	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	***	***	***	***	***	***	***	***	***	***
T-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHANE	---	ND	ND	ND	2.1	ND	ND	ND	ND	ND
C-1,2-DICHLOROETHENE	2.5	ND	ND	ND	---	---	---	---	ND	ND
CHLOROFORM	ND	ND	---	ND	ND	ND	ND	ND	---	---
1,1,1-TRICHLOROETHANE	---	---	---	---	6.9	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	89.6	11.6	11.2	6.9	1.6	27.6	26.2	25.9	17.2	1.4
1,1,2-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE	ND	ND	ND	ND	---	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	---	ND	ND	ND	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	---	ND	ND	ND	ND	ND	ND

	MW150	MW151	MW151 Field Dup	MW-153	MW154	MW155	MW155 Lab Dup	MW158	MW159	MW160
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHENE	ND	ND	ND	ND	2.3	ND	ND	1.0	1.5	ND
METHYLENE CHLORIDE	***	***	***	***	***	***	***	***	***	***
T-1,2-DICHLOROETHENE	ND	ND	ND	ND	---	ND	ND	ND	ND	ND
1,1-DICHLOROETHANE	ND	ND	ND	ND	5.6	ND	ND	1.7	1.0	ND
C-1,2-DICHLOROETHENE	ND	ND	ND	ND	15.6	ND	ND	1.1	3.5	ND
CHLOROFORM	1.1	ND	ND	ND	1.2	---	---	1.2	1.0	---
1,1,1-TRICHLOROETHANE	ND	ND	ND	ND	64.2	ND	ND	12.7	6.0	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	4.6	3.0	2.9	ND	259	61.9	58.3	2.0	227	1.5
1,1,2-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 3. Quantitation Report for S.R. # SF-2-227 from Hill.

Concentration = ppb

Compound	MW161	MW162	MW163	MW164	MW164 Field Dup	MW165	MW167	MW168	MW169	OU5-FB1
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHENE	---	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	***	***	***	***	***	***	***	***	***	***
T-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHANE	---	ND	ND	ND	ND	ND	ND	ND	ND	ND
C-1,2-DICHLOROETHENE	ND	ND	1.0	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	---	ND	---	---	2.1	1.2	ND	ND	7.5
1,1,1-TRICHLOROETHANE	1.1	---	ND	ND	ND	ND	ND	---	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	5.3	ND	ND	ND	ND
1,2-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	4.7	4.6	35.8	---	---	8.9	---	---	ND	ND
1,1,2-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Compound	OU5-FB1 Lab Dup	TAD-4	TAD-6	MP-1	MP-1D	MP-1D Field Dup	MP-1D Lab Dup	MP-2	MP-2D	MP-3
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	***	***	***	***	***	***	***	***	***	***
T-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	5.1	ND
CHLOROFORM	7.8	ND	ND	ND	ND	---	---	1.1	ND	ND
1,1,1-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	ND	ND	2.2	ND	12.6	12.8	13.0	6.1	5.4	---
1,1,2-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Below Calibration Limit(1.0 ppb)   Dup = Duplicate   *** = Below Calibration Limit(5.0 ppb)

Table 4. Quantitation Report for S.R. # SF-2-227 from Hill.

Concentration = ppb

Compound	MP-5	MP-6	MP-6 Lab Dup	MP-7	MP-8	MP-15	MP-18	MEADOW PARK SEEP	MEADOW PARK DRAINAGE	MARTIN SPRING
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	---
METHYLENE CHLORIDE	***	***	***	***	***	***	***	***	***	***
T-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.4
C-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.2
CHLOROFORM	ND	---	ND	ND	---	---	---	3.1	1.5	ND
1,1,1-TRICHLOROETHANE	1.2	ND	ND	ND	ND	1.2	ND	ND	ND	4.1
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	2.1	ND
1,2-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	12.4	ND	ND	3.5	ND	11.9	ND	ND	5.2	1.0
1,1,2-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	---	ND	ND	ND	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	---	ND	ND	ND	ND	ND	ND

Compound	MARTIN SPRING Lab Dup	MARTIN SPRING Field Dup	QC0909C 20 ppb	QC0909D 200 ppb	QC0909E 20 ppb	QC0909F 200 ppb	QC0909G 20 ppb	QC0909H 200 ppb	QC0909I 20 ppb	QC0909J 200 ppb
VINYL CHLORIDE	ND	ND	21.4	204	21.6	199	21.0	211	20.7	207
1,1-DICHLOROETHENE	---	---	23.8	222	23.5	223	23.6	234	22.7	228
METHYLENE CHLORIDE	***	***	20.7	207	23.8	215	21.2	192	22.9	210
T-1,2-DICHLOROETHENE	ND	ND	21.2	211	21.6	205	21.1	208	21.9	206
1,1-DICHLOROETHANE	1.3	1.5	20.2	206	21.9	209	20.3	203	22.2	207
C-1,2-DICHLOROETHENE	2.2	2.3	19.9	208	21.1	211	19.9	193	22.0	204
CHLOROFORM	ND	ND	18.6	195	19.7	197	18.8	184	21.3	192
1,1,1-TRICHLOROETHANE	3.7	3.8	21.5	200	21.0	196	20.5	209	20.9	209
CARBON TETRACHLORIDE	ND	ND	20.9	198	20.1	194	20.9	208	20.3	204
1,2-DICHLOROETHANE	ND	ND	17.6	204	21.3	208	19.4	183	22.4	194
TRICHLOROETHENE	1.0	1.0	18.0	180	18.8	181	18.1	184	19.4	179
1,1,2-TRICHLOROETHANE	ND	ND	N	N	N	N	N	N	N	N
TETRACHLOROETHENE	ND	ND	20.4	190	19.6	191	20.1	196	20.4	195
CHLOROBENZENE	ND	ND	20.0	202	20.6	210	20.5	197	22.3	204
1,3-DICHLOROBENZENE	ND	ND	20.0	[illegible]	20.4	216	20.6	199	22.2	203
1,4-DICHLOROBENZENE	ND	ND	19.8	[illegible]	20.6	206	20.2	194	22.4	199
1,2-DICHLOROBENZENE	ND	ND	20.7	[illegible]	21.6	215	20.8	199	23.2	208

Table 5. Quantitation Report for S.R. # SF-2-227 from Hill.

Concentration = ppb

Compound	QC0909K 20 ppb	QC0909L 200 ppb	QC0909M 20 ppb	QC0909N 200 ppb	QC0916A 100 ppb	BL0909A	BL0909B
VINYL CHLORIDE	22.2	210	21.8	201	NI	ND	ND
1,1-DICHLOROETHENE	23.7	231	23.4	228	103	ND	ND
METHYLENE CHLORIDE	20.3	213	20.3	196	104	***	***
T-1,2-DICHLOROETHENE	20.6	207	20.8	206	104	ND	ND
1,1-DICHLOROETHANE	20.7	210	20.4	206	104	ND	ND
C-1,2-DICHLOROETHENE	20.6	208	20.0	196	103	ND	ND
CHLOROFORM	19.6	197	18.9	183	94.0	ND	ND
1,1,1-TRICHLOROETHANE	21.3	216	21.5	208	104	ND	ND
CARBON TETRACHLORIDE	21.6	208	21.7	205	105	ND	ND
1,2-DICHLOROETHANE	18.4	201	17.7	188	99.1	ND	ND
TRICHLOROETHENE	18.3	183	18.0	179	101	ND	ND
1,1,2-TRICHLOROETHANE	NI	NI	NI	NI	109	ND	ND
TETRACHLOROETHENE	20.2	196	19.7	190	118	ND	ND
CHLOROBENZENE	20.7	204	19.4	198	99.0	ND	ND
1,3-DICHLOROBENZENE	20.3	202	18.6	199	103	ND	ND
1,4-DICHLOROBENZENE	19.6	200	18.9	193	102	ND	ND
1,2-DICHLOROBENZENE	20.5	204	19.6	196	101	ND	ND

NI = Not Included in QC ND = None Detected QC = Quality Control Std. BL = Blank
*** = Below Calibration Limit(5.0 ppb)

HILL AIR FORCE BASE
FIELD DATA

MW-127	8-9-96	320	7.2	578	40	208	<.05	<.2	0.4
MW-128	8-9-96	303	7.4	649	160	214	<.05	<.2	0.6
MW-138	8-9-96	68	7.5	916	162	305	.4	<.2	0.2
MW-137	8-9-96	273	7.2	1317	210	377	<.05	<.2	0.2
MW-137A	8-9-96	257	7.2	1302	220	365	<.05	<.2	0.2
MW-150	8-9-96	270	7.6	689	80	204	<.05	<.2	0.4
MW-151	8-9-96	265	7.7	558	90	169	<.05	<.2	.4
MW-159	8-9-96	254	7.3	1411	104	427	<.05	<.2	<.1
MW-130	8-9-96	275	8.4	571	184	205	<.05	<.2	0.1
M2-169	8-10-96	231	7.2	1375	230	501	<.05	<.2	0.1
MW-148	8-10-96	247	7.7	670	106	225	<.05	<.2	0.6
MW-163	8-10-96	233	7.2	1310	222	444	<.05	<.2	0.3
MW-154	8-10-96	251	7.3	689	150	273	<.05	<.2	0.3
MW-155	8-10-96	240	7.1	699	128	234	<.05	<.2	[illegible]
MW-135	8-10-96	-75	7.3	763	146	251	.9	<.2	<.1
TAD-6	8-10-96	149	7.9	977	130	260	<.05	<.2	
MW-129	8-10-96	161	8.1	751	110	206	<.05	<.2	

MAN
TECH

Ref: 96-BN14

August 12, 1996

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift

Dear Don:

As requested in Service Request #SFTA-2-99, dissolved hydrogen analysis was completed on 21 monitoring wells at Hill AFB. The dates for these analyses were August 6, 1996 - August 10, 1996. The calibration range for these analyses is from 0.1 to 10.0 ppm. The concentrations for hydrogen are given in parts per million.

Sample	Concentration (ppm)
MW-158	3.4
MW-161	0.3
MW-162	0.1
MW-160	6.2
MW-160 DUP	6.1
MW-124	0.1
MW-145	0.5
MW-136	0.1
MW-147	0.4
MW-122	0.5
MW-142	0.4
MW-125	0.3
MW-125 DUP	0.4
MW-143	0.3
MW-140	0.2
MW-127	0.3
MW-138	0.1

MW-137	0.5
MW-137 DUP	0.5
MW-169	0.7
MW-163	0.3
MW-154	0.4
MW-135	0.2
MW-135 DUP	0.2
TAD-6	0.5

It should be noted that TAD-6 had stainless steel well casing.

If you have any questions, please feel free to call me.

Sincerely,

Bryan Newell

Bryan Newell

xc: R.L.Cosby
G.B. Smith
J.T. Wilson
J.L. Seeley

MAN
TECH

Ref: 96-DF56

Sept. 4, 1996

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection and Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift SV

Dear Don:

As requested in Service Request SF-2-227, GC/MS analysis for phenols and aliphatic/aromatic acids was done on three water samples taken at Hill AFB. These samples were labeled: MW-138, MW-137 and MW-127. These samples were received on Aug. 12 and 13, 1996. Derivatization of the samples was done by Amy Zhao on Aug. 22, 1996. The extract was analyzed by GC/MS on Aug. 28, 1996. RSKERL SOP 177 was used for the extraction, derivatization and GC/MS analysis of the samples.

Table I provides the concentrations of the phenols and aliphatic/aromatic acids found in the water samples from Hill AFB. Derivative and extraction blanks, an extraction recovery and a 100 ppb check standard are also included in the table.

If you should have any questions, please feel free to contact me.

Sincerely,

Dennis D Fine

Dennis D. Fine

xc: J. Wilson
J. Seeley
G. Smith
R. Cosby
D. Fine

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

Table I. Quantitative Report and QC Data for Phenols and Aliphatic and Aromatic Acids from Water Samples from Hill AFB (Service Request SF-2-227)

Concentration ppb

		MW-139	MW-137	MW-127	Extraction Blank	50 ppb Extraction Recovery	100 ppb Check Standard
1	PROPANOIC ACID - PFB	15	14	***	***	5	124
2	2-METHYLPROPANOIC ACID - PFB	***	***	***	***	19	120
3	TRIMETHYL ACETIC ACID - PFB	***	***	***	***	48	119
4	BUTYRIC ACID - PFB	5	***	5	N.F.	15	127
5	2-METHYLBUTYRIC ACID - PFB	***	***	***	***	42	116
6	3-METHYLBUTYRIC ACID - PFB	***	***	***	***	41	115
7	3,3-DIMETHYLBUTYRIC ACID - PFB	***	***	***	***	59	114
8	PENTANOIC ACID - PFB	***	***	***	***	44	113
9	2,3-DIMETHYLBUTYRIC ACID - PFB	***	***	***	***	59	110
10	2-ETHYLBUTYRIC ACID - PFB	***	***	***	***	58	111
11	2-METHYLPENTANOIC ACID - PFB	***	***	***	***	57	110
12	3-METHYLPENTANOIC ACID - PFB	***	***	***	***	57	110
13	4-METHYLPENTANOIC ACID - PFB	***	***	***	***	56	109
14	HEXANOIC ACID - PFB	6	***	6	***	62	111
15	2-METHYLHEXANOIC ACID - PFB	***	***	***	***	56	104
16	PHENOL - PFB	***	N.F	N.F.	5	63	111
17	CYCLOPENTANECARBOXYLIC ACID - PFB	N.F.	***	***	N.F.	56	146
18	5-METHYLHEXANOIC ACID - PFB	N.F.	***	***	N.F.	61	139
19	o-CRESOL - PFB	N.F.	N.F.	N.F.	N.F.	70	102
20	2-ETHYLHEXANOIC ACID - PFB	***	***	***	***	59	104
21	HEPTANOIC ACID - PFB	N.F.	N.F.	***	N.F.	41	94
22	m-CRESOL - PFB	N.F.	N.F.	N.F.	N.F.	66	102
23	p-CRESOL - PFB	N.F.	N.F.	N.F.	N.F.	68	102
24	1-CYCLOPENTENE-1-CARBOXYLIC ACID - PFB	N.F.	***	N.F.	***	51	113
25	o-ETHYLPHENOL - PFB	N.F.	N.F.	N.F.	N.F.	70	101
26	CYCLOPENTANEACETIC ACID - PFB	N.F.	***	N.F.	N.F.	56	112
27	2,6-DIMETHYLPHENOL - PFB	N.F.	N.F.	N.F.	N.F.	62	94
28	2,5-DIMETHYLPHENOL - PFB	N.F.	N.F.	N.F.	N.F.	71	106
29	CYCLOHEXANECARBOXYLIC ACID - PFB	N.F.	N.F.	N.F.	N.F.	55	109
30	3-CYCLOHEXENE-1-CARBOXYLIC ACID - PFB	***	N.F.	***	***	57	113
31	2,4-DIMETHYLPHENOL - PFB	N.F.	N.F.	N.F.	N.F.	59	96
32	3,5-DIMETHYLPHENOL & M-ETHYLPHENOL - PFB	N.F.	N.F.	N.F.	N.F.	66	103
33	OCTANOIC ACID - PFB	12	***	***	***	60	114
34	2,3-DIMETHYLPHENOL - PFB	N.F.	N.F.	N.F.	N.F.	65	104
35	p-ETHYLPHENOL - PFB	N.F.	N.F.	N.F.	N.F.	66	95
36	BENZOIC ACID - PFB	6	7	9	12	63	114
37	3,4-DIMETHYLPHENOL - PFB	N.F.	N.F.	N.F.	***	67	96
38	m-METHYLBENZOIC ACID - PFB	N.F.	N.F.	N.F.	N.F.	56	117
39	1-CYCLOHEXENE-1-CARBOXYLIC ACID - PFB	N.F.	***	***	***	63	114
40	CYCLOHEXANEACETIC ACID - PFB	N.F.	N.F.	N.F.	N.F.	56	109
41	2-PHENYLPROPANOIC ACID - PFB	N.F.	N.F.	N.F.	N.F.	60	118
42	o-METHYLBENZOIC ACID - PFB	N.F.	***	N.F.	N.F.	62	116
43	PHENYLACETIC ACID - PFB	N.F.	N.F.	N.F.	N.F.	61	116
44	m-TOLYLACETIC ACID - PFB	N.F.	N.F.	N.F.	N.F.	63	118
45	o-TOLYLACETIC ACID - PFB	N.F.	N.F.	N.F.	N.F.	64	90
46	2,6-DIMETHYLBENZOIC ACID - PFB	N.F.	***	N.F.	N.F.	67	122
47	p-TOLYLACETIC ACID - PFB	N.F.	N.F.	N.F.	N.F.	56	124
48	p-METHYLBENZOIC ACID - PFB	N.F.	***	N.F.	***	62	121
49	3-PHENYLPROPANOIC ACID - PFB	N.F.	N.F.	N.F.	N.F.	60	106
50	2,5-DIMETHYLBENZOIC ACID - PFB	N.F.	N.F.	N.F.	N.F.	56	109
51	DECANOIC ACID - PFB	7	***	N.F.	N.F.	65	109
52	2,4-DIMETHYLBENZOIC ACID - PFB	N.F.	N.F.	N.F.	N.F.	62	114
53	3,5-DIMETHYLBENZOIC ACID - PFB	N.F.	N.F.	N.F.	***	53	105
54	2,3-DIMETHYLBENZOIC ACID - PFB	N.F.	N.F.	N.F.	N.F.	59	118
55	4-ETHYLBENZOIC ACID - PFB	N.F.	N.F.	N.F.	N.F.	61	113
56	2,4,6-TRIMETHYLBENZOIC ACID - PFB	N.F.	N.F.	N.F.	N.F.	59	97
57	3,4-DIMETHYLBENZOIC ACID - PFB	N.F.	N.F.	N.F.	N.F.	64	116
58	2,4,5-TRIMETHYLBENZOIC ACID - PFB	N.F.	N.F.	N.F.	N.F.	60	111

*** indicates concentration of extract was below lowest calibration standard (5 ppb).

N.F. indicates not found.

Ref: 96-NV145/vg

August 22, 1996

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: J.L. Seeley

Dear Don:

Attached is the metal analysis report (4559.LST) for 7 samples (Hill AFB) submitted to MERSC as part of Service Request #67 under EPA Contract #68-C3-0322. The samples were received on August 15 and analyzed August 16, 1996. The samples did not receive any further treatment and they were analyzed using the ICAP system. Lead was determined using *GF-AAS and results are in* report PB60820.LIS;1. SOP for the ICP, GF-AA and sample calculations were according to the procedure and instructions provided by Mr. Don Clark.

If you have any questions, please feel free to contact me.

Sincerely,

Nohora Vela

Nohora Vela

xc: R.L. Cosby
R. Puls
J.T. Wilson

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

```
                                   ELEMENTAL CONSTITUENT  ALYSIS BY: ICAP (DATA.DAT)
                   THIS REPORT (USER$DISK:[CLARK.ICAP]LIST.LST;4559)  S GENERATED FROM USER$DISK:[CLARK.ICAP]OUTPUT.DAT;3104

PROJECT: AQ FILTERED SAMPLES. HILL AFB. DIRECT READING
         KAMPBELL
         SR67

CONCENTRATION IN: MG/L

TAG NO.  14652                       14653                       14654                       14655
STATION  MW-167                      MW-124                      MW-145                      MW-162
TIME        14:54                       14:51                       15:01                       14:56
DATE      16-AUG-96                   16-AUG-96                   16-AUG-96                   16-AUG-96
PR DIL         1.0000                      1.0000                      1.0000                      1.0000
DIL            1.0000                      1.0000                      1.0000                      1.0000

ELEMENT     VALUE      STDV +/-        VALUE      STDV +/-        VALUE      STDV +/-        VALUE      STDV +/-        LOD
-------  ------------ ------------  ------------ ------------  ------------ ------------  ------------ ------------  ------------

  Na-1      55.3          5.5           28.3          2.8           79.9          7.9          104.          10.           0.0360
  K          6.8          1.3            2.2          1.3           <1.3          1.3            3.1          1.3          1.3030
  Ca        78.7          7.8           87.0          8.7          131.          13.           166.          16.           0.0164
  Mg        84.3          8.4           35.0          3.5           30.9          3.1           60.9          6.0          0.0732
  Fe       <0.0050        0.0050        <0.0045       0.0045        <0.0044       0.0044        <0.0047       0.0047       0.0043
  Mn       <0.0022        0.0022        <0.0012       0.0012        <0.0011       0.0011        <0.0018       0.0018       0.0007
  Co       <0.0094        0.0094        <0.0094       0.0094        <0.0094       0.0094        <0.0094       0.0094       0.0094
  Mo       <0.067         0.067         <0.067        0.067         <0.067        0.067         <0.067        0.067        0.0676
  Al       <0.094         0.094         <0.094        0.094         <0.094        0.094         <0.094        0.094        0.0945
  As       <0.025         0.025         <0.025        0.025         <0.025        0.025         <0.025        0.025        0.0256
  Se       <0.025         0.025         <0.025        0.025         <0.025        0.025         <0.025        0.025        0.0259
  Cd       <0.0013        0.0013        <0.0013       0.0013        <0.0013       0.0013        <0.0013       0.0013       0.0013
  Be       <0.0009        0.0009        <0.0010       0.0010        <0.0013       0.0013        <0.0015       0.0015       0.0007
  Cu       <0.012         0.012         <0.012        0.012         <0.012        0.012         <0.012        0.012        0.0124
  Cr        0.0023        0.0014         0.0045       0.0014         0.0039       0.0014         0.0036       0.0014       0.0014
  Ni       <0.0054        0.0054        <0.0054       0.0054        <0.0054       0.0054        <0.0054       0.0054       0.0054
  Zn       <0.11          0.11          <0.11         0.11          <0.11         0.11          <0.11         0.11         0.1195
  Ag       <0.013         0.013         <0.013        0.013         <0.013        0.013         <0.013        0.013        0.0139
  Tl       <0.0056        0.0056        <0.0056       0.0056        <0.0056       0.0056        <0.0056       0.0056       0.0056
  Pb       <0.023         0.023         <0.023        0.023         <0.023        0.023         <0.023        0.023        0.0234
  Sr        0.743         0.074          0.321        0.032          0.493        0.049          0.875        0.087        0.0008
  V        <0.020         0.020         <0.020        0.020         <0.020        0.020         <0.020        0.020        0.0208
  Ba        0.147         0.014          0.339        0.033          0.451        0.045          0.319        0.031        0.0022
  B         0.167         0.015          0.0785       0.0083         0.152        0.014          0.148        0.013        0.0083
  Ti       <0.0048        0.0048        <0.0048       0.0048        <0.0048       0.0048        <0.0048       0.0048       0.0048



< VALUE=LIMIT OF DETECTION DETERMINED BY INSTRUMENT SENSITIVITY, SAMPLE DILUTION,  AND MATRIX INTERFERENCE.
  RESULTS ACCURATE TO 2 SIGNIFICANT DIGITS                                                   EPA/RSKERL/ADA, OK
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                                    ELEMENTAL CONSTITUENTS ANALYSIS BY: ICAP (DATA.DAT)
                       THIS REPORT (USER$DISK:[CLARK.ICAP]LIST.LST;4559) WAS GENERATED FROM USER$DISK:[CLARK.ICAP]OUTPUT.DAT;3104

PROJECT: AQ FILTERED SAMPLES. HILL AFB. DIRECT READING
         KAMPBELL
         SR67

CONCENTRATION IN: MG/L

TAG NO.  14656                       14657                       14658                       ZSTD5
STATION  MW-122                      MW-127                      MW-169                      ----------
TIME        14:59                       15:03                       14:49                       15:20
DATE      16-AUG-96                   16-AUG-96                   16-AUG-96                   16-AUG-96
PR DIL         1.0000                      1.0000                      1.0000                      1.0000
DIL            1.0000                      1.0000                      1.0000                      1.0000

ELEMENT     VALUE       STDV +/-        VALUE       STDV +/-        VALUE       STDV +/-        VALUE       STDV +/-        LOD
------- ------------ ------------   ------------ ------------   ------------ ------------   ------------ ------------   ------------

 Na-1      68.5         6.8            26.5         2.6           102.          10.             0.089        0.036          0.0360
 K         <1.3         1.3            <1.3         1.3            26.0          2.5           <1.3          1.3            1.3030
 Ca       106.         10.             68.8         6.8            44.0          4.4            0.053        0.016          0.0164
 Mg        33.0         3.3            21.2         2.1            96.6          9.6           <0.24         0.24           0.0732
 Fe         0.0087      0.0044         <0.0044      0.0044         <0.0052       0.0052        98.2          9.8            0.0043
 Mn         0.0074      0.0018          0.0851      0.0089         <0.0025       0.0025        97.7          9.7            0.0007
 Co        <0.0094      0.0094         <0.0094      0.0094         <0.0094       0.0094        <0.0094       0.0094         0.0094
 Mo        <0.067       0.067          <0.067       0.067          <0.067        0.067         <0.067        0.067          0.0676
 Al        <0.094       0.094          <0.094       0.094          <0.094        0.094         96.3          9.6            0.0945
 As        <0.025       0.025          <0.025       0.025          <0.025        0.025         <0.18         0.18           0.0256
 Se        <0.025       0.025          <0.025       0.025          <0.025        0.025         <0.10         0.10           0.0259
 Cd        <0.0013      0.0013         <0.0013      0.0013         <0.0013       0.0013         0.0021       0.0013         0.0013
 Be        <0.0011      0.0011         <0.0009      0.0009         <0.0008       0.0008         0.0025       0.0007         0.0007
 Cu        <0.012       0.012          <0.012       0.012          <0.012        0.012         <0.013        0.013          0.0124
 Cr         0.0019      0.0014          0.0061      0.0014          0.0032       0.0014        <0.0016       0.0016         0.0014
 Ni         0.0612      0.0062          0.0839      0.0082         <0.0054       0.0054        <0.0054       0.0054         0.0054
 Zn        <0.11        0.11           <0.11        0.11           <0.11         0.11          <0.11         0.11           0.1195
 Ag        <0.013       0.013          <0.013       0.013          <0.013        0.013         <0.014        0.014          0.0139
 Tl        <0.0056      0.0056         <0.0056      0.0056         <0.0056       0.0056        <0.047        0.047          0.0056
 Pb        <0.023       0.023          <0.023       0.023          <0.023        0.023         <0.059        0.059          0.0234
 Sr         0.483       0.048           0.290       0.028           0.785        0.078         <0.0008       0.0008         0.0008
 V         <0.020       0.020          <0.020       0.020          <0.020        0.020         <0.020        0.020          0.0208
 Ba         0.248       0.024           0.136       0.013           0.146        0.014         <0.0022       0.0022         0.0022
 B          0.209       0.020           0.0687      0.0083          0.479        0.047         <0.010        0.010          0.0083
 Ti        <0.0048      0.0048         <0.0048      0.0048         <0.0048       0.0048        <0.0048       0.0048         0.0048



< VALUE=LIMIT OF DETECTION DETERMINED BY INSTRUMENT SENSITIVITY, SAMPLE DILUTION,  AND MATRIX INTERFERENCE.
  RESULTS ACCURATE TO 2 SIGNIFICANT DIGITS                                                        EPA/RSKERL/ADA, OK
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                                        ELEMENTAL CONSTITUENTS [illegible]LYSIS BY: ICAP (DATA.DAT)
                    THIS REPORT (USER$DISK:[CLARK.ICAP]LIST.LST;4559) W[illegible] GENERATED FROM USER$DISK:[CLARK.ICAP]OUTPUT.DAT;3104

PROJECT: AQ FILTERED SAMPLES. HILL AFB. DIRECT READING
         KAMPBELL
         SR67

CONCENTRATION IN: MG/L

TAG NO.  IECCHK2
STATION  ----------
TIME        15:22
DATE       16-AUG-96
PR DIL         1.0000
DIL            1.0000

ELEMENT     VALUE       STDV +/-       LOD
------- ------------ ------------ ------------

  Na-1      <0.036        0.036        0.0360
  K         <1.3          1.3          1.3030
  Ca       283.          28.           0.0164
  Mg       251.          25.           0.0732
  Fe        <0.010        0.010        0.0043
  Mn        <0.0065       0.0065       0.0007
  Co        <0.013        0.013        0.0094
  Mo        <0.067        0.067        0.0676
  Al        <0.15         0.15         0.0945
  As        <0.034        0.034        0.0256
  Se        <0.026        0.026        0.0259
  Cd         0.0158       0.0019       0.0013
  Be        <0.0066       0.0066       0.0007
  Cu        <0.017        0.017        0.0124
  Cr         0.0049       0.0015       0.0014
  Ni        <0.0054       0.0054       0.0054
  Zn        <0.11         0.11         0.1195
  Ag        <0.033        0.033        0.0139
  Tl         1.6          1.1          0.0056
  Pb        <0.024        0.024        0.0234
  Sr         0.0017       0.0008       0.0008
  V         17.7          1.7          0.0208
  Ba         0.0129       0.0026       0.0022
  B         <0.0095       0.0095       0.0083
  Ti        48.1          4.8          0.0048



< VALUE=LIMIT OF DETECTION DETERMINED BY INSTRUMENT SENSITIVITY, SAMPLE DILUTION,  AND MATRIX INTERFERENCE.
  RESULTS ACCURATE TO 2 SIGNIFICANT DIGITS                                                 EPA/RSKERL/ADA, OK
```

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                                   ELEMENTAL CONSTITUENTS ANALYSIS BY: ICAP (DATA.DAT)
              THIS REPORT (USER$DISK:[CLARK.ICAP]LIST.LST;4559) WAS GENERATED FROM USER$DISK:[CLARK.ICAP]OUTPUT.DAT;3104

PROJECT: AQ FILTERED SAMPLES. HILL AFB. DIRECT READING          20-AUG-96      08:55:29
         KAMPBELL
         SR67

THIS REPORT WAS GENERATED WITH THE FOLLOWING INFORMATION:

         ERROR LEVEL PERCENTAGE :  10%


         STATISTICAL SENSITIVITIES WITH A 2.0  SIGMA INTERVAL WERE USED


         CONCENTRATION IN: MG/L


         THE CONSTANT FILES USED:

         USER$DISK:[CLARK.ICAP]TYPE1.AMAX;1
         USER$DISK:[CLARK.ICAP]TYPE1.XQCA;1
         USER$DISK:[CLARK.ICAP]TYPE1.XQCB;1
         USER$DISK:[CLARK.ICAP]TYPE1.XQCC;1
         USER$DISK:[CLARK.ICAP]TYPE1.STD1;1
         USER$DISK:[CLARK.ICAP]TYPE1.STD2;1
         USER$DISK:[CLARK.ICAP]TYPE1.STD3;1
         USER$DISK:[CLARK.ICAP]TYPE1.STD4;1
         USER$DISK:[CLARK.ICAP]TYPE1.STD5;1
         USER$DISK:[CLARK.ICAP]TYPE1.XSS1;1
         USER$DISK:[CLARK.ICAP]TYPE1.XSS2;1
         USER$DISK:[CLARK.ICAP]TYPE1.FIXX;1
         USER$DISK:[CLARK.ICAP]TYPE1.LCN;46
                      LCN TIME: 15:53:07  LCN DATE: 19-JUN-96  FILTER FACTOR: 0.000002


         THE DATA FILES USED:

         USER$DISK:[CLARK.ICAP]DATA.DAT;293         (INSTRUMENT RAW DATA)
         USER$DISK:[CLARK.ICAP]IC0001.DAT;3931      (INSTRUMENT CALC. DATA)
         USER$DISK:[CLARK.ICAP]TAG.DAT;4885         (ORIGINAL TAG FILE)
         USER$DISK:[CLARK.ICAP]TAG.DAT;4890         (TAG FILE FOR CALC.)
         USER$DISK:[CLARK.ICAP]OUTPUT.DAT;3104
         USER$DISK:[CLARK.ICAP]OUTPUT.LST;3020
         USER$DISK:[CLARK.ICAP]ARCH.DAT;16
         USER$DISK:[CLARK.ICAP]LIST.LST;4559
         USER$DISK:[CLARK.ICAP]TRAILER.LST;[illegible]
```

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                    ELEMENTAL CONSTITUENT: [illegible]LYSIS BY AA MEASUREMENTS
THIS REPORT ([.REPORT]PB60820.LIS;1) WAS GENERATED FROM DATASET [.DATA]PB60820.DAT;2

PROJECT: AQ SAMPLES. HILL AFB. KAMPBELL. SR67

METHOD: LEAD BY GF-AAS

CONCENTRATION UNITS: MG/L

        TAG       SAD   STATION    MACHINE  PRIMARY  REGULAR       FINAL
       NUMBER      #     IDENT     READING  DILUTION DILUTION  CONCENTRATION
     ---------- ----- ----------  -------- -------- -------- ----------------
     14652      14652 MW-167         0.001    1.000    1.000            0.001
     14652      14652 MW-167         0.001    1.000    1.000            0.001
     14653      14653 MW-124         0.002    1.000    1.000            0.002
     14653      14653 MW-124         0.002    1.000    1.000            0.002
     14654      14654 MW-145         0.000    1.000    1.000            0.000
     14654      14654 MW-145         0.001    1.000    1.000            0.001
     14655      14655 MW-162         0.001    1.000    1.000            0.001
     14655      14655 MW-162         0.000    1.000    1.000            0.000
     14656      14656 MW-122         0.002    1.000    1.000            0.002
     14656      14656 MW-122         0.002    1.000    1.000            0.002
     14657      14657 MW-127         0.001    1.000    1.000            0.001
     14657      14657 MW-127         0.001    1.000    1.000            0.001
     14658      14658 MW-169        -0.000    1.000    1.000            0.000
     14658      14658 MW-169        -0.000    1.000    1.000            0.000
     BLANK      $$$$$ **********     0.001    1.000    1.000            0.001
     BLANK      $$$$$ **********     0.001    1.000    1.000            0.001
     STD2PPB    $$$$$ **********     0.003    1.000    1.000            0.003
     STD2PPB    $$$$$ **********     0.004    1.000    1.000            0.004
     STD5PPB    $$$$$ **********     0.007    1.000    1.000            0.007
     STD5PPB    $$$$$ **********     0.007    1.000    1.000            0.007
     STD10PPB   $$$$$ **********     0.011    1.000    1.000            0.011
     STD10PPB   $$$$$ **********     0.012    1.000    1.000            0.012
     STD20PPB   $$$$$ **********     0.022    1.000    1.000            0.022
     STD20PPB   $$$$$ **********     0.025    1.000    1.000            0.025
     STD50PPB   $$$$$ **********     0.050    1.000    1.000            0.050
     STD50PPB   $$$$$ **********     0.052    1.000    1.000            0.052
     STD100PPB  $$$$$ **********     0.095    1.000    1.000            0.095
     STD100PPB  $$$$$ **********     0.099    1.000    1.000            0.099
```

Ref: 96-TH59/vg
96-LP94/vg
96-MW87/vg
August 21, 1996

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift SV

Dear Don:

Attached are the results of 43 samples from Hill AFB submitted to MERSC as part of Service Request #SF-2-227. The samples were received August 12 and 13, 1996 and analyzed immediately. The methods used for analysis were EPA Methods 353.1 for NO_2 and NO_3, 350.1 for NH_3, and Waters capillary electrophoresis Method N-601 for Cl and SO_4. Quality assurance measures performed on this set of samples included spikes, duplicates, known AQC samples and blanks.

If you have any questions concerning these results, please feel free to contact us.

Sincerely,

Tim Hensely

Lynda Pennington
Lynda Pennington

Mark White

xc: R.L. Cosby
G.B. Smith
J.L. Seeley
J.T. Wilson

ManTech Environmental Research Services Corporation
R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

Sample	mg/L Cl^-	mg/L $SO_4^=$	mg/L $NO_2^-+NO_3^-(N)$	mg/L NH_3
MW-139	118	61.1	.17	.72
MW-158	108	45.2	6.56	<.05
MW-146	196	37.3	7.00	<.05
MW-146 Dup	200	37.0	----	----
MW-167	86.0	65.7	4.21	<.05
MW-161	88.5	83.8	9.01	<.05
MW-141	53.4	52.3	3.23	<.05
MW-162	264	69.4	7.31	<.05
MW-134	79.8	54.9	3.76	<.05
MW-160	81.1	45.3	3.34	<.05
MW-133	629	57.1	27.8	<.05
MW-133 Dup	----	----	27.5	<.05
MW-164	85.6	79.5	7.35	<.05
MW-124	100	44.4	11.2	<.05
MW-124 Dup	99.2	44.0	----	----
MW-144	131	59.8	8.02	<.05
MW-165	68.7	55.6	5.18	<.05
MW-145	161	44.6	17.9	<.05
MW-136	116	38.5	3.46	<.05
MW-149	52.3	25.2	3.33	<.05
MW-149 Dup	51.8	25.1	----	----
MW-159	122	73.0	7.31	<.05
MW-147	61.1	65.3	7.58	<.05
MW-147A	60.2	64.6	7.75	<.05
MW-122	138	49.7	7.94	<.05
MW-142	100	69.3	5.55	<.05
MW-125	33.2	21.5	.96	<.05
MW-143	92.0	88.6	9.42	<.05
MW-126	44.3	35.8	2.75	<.05
MW-126 Dup	43.8	34.9	----	----
MW-140	45.8	47.3	11.8	<.05
MW-140 Dup	----	----	12.2	<.05
MW-127	27.2	21.4	.59	<.05
MW-128	36.0	49.9	.07	<.05
MW-137	151	51.7	4.10	<.05
MW-137A	151	55.0	3.97	<.05
MW-130	16.1	29.2	3.91	<.05
MW-138	59.3	43.2	.32	.93
MW-150	73.4	35.9	4.00	<.05
MW-150 Dup	74.5	36.7	----	----
MW-151	56.7	17.7	2.00	<.05

Sample	mg/L Cl^-	mg/L $SO_4^=$	mg/L $NO_2^- + NO_3^-$ (N)	mg/L NH_3
MW-151 Dup	----	----	1.99	<.05
MW-169	71.4	77.6	7.13	<.05
MW-148	40.8	37.2	3.53	<.05
MW-163	78.0	80.8	9.60	<.05
MW-135	37.8	61.4	.19	.32
TAD-6	111	35.5	1.04	<.05
MW-129	70.8	31.7	4.15	<.05
MW-129 Dup	70.0	33.1	----	----
MW-168	86.8	73.1	5.33	<.05
MW-155	72.2	49.3	1.85	<.05
MW-155 Dup	----	----	1.88	<.05
MW-154	25.0	24.5	.53	<.05
Blank	<.5	<.5	<.05	<.05
AQC	56.0	55.5	.36	1.49
AQC T.V.	55.9	52.0	.39	1.40
Spike Rec.	100%	105%	98%	101%
	----	----	101%	101%

MAN
TECH

Ref: 96-JH78/vg

August 30, 1996

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift SV

Dear Don:

Find attached results for methane and ethylene on samples received August 12 and 14, 1996 from Hill AFB under Service Request #SF-2-227. Samples were prepared and calculations done as per RSKSOP-175. Analyses were performed as per RSKSOP-147.

If you have any questions concerning this data, please feel free to contact me.

Sincerely,

Jeff Hick

Jeff Hickerson

xc: R.L. Cosby
G.B. Smith
J.L. Seeley

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

SR# SF-2-227
HILL

ANALYSIS PERFORMED 8-21-96

SAMPLE	METHANE	ETHYLENE
LAB BLANK	BLQ	ND
MW-122	BLQ	ND
MW-124	BLQ	ND
MW-125	0.021	ND
MW-126	BLQ	ND
" FIELD DUP	BLQ	ND
MW-127	0.012	ND
MW-128	BLQ	ND
MW-130	BLQ	ND
MW-133	BLQ	ND
MW-134	BLQ	ND
" LAB DUP	BLQ	ND

ANALYSIS PERFORMED 8-22-96

SAMPLE	METHANE	ETHYLENE
LAB BLANK	BLQ	ND
MW-136	BLQ	ND
MW-137	BLQ	ND
MW-137A	BLQ	ND
MW-138	0.035	ND
" FIELD DUP	0.032	ND
MW-139	0.428	ND
MW-140	BLQ	ND
MW-141	BLQ	ND
MW-142	BLQ	ND
MW-143	BLQ	ND
" LAB DUP	BLQ	ND
MW-144	BLQ	ND
MW-145	BLQ	ND
MW-146	BLQ	ND
MW-147	BLQ	ND
MW-147A	BLQ	ND
" FIELD DUP	BLQ	ND

ANALYSIS PERFORMED 8-23-96

SAMPLE	METHANE	ETHYLENE
LAB BLANK	BLQ	ND
MW-129	BLQ	ND
MW-135	0.089	ND
MW-148	BLQ	ND
MW-149	BLQ	ND
" LAB DUP	BLQ	ND
MW-150	BLQ	ND
MW-151	BLQ	ND
MW-154	0.041	ND
MW-155	0.006	ND
MW-158	BLQ	ND
" FIELD DUP	BLQ	ND
MW-159	BLQ	ND
MW-160	BLQ	ND

ANALYSIS PERFORMED 8-26-96

SAMPLE	METHANE	ETHYLENE
LAB BLANK	BLQ	ND
MW-161	BLQ	ND
MW-162	BLQ	ND
MW-163	BLQ	ND
MW-164	BLQ	ND
MW-165	BLQ	ND
" FIELD DUP	BLQ	ND
MW-167	BLQ	ND
MW-168	BLQ	ND
MW-169	BLQ	ND
TAD-6	BLQ	ND
MP-1	BLQ	ND
" LAB DUP	BLQ	ND

ANALYSIS PERFORMED 8-27-96

SAMPLE	METHANE	ETHYLENE
LAB BLANK	BLQ	ND
MP-1D	BLQ	ND
MP-2	BLQ	ND
MP-2D	BLQ	ND
MP-3	0.018	ND
" LAB DUP	0.018	ND
MP-5	0.005	ND
MP-6	0.003	ND
MP-7	BLQ	ND
MP-8	0.006	ND
MP-15	BLQ	ND
" FIELD DUP	BLQ	ND
MP-18	0.010	ND
MW-153	BLQ	ND
TAD-4	0.009	ND
10 PPM CH4	10.00	NA
100 PPM CH4	100.06	NA
1000 PPM CH4	999.73	NA
1% CH4	1.00	NA
10 PPM C2H4	NA	10.25
100 PPM C2H4	NA	99.97

LIMIT OF QUANTITATION.

METHANE	ETHYLENE
0.001	0.003

SAMPLE UNITS ARE mg/L.
STANDARDS UNITS CORRESPOND
TO THE SAMPLE COLUMN.

BLQ DENOTES BELOW LIMIT OF QUANTITATION.
ND DENOTES NONE DETECTED.
NA DENOTES NOT ANALYZED.

MAN
TECH

Ref: 96-SH88/vg

August 28, 1996

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift

Dear Don:

Attached are TOC results for 55 Hill liquids submitted August 26, 1996 under Service Request #SF-2-227. Sample analysis was begun August 26, 1996 and completed August 28, 1996 using RSKSOP-102.

Blanks, duplicates, and AQC samples were analyzed along with your samples, as appropriate, for quality control. If you have any questions concerning this data, please feel free to ask me.

Sincerely,

Sharon Hightower

Sharon Hightower

xc: R.L. Cosby
G.B. Smith
J.L. Seeley

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

KAMPBELL HILL LIQUIDS SF-2-227

SAMPLE	MG/L TOC
MW122	2.37
MW124	1.70
MW125	1.62
MW126	1.53
MW127	2.10
MW127 DUP	1.91
MW128	2.15
MW129	3.23
MW130	4.29
MW133	2.07
MW134	2.05
MW134 DUP	1.91
MW135	1.18
MW136	1.54
MW137	2.41
MW137A	2.56
MW138	2.25
MW139	2.88
MW140	1.92
MW140 DUP	1.96
MW141	2.14
MW142	2.79
MW143	2.82
MW144	1.97
MW145	1.94
MW146	2.59
MW147	4.62
MW147A	4.05
MW148	6.84
MW149	1.53
MW150	1.25
MW151	.900
MW153	2.69
MW154	3.61
MW155	2.35
MW158	2.89
MW159	2.89
MW159 DUP	3.04
MW160	2.09
MW161	1.90
MW162	106
MW162 DUP	106
MW163	5.38
MW164	2.23
MW165	1.26
MW167	1.77
MW168	2.27

SAMPLE	MG/L TOC
MW169	2.77
MP1D	.651
MPS	3.35
MP1	.792
MP2D	1.11
MP3	8.26
MP6	3.06
MP7	3.93
MP8	3.37
MP15	1.90
MP18	23.4
TAD-4	6.09
TAD-6	1.69
TAD-6 DUP	1.70
WPO35-II	38.3
WPO35-II STD t.v.=40.1	

APPENDIX D

MODEL INPUT PARAMETERS, RELATED CALCULATIONS, AND SENSITIVITY ANALYSIS RESULTS

EXAMPLE CALCULATIONS

1) Hydraulic Conductivity Corrections

Hydraulic conductivity (K) values derived from slug tests and presented by Radian (1995) were corrected as follows:

- to use the borehole and casing radii instead of diameters; and
- to use a calculated effective casing radius where the water level was rising in the screen during the test.

The hydraulic conductivity calculations were performed by the AQTESOLV® software (Geraghty & Miller, 1994). The governing equations for the Bouwer and Rice (1979) method (as presented in Bouwer, 1989) that are used to compute K values are presented on the following page.

2) Contaminant Velocity

The estimated migration rate of TCE between MW143 and MW163, used to compute a TCE biodegradation rate along this flowpath, is 0.24 ft/day.

The advective migration velocity of groundwater = $V_{water} = K(i)/n_e$, where K is the hydraulic conductivity along the desired flowpath (2.8 ft/day--average of 7 slug test values in the vicinity of the desired flowpath), i is the hydraulic gradient along the flowpath (0.027 ft/ft, Figure 3.8), and n_e is the estimated effective porosity of the water-bearing materials (0.20, Section 3.4.2).

Performing the calculation, $V_{water} = 0.38$ ft/day

To obtain the TCE velocity, V_{water} is divided by the estimated retardation coefficient for TCE (1.57--see Table 5.2): $V_{water}/1.57 = 0.24$ ft/day.

3) Retardation Coefficient

$R = K_{oc}$ + [(bulk density x distribution coefficient)/effective porosity)]

K_{oc} = soil sorption coefficient normalized for total organic carbon content = 87 L/kg (Table 5.2)

Bulk density of the aquifer material = 1.65 kg/L (Table 5.2)

Effective porosity of the aquifer material = 0.20 (Table 5.2)

Distribution coefficient = $K_{oc}(f_{oc})$, where f_{oc} is the percent organic carbon in the aquifer matrix = 0.00079 average (Table 5.2).

Completing the calculation, the average retardation coefficient (R) = 1.57

From Bouwer, 1989

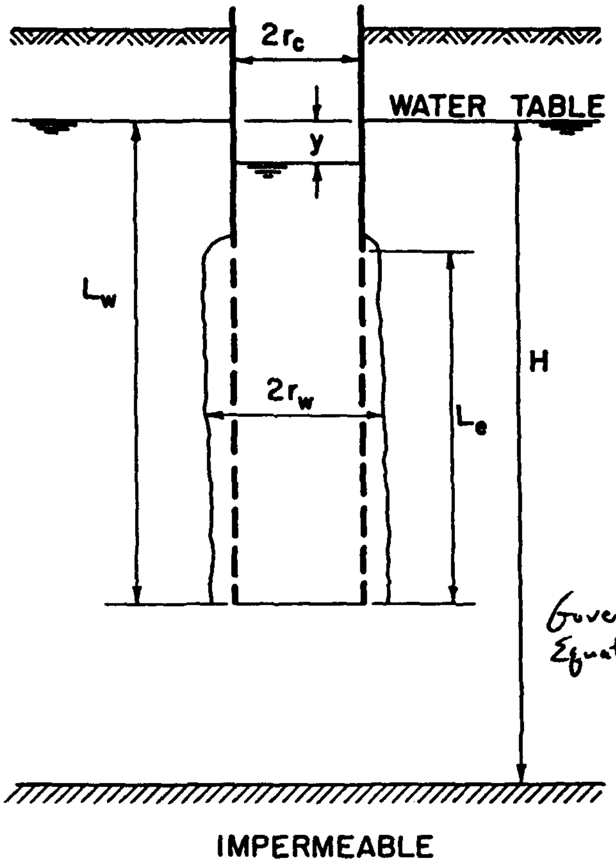

Fig. 1. Geometry and symbols for slug test on partially *penetrating, partially screened well in unconfined aquifer* with gravel pack and/or developed zone around screen.

well; R_e = effective radial distance over which y is dissipated; and r_w = radial distance of undisturbed portion of aquifer from centerline.

Values of R_e were determined with an electrical resistance network analog for different values of r_w, L_e, L_w, and H (see Figure 1 for meaning of geometry symbols). The value of r_w is the radius of the screened or open section of the well *plus the thickness of a sand or gravel pack and/or* of the developed zone around the well. Thus, r_w is the radial distance from the center of the well to normal K of the aquifer. Because the thickness of the developed zone is almost never known, the tendency is to ignore it and take only gravel or sand packs into account.

The rate of rise dy/dt of the water level in the well after the water level has been quickly lowered some distance is

$$\frac{dy}{dt} = -\frac{Q}{\pi r_c^2} \qquad (2)$$

where r_c is the radius of the casing or other section of the well where the rise of the water level is

discussion of effective casing radius.

measured. If the water level rises in the screened or open section of the well with a gravel pack around it, the thickness and porosity of the gravel envelope should be taken into account when calculating the equivalent value of r_c for the rising water level. This calculation is based on the total free-water surface area in the well and sand or gravel pack, calculated as $\pi r_c^2 + \pi(r_w^2 - r_c^2)n$, where n is the porosity, and $r_w - r_c$ is the thickness of the envelope. The equivalent radius of a circle giving this total area is then calculated as $[(1-n)r_c^2 + nr_w^2]^{1/2}$. *For example, if the radius of* the screen or perforated casing is 20 cm and there is 8 cm gravel pack with a porosity of 30 percent, r_c should be taken as 25.9 cm, while r_w is 28 cm.

Solving equation (2) for Q, equating the resulting expression to equation (1), integrating, and solving for K yields

Governing Equation $\Rightarrow$

$$K = \frac{r_c^2 \ln(R_e/r_w)}{2L_e} \frac{1}{t} \ln\frac{y_0}{y_t} \qquad (3)$$

where y_0 = y at time zero; and y_t = y at time t.

The results of the analog analyses to evaluate R_e *for various system geometries were expressed* in terms of the dimensionless ratio $\ln(R_e/r_w)$. The data could be fitted into two equations, one for the case where $L_w < H$, and one where $L_w = H$. The resulting equations were, respectively,

Supporting Equations

$$\ln\frac{R_e}{r_w} = \left[\frac{1.1}{\ln(L_w/r_w)} + \frac{A + B\ln[(H - L_w)/r_w]}{L_e/r_w}\right]^{-1} \qquad (4)$$

and

$$\ln\frac{R_e}{r_w} = \left[\frac{1.1}{\ln(L_w/r_w)} + \frac{C}{L_e/r_w}\right]^{-1} \qquad (5)$$

where A, B, and C are dimensionless numbers plotted in Figure 2 as a function of L_e/r_w.

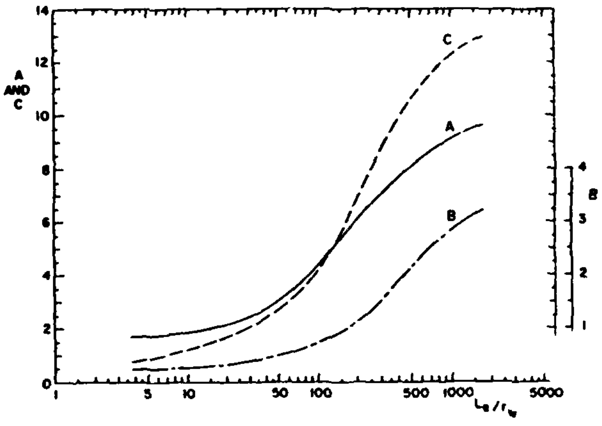

Fig. 2. Dimensionless parameters A, B, and C as a function of L_e/r_w for calculation of $\ln(R_e/r_w)$.

4) Biodegradation Rate Calculation Using the Method of Moutoux *et al.* (1996)

An excerpt from Moutoux *et al.* (1996) that describes the calculation of biodegradation rates for chlorinated solvents using the carbon core as a tracer follows this calculation sheet. This excerpt provides the equations that were used to compute TCE reductive dechlorination rates for OU5.

ESTIMATING THE CHANGING RATE OF ANAEROBIC REDUCTIVE DECHLORINATION OF CHLORINATED ALIPHATIC HYDROCARBONS IN THE PRESENCE OF PETROLEUM HYDROCARBONS

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Published in the Proceedings of the
1996
API/NGWA Conference on Petroleum Hydrocarbons and
Organic Chemicals in Ground Water
November 13 - 15, 1996

The Westin Galleria
Houston, Texas

From Moutoux et al. (1996)

very sensitive to hydrogeologic variability, as well as to the proximity of the sampled points to the dominant flow path of the plume, both laterally and vertically. This can contribute to the generation of less than desirable correlation coefficients (R^2) and bring the first-order assumption into question.

Total chlorinated ethene attenuation rates have been estimated for three sites: a former fire training area at Plattsburgh Air Force Base (AFB) (FT-002), a former fire training area at Cape Canaveral Air Station (AS) (FT-17), and a former bomber assembly plant at Offutt AFB (Bldg. 301). A brief summary of historical site information is provided in Table 1; site characterization data are summarized in Table 2. Total estimated chlorinated ethene attenuation rates for the three sites (Table 3) ranged from 0.00021 to 0.00051 day^{-1}, with the magnitude of the rates closely tied to the average retarded contaminant velocity. As an example, a log-linear plot of data collected from Plattsburgh AFB in 1995 is provided in Figure 1.

ESTIMATING FIRST-ORDER BIODEGRADATION FOR A STEADY-STATE PLUME

In order to ensure that some portion of observed decreases in contaminant concentrations can be attributed to biodegradation, measured contaminant concentrations must be corrected for the effects of dispersion, dilution, and sorption. Buscheck and Alcantar (1995) derive a relationship that allows calculation of first-order biodegradation rate constants for steady-state plumes. This method involves coupling the regression of contaminant concentration (plotted on a logarithmic scale) versus distance downgradient (plotted on a linear scale) to an analytical solution for one-dimensional, steady-state, contaminant transport that includes advection, dispersion, sorption, and biodegradation.

The relationship developed by Buscheck and Alcantar (1995) was applied to the data from all three sites, although each of these plumes is suspected to be expanding. As expected, the rates attributed to biodegradation are less than the total attenuation rates, with estimated rates ranging from one-half to three-quarters of the total attenuation rate. Data and results are presented in Tables 2 and 3, respectively. Figure 2 provides, as an example, the log-linear plot used in the calculation of the 1995 Plattsburgh AFB biodegradation rate. Because this technique uses the same concentration data as the total attenuation technique, it is equally sensitive to sampling locations and hydrogeologic variability.

For an expanding plume, this first-order approximation can be viewed as an upper bound on the biodegradation rate. Use of this method results in an overestimation of the rate of biodegradation because a typical expanding plume exhibits decreasing source area concentrations, increasing downgradient (and crossgradient) concentrations, or both. Over time, these changes result in a decreasing slope on a log-linear plot, and consequently a decreasing biodegradation rate.

↘ ↙

ESTIMATING FIRST-ORDER REDUCTIVE DECHLORINATION: THE CARBON CORE AS A TRACER

A convenient way to isolate the rate of biodegradation from other attenuation processes is to use as tracers compounds or elements associated with the contaminant plume that are relatively unaffected or predictably affected by biological processes occurring within the aquifer. When present, the trimethylbenzene isomers associated with fuels can serve as useful tracers under certain geochemical conditions (Wiedemeier *et al.*, 1995 and 1996a). Likewise, chloride, a degradation product of chlorinated solvent biodegradation has the potential to serve as a useful tracer (Wiedemeier *et al.*, 1996b). This section describes a tracer method that can be used with reductively dehalogenated solvent plumes, and involves tracking the "carbon" core of the chlorinated compounds in relation to the remaining chlorine mass.

Measured tracer and contaminant concentrations from a minimum of two points along a flow path can be used to estimate the amount of contaminant remaining at each point if biodegradation had been the only attenuation process operating to reduce contaminant concentrations. To accomplish this, it is assumed that the fraction of contaminant remaining as a result of all attenuation processes is equivalent to the fraction of contaminant remaining as a result of non-destructive attenuation mechanisms only, multiplied by the fraction of contaminant remaining as a result of biodegradation. The fraction of contaminant remaining as a result of all attenuation processes can be computed from the measured contaminant concentrations at two points along a flow path. The fraction of contaminant remaining as a result of non-destructive attenuation mechanisms only can be estimated from the tracer concentrations at the same two points, because an ideal tracer is affected by non-destructive attenuation mechanisms to the same degree as the contaminant of interest and is not affected by biologic processes. The following equation uses these assumptions to solve for the estimated downgradient contaminant concentration if biodegradation had been the only attenuation process operating between two points (*i* and *i-1*) along the flow path:

$$C_{i,corr} = C_{i-1,corr}\left(\frac{C_i}{C_{i-1}}\right)\left(\frac{T_{i-1}}{T_i}\right) \qquad (5)$$

where $C_{i,corr}$= corrected contaminant concentration at point i; $C_{i-1,corr}$= corrected contaminant concentration at point i-1 (Note that if point i-1 is the first or most upgradient point, $C_{i-1,corr}$ is equivalent to the observed contaminant concentration.); C_i = observed contaminant concentration at point i; C_{i-1}= observed contaminant concentration at point i-1; T_i = observed tracer concentration at point i; and T_{i-1}= observed tracer concentration at point i-1.

This equation can be used to estimate the theoretical contaminant concentration resulting from biodegradation alone for every point along a flow path on the basis of the measured contaminant concentration at the point of plume origin and the contaminant/tracer ratios between consecutive points along the flow path. This series of points can then be used to estimate a first-order rate of biodegradation as described for estimating total attenuation rates.

During reductive dechlorination, the source chlorinated solvent undergoes successive transformations involving the replacement of a chlorine atom by a hydrogen atom; however, the carbon core of both the parent and daughter compounds remains unchanged (i.e., no carbon bonds are broken). The carbon core is subject to the same non-destructive attenuation mechanisms that act on the larger chlorinated molecule, but it is unaffected by biologically mediated reductive dechlorination. For this reason, tracking the carbon core of dissolved chlorinated solvents can serve as a theoretically perfect "tracer" for biodegradation via reductive dechlorination.

In order to use the carbon core of the chlorinated parent and daughter compounds as a "tracer" for reductive dechlorination, "equivalents" for the dissolved mass of carbon and chlorine must be calculated for each point along a flow path. The "equivalents" are calculated by first converting contaminant concentrations into molar concentrations. For chlorinated ethenes, the carbon equivalent is calculated by multiplying the number of carbon atoms per molecule of chlorinated ethene (2) by the sum of the molar concentrations for PCE, TCE, DCE, VC, and ethene:

$$\mathrm{Ceq}_i = 2\,(M_{\mathrm{PCE},i} + M_{\mathrm{TCE},i} + M_{\mathrm{DCE},i} + M_{\mathrm{VC},i} + M_{\mathrm{Ethene},i}) \qquad (6)$$

where Ceq_i = carbon equivalent at point i; $M_{\mathrm{PCE},i}$ = molar concentration of PCE at point i; $M_{\mathrm{TCE},i}$ = molar concentration of TCE at point i; $M_{\mathrm{DCE},i}$ = molar concentration of DCE at point i; $M_{\mathrm{VC},i}$ = molar concentration of VC at point i; and $M_{\mathrm{Ethene},i}$ = molar concentration of ethene at point i.

The chlorine "equivalent" is defined as the sum of the products of molar concentration and chlorine atoms per molecule for each parent and daughter compound. For the chlorinated ethenes, the numbers of chlorine atoms per molecule are 4 for PCE, 3 for TCE, 2 for DCE, 1 for VC, and 0 for ethene:

$$\text{Cleq}_i = (M_{\text{PCE},i}*4) + (M_{\text{TCE},i}*3) + (M_{\text{DCE},i}*2) + M_{\text{VC},i} \quad (7)$$

where Cleq_i = chlorine equivalent at point i.

Using equation 5, and substituting Ceq for tracer concentrations and Cleq for observed contaminant concentrations, yields the theoretical total CAH concentrations at downgradient locations if reductive dechlorination had been the only natural attenuation process operating along the flow path. The same process can be used to determine the theoretical chlorine equivalents. Chlorine equivalents, carbon equivalents, the corrected total CAH concentrations, and the corrected chlorine equivalents for the Cape Canaveral AS, Plattsburgh AFB, and Offutt AFB sites are presented in Table 4. The corrected CAH concentrations are useful for comparison to other techniques; the corrected chlorine equivalents simplify visualization of the reductive dechlorination rate. Either the corrected total CAH concentrations or corrected chlorine equivalents can be used to calculate identical first-order rates for dechlorination (Table 3). An example log-linear plot is provided in Figure 3 for the 1995 Plattsburgh AFB calculation.

The results serve to illustrate two important aspects of this technique. First, the calculated first-order rate is for reductive dechlorination only. The Bldg. 301 plume at Offutt AFB is characterized by predominantly aerobic conditions and low daughter product concentrations throughout large portions of the plume; therefore, reductive dechlorination is expected only in isolated portions of the plume. This technique estimates a low reductive dechlorination rate with a low R^2 because limited reductive dechlorination appears to be occurring both at the head and the tail of the plume; however, little to no reductive dechlorination occurs through the central portion of the plume. Anaerobic, reducing conditions with large daughter product concentrations prevail at the fire training areas at Cape Canaveral AS and Plattsburgh AFB. Consequently, both have reductive dechlorination rates estimated with a high degree of correlation.

Secondly, the rate estimate does not adequately assess the total biodegradation rate if biodegradation mechanisms other than reductive dechlorination are operant. Alternate biodegradation avenues are available for lower molecular weight solvents such as VC as groundwater conditions become less reducing. For instance, at the Plattsburgh AFB FT-002 site, groundwater geochemistry becomes less reducing between 2,000 and 2,500 feet downgradient from the source area; therefore, a reductive dechlorination rate cannot be calculated beyond this point. The combination of slowing reductive dechlorination rates and the destruction of VC (and perhaps other parent and daughter products) by alternate biodegradation processes renders the technique inappropriate.

SECOND-ORDER DEGRADATION RATE ESTIMATES

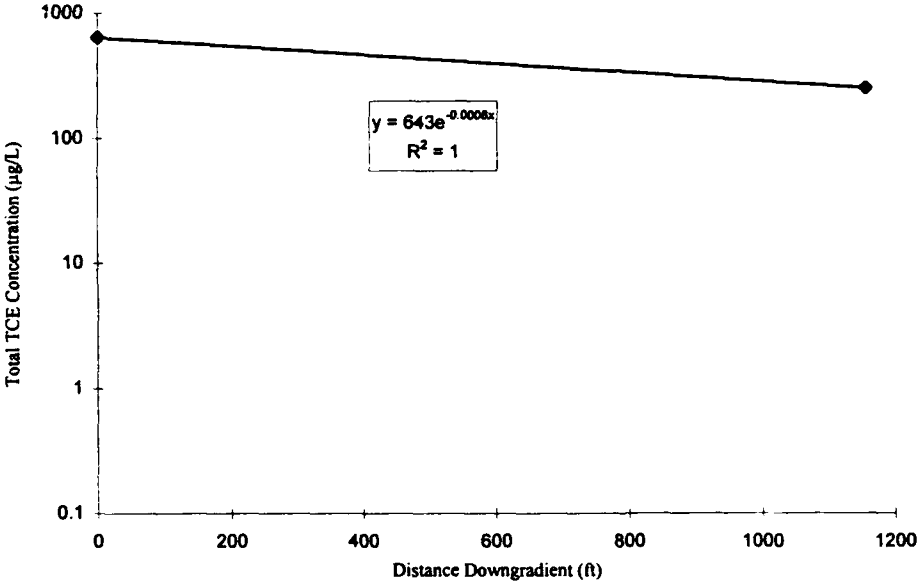
Although a first-order rate assumption may provide a reasonable approximation of how BTEX and CAH compounds are degrading in groundwater systems, this approach may neglect the importance of the electron donor-electron acceptor redox couples or the variable rate of biomass growth expected throughout the plume. As discussed previously, a first-order kinetic model may not provide the best approximation of how CAH compounds are dechlorinated (biodegraded) in the presence of another limited substrate, the electron donor (BTEX). Because highly-chlorinated CAH compounds are rarely used as primary substrates for microbial metabolism (e.g., McCarty and Semprini, 1994), the dechlorination of these compounds is dependent upon the microbial utilization of a primary substrate such as BTEX. Therefore, the degradation kinetics of this dual-dependency reaction may be more appropriately approximated by a bimolecular reaction rate expression (see equation 3). The linear form of this second-order equation is:

$$\frac{1}{[A]_o + [B]_o} \ln\left[\frac{[A]_o[B]}{[B]_o[A]}\right] = kt \quad (8)$$

FIRST-ORDER RATE CONSTANT CALCULATION
USING THE METHOD OF BUSCHECK AND ALCANTAR (1995)
OU5 RNA TS
HILL AFB, UTAH

Point	Distance Downgradient	TCE spring 1996
MW138	0	643
MW159	1155	253

PLOT OF TOTAL TCE CONCENTRATION VERSUS DISTANCE



$\lambda = v_c/4\alpha_x([1+2\alpha_x(k/v_x)]^2-1)$

where $v_c = 0.03$ ft/day

$\alpha_x = 115$ feet

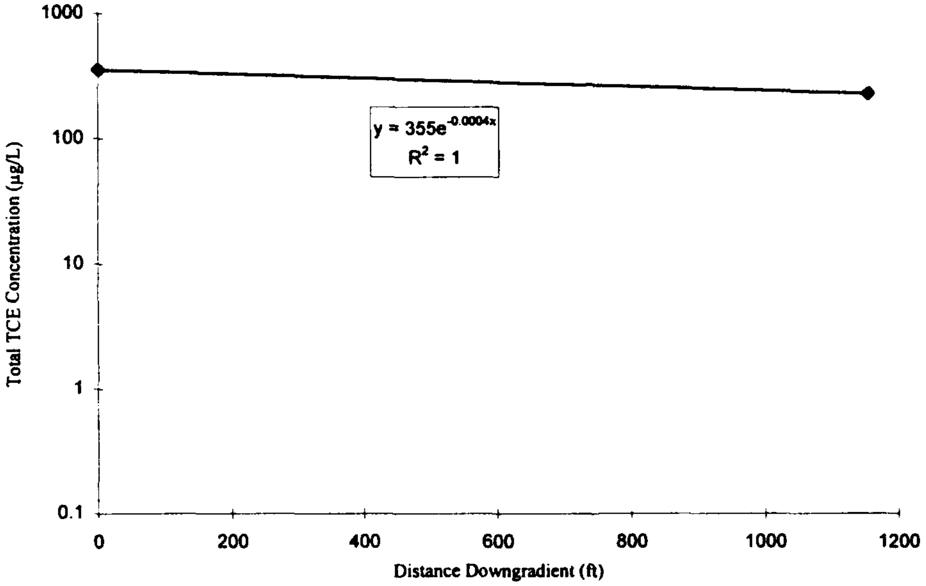
$k/v = 0.0008$

therefore $\lambda = 2.62E-05$

FIRST-ORDER RATE CONSTANT CALCULATION
USING THE METHOD OF BUSCHECK AND ALCANTAR (1995)
OU5 RNA TS
HILL AFB, UTAH

Point	Distance Downgradient	TCE Aug-96
MW138	0	355
MW159	1155	227

PLOT OF TOTAL TCE CONCENTRATION VERSUS DISTANCE



$\lambda = v_c/4\alpha_x([1+2\alpha_x(k/v_x)]^2-1)$

where v_c = 0.03 ft/day

α_x = 115 feet

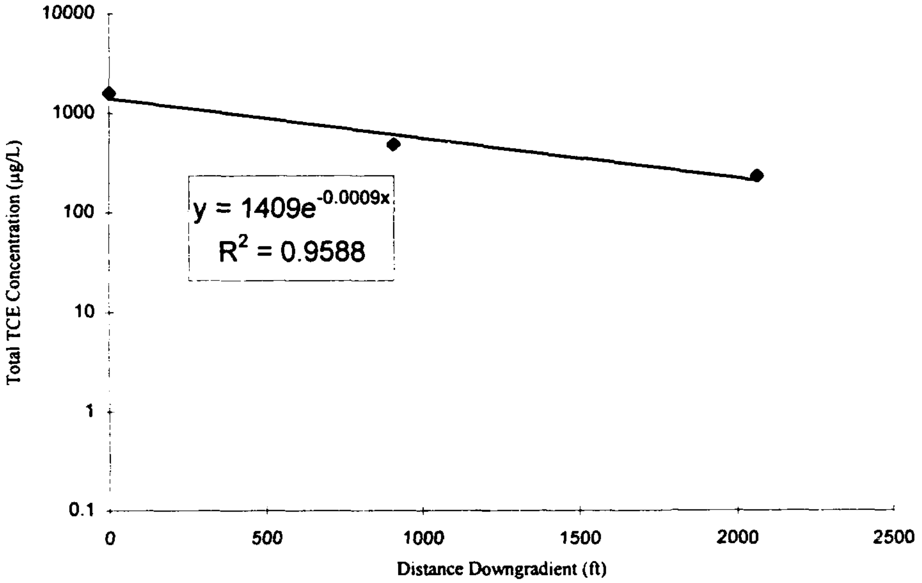
k/v = 0.0004

therefore λ = 1.26E-05

FIRST-ORDER RATE CONSTANT CALCULATION
USING THE METHOD OF BUSCHECK AND ALCANTAR (1995)
OU5 RNA TS
HILL AFB, UTAH

Point	Distance Downgradient	TCE Mar-95
MW127	0	1600
MW138	910	486
MW159	2065	233

PLOT OF TOTAL TCE CONCENTRATION VERSUS DISTANCE



$\lambda = v_c/4\alpha_x([1+2\alpha_x(k/v_x)]^2-1)$

where $v_c =$ 0.3 ft/day

$\alpha_x =$ 206 feet

$k/v =$ 0.0009

therefore $\lambda =$ 3.20E-04

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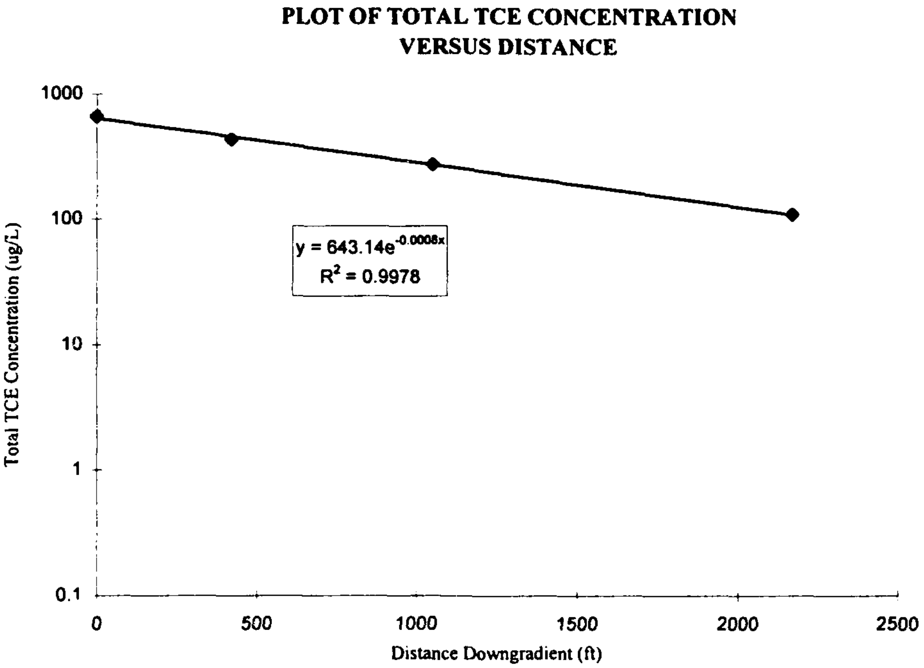
FIRST-ORDER RATE CONSTANT CALCULATION
USING THE METHOD OF BUSCHECK AND ALCANTAR (1995)
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Point	Distance Downgradient	TCE (μg/L) Oct-95
MW154	0	668
MW132	420	434
MW138	1050	274
MW159	2170	110



$\lambda = v_c/4\alpha_x([1+2\alpha_x(k/v_x)]^2-1)$

where $v_c = 0.3$

$\alpha_x = 217$

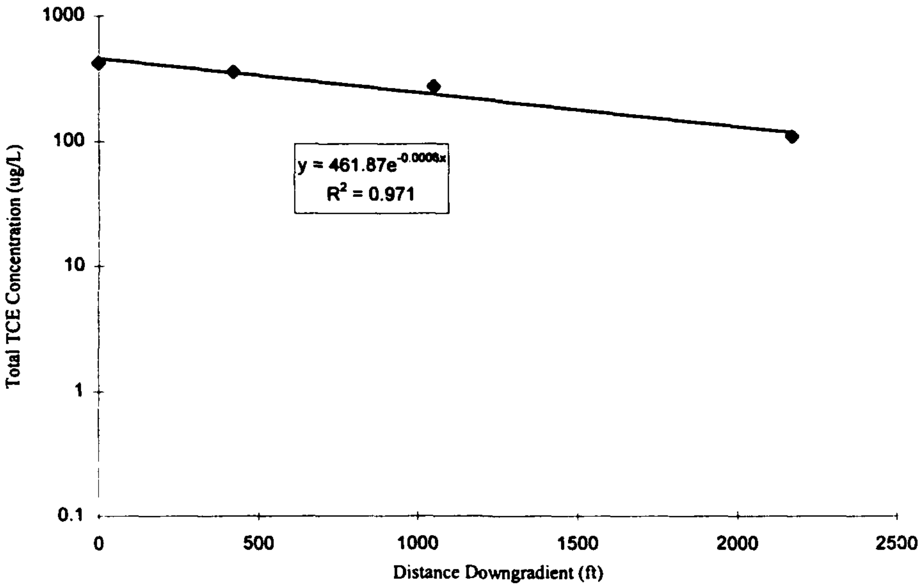
$k/v = 0.0008$

therefore $\lambda = 0.00028$

FIRST-ORDER RATE CONSTANT CALCULATION
USING THE METHOD OF BUSCHECK AND ALCANTAR (1995)
OU5 RNA TS
HILL AIR FORCE BASE, UTAH

Point	Distance Downgradient	TCE (μg/L) Oct-95
MW154	0	424
MW132	420	361
MW138	1050	274
MW159	2170	110

PLOT OF TOTAL TCE CONCENTRATION VERSUS DISTANCE



$$\lambda = v_c/4\alpha_x([1+2\alpha_x(k/v_x)]^2-1)$$

where $v_c = 0.3$

$\alpha_x = 217$

$k/v = 0.0006$

therefore $\lambda = 0.00020$

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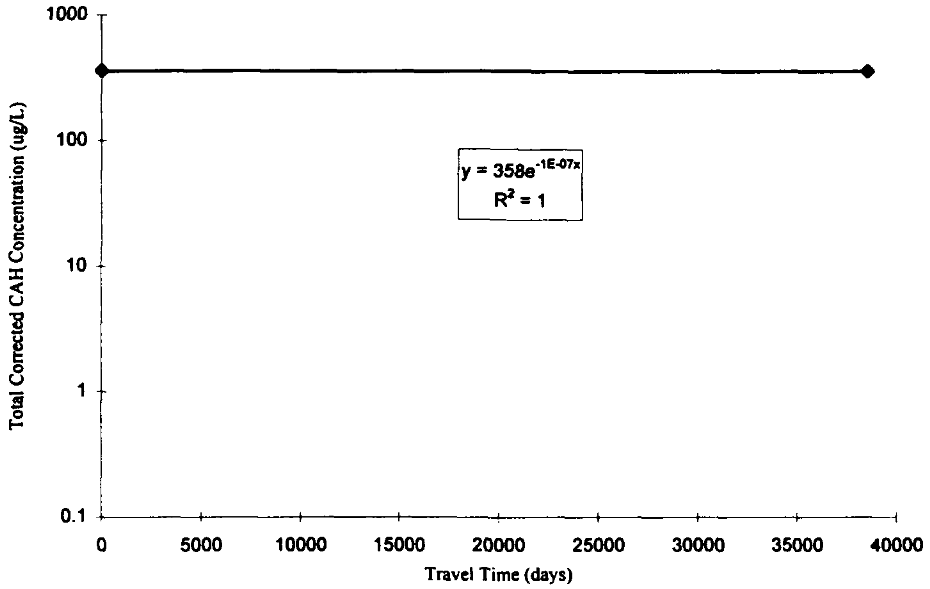
REDUCTIVE DECHLORINATION RATE
USING THE METHOD OF MOUTOUX (1996)
OU5 RNA TS
HILL AFB, UTAH

		Aug-96
	Travel Time	Corrected Total CAH
Point	(days)	Concentration (ug/L)
MW138	0	358
MW159	38500	356

PLOT OF TOTAL CORRECTED CAH CONCENTRATION VERSUS TRAVEL TIME



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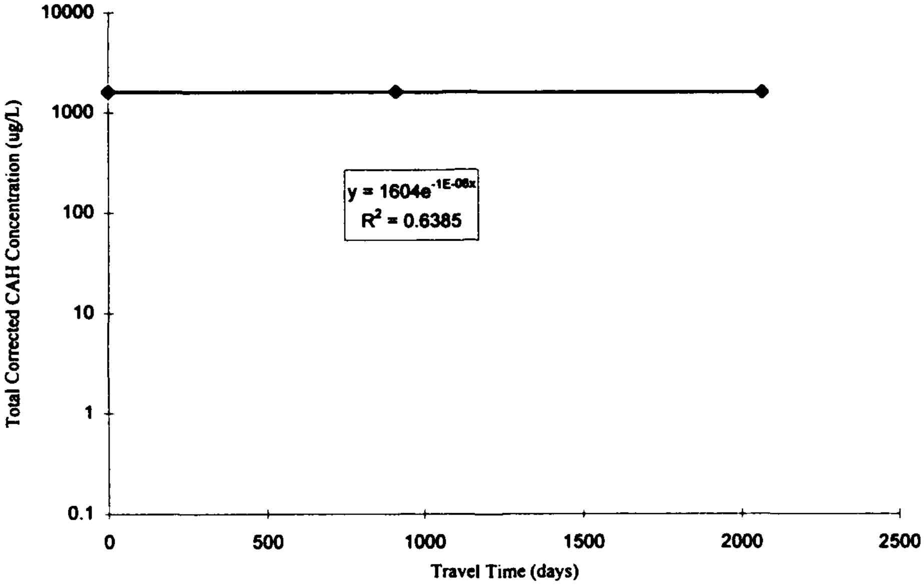
Computation of Corrected CAH Concentrations using the method of Moutoux (1995)									
August 1996 data									
Step 1: Enter Data									
Well	PCE	TCE	DCE	VC	Ethene	Total CAHs	Distance From Source (ft)	CAH velocity (ft/day)	CAH Travel Time (day)
MW138	0	355	3.1	0	0	358.1	0	0.03	0
MW159	0	227	5	0	0	232	1155	0.03	38500
Step 2: Compute Molar Concentrations (micromoles/Liter)									
	PCE	TCE	DCE	VC	Ethene	Total CAHs			
MW138	0	2.730769	0.032292	0	0	2.7630609			
MW159	0	1.746154	0.052083	0	0	1.79823718			
Step 3: Compute Carbon Equivalents				**Step 4: Compute Chlorine Equivalents**					
MW138	5.526122			8.256891					
MW159	3.596474			5.342628					
Step 5: Compute Corrected CAH Concentrations									
	C(i-1,corr)	C(i)/C(i-1)	T(i-1)/T(i)	Ci (corr)					
MW138	358.1			358.1					
MW159	358.1	0.647051	1.536539	356.0297					

REDUCTIVE DECHLORINATION RATE
USING THE METHOD OF MOUTOUX (1996)
OU5 RNA TS
HILL AFB, UTAH

Point	Travel Time (days)	Mar-95 Corrected Total CAH Concentration (ug/L)
MW127	0	1603
MW138	910	1604
MW159	2065	1599

PLOT OF TOTAL CORRECTED CAH CONCENTRATION VERSUS TRAVEL TIME



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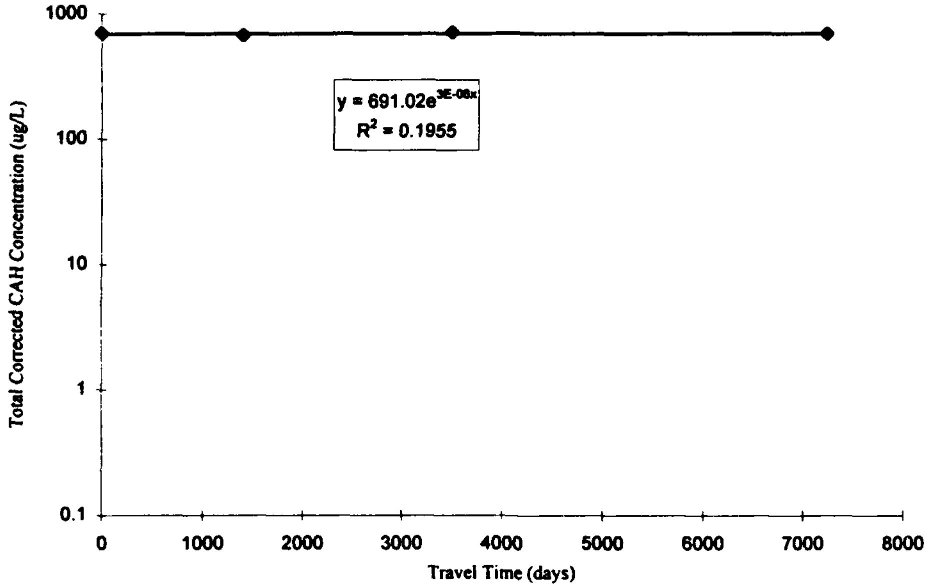
Computation of Corrected CAH Concentrations using the method of Moutoux (1995)									
March 1995 data from Radian									
Step 1: Enter Data									
Well	PCE	TCE	DCE	VC	Ethene	Total CAHs	Distance From Source (ft)	CAH velocity (ft/day)	CAH Travel Time (day)
MW127	0	1600	2.9	0	0	1602.9	0	0.3	0
MW138	0	486	0	0	0	486	910	0.3	3033.333
MW159	0	233	1.8	0	0	234.8	2065	0.3	6883.333
Step 2: Compute Molar Concentrations (micromoles/Liter)									
	PCE	TCE	DCE	VC	Ethene	Total CAHs			
MW127	0	12.30769	0.030208	0	0	12.3379006			
MW138	0	3.738462	0	0	0	3.73846154			
MW159	0	1.792308	0.01875	0	0	1.81105769			
Step 3: Compute Carbon Equivalents				**Step 4: Compute Chlorine Equivalents**					
MW127	24.6758			36.98349					
MW138	7.476923			11.21538					
MW159	3.622115			5.414423					
Step 5: Compute Corrected CAH Concentrations									
	C(i-1,corr)	C(i)/C(i-1)	T(i-1)/T(i)	Ci (corr)					
MW127	1602.9			1602.9					
MW138	1602.9	0.303254	3.300261	1604.209					
MW159	1604.209	0.482767	2.064242	1598.673					

REDUCTIVE DECHLORINATION RATE
USING THE METHOD OF MOUTOUX (1996)
OU5 RNA TS
HILL AFB, UTAH

		Oct-95
Point	Travel Time (days)	Corrected Total CAH Concentration (ug/L)
MW154	0	699
MW132	1400	676
MW138	3500	712
MW159	7233	704

PLOT OF TOTAL CORRECTED CAH CONCENTRATION VERSUS TRAVEL TIME



Computation of Corrected CAH Concentrations using the method of Moutoux (1995)

October 1995 data from Radian

Step 1: Enter Data

Well	PCE	TCE	DCE	VC	Ethene	Total CAHs	Distance From Source (ft)	CAH velocity (ft/day)	CAH Travel Time (day)
MW154	0	668	31	0	0	699	0	0.3	0
MW132	0	434	60	0	0	494	420	0.3	1400
MW138	0	274	1	0	0	275	1050	0.3	3500
MW159	0	110	3.1	0	0	113.1	2170	0.3	7233.333

Step 2: Compute Molar Concentrations (micromoles/Liter)

	PCE	TCE	DCE	VC	Ethene	Total CAHs
MW154	0	5.138462	0.322917	0	0	5.46137821
MW132	0	3.338462	0.625	0	0	3.96346154
MW138	0	2.107692	0.010417	0	0	2.11810897
MW159	0	0.846154	0.032292	0	0	0.87844551

Step 3: Compute Carbon Equivalents		Step 4: Compute Chlorine Equivalents
MW154	10.92276	16.06122
MW132	7.926923	11.26538
MW138	4.236218	6.34391
MW159	1.756891	2.603045

Step 5: Compute Corrected CAH Concentrations

	C(i-1,corr)	C(i)/C(i-1)	T(i-1)/T(i)	Ci (corr)
MW154	699			699
MW132	699	0.701403	1.377931	675.5731
MW138	675.5731	0.563133	1.871226	711.8847
MW159	711.8847	0.410322	2.411201	704.3164

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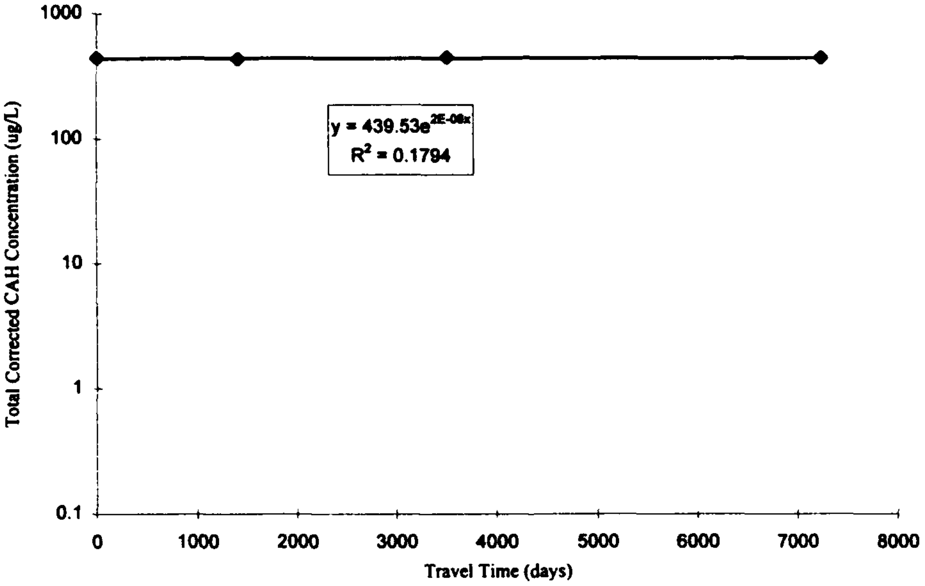
REDUCTIVE DECHLORINATION RATE USING THE METHOD OF MOUTOUX (1996)
OU5 RNA TS
HILL AFB, UTAH

		Oct-95
Point	Travel Time (days)	Corrected Total CAH Concentration (ug/L)
MW154	0	441
MW132	1400	435
MW138	3500	448
MW159	7233	443

PLOT OF TOTAL CORRECTED CAH CONCENTRATION VERSUS TRAVEL TIME



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Computation of Corrected CAH Concentrations using the method of Moutoux (1995)									
October 1995 data from Radian									
Step 1: Enter Data									
Well	PCE	TCE	DCE	VC	Ethene	Total CAHs	Distance From Source (ft)	CAH velocity (ft/day)	CAH Travel Time (day)
MW154	0	424	16.9	0	0	440.9	0	0.3	0
MW132	0	361	26	0	0	387	420	0.3	1400
MW138	0	274	1	0	0	275	1050	0.3	3500
MW159	0	110	3.1	0	0	113.1	2170	0.3	7233.333
Step 2: Compute Molar Concentrations (micromoles/Liter)									
	PCE	TCE	DCE	VC	Ethene	Total CAHs			
MW154	0	3.261538	0.176042	0	0	3.43758013			
MW132	0	2.776923	0.270833	0	0	3.04775641			
MW138	0	2.107692	0.010417	0	0	2.11810897			
MW159	0	0.846154	0.032292	0	0	0.87844551			
Step 3: Compute Carbon Equivalents				**Step 4: Compute Chlorine Equivalents**					
MW154	6.87516			10.1367					
MW132	6.095513			8.872436					
MW138	4.236218			6.34391					
MW159	1.756891			2.603045					
Step 5: Compute Corrected CAH Concentrations									
	C(i-1,corr)	C(i)/C(i-1)	T(i-1)/T(i)	Ci (corr)					
MW154	440.9			440.9					
MW132	440.9	0.875279	1.127905	435.2703					
MW138	435.2703	0.715013	1.438904	447.8217					
MW159	447.8217	0.410322	2.411201	443.0607					

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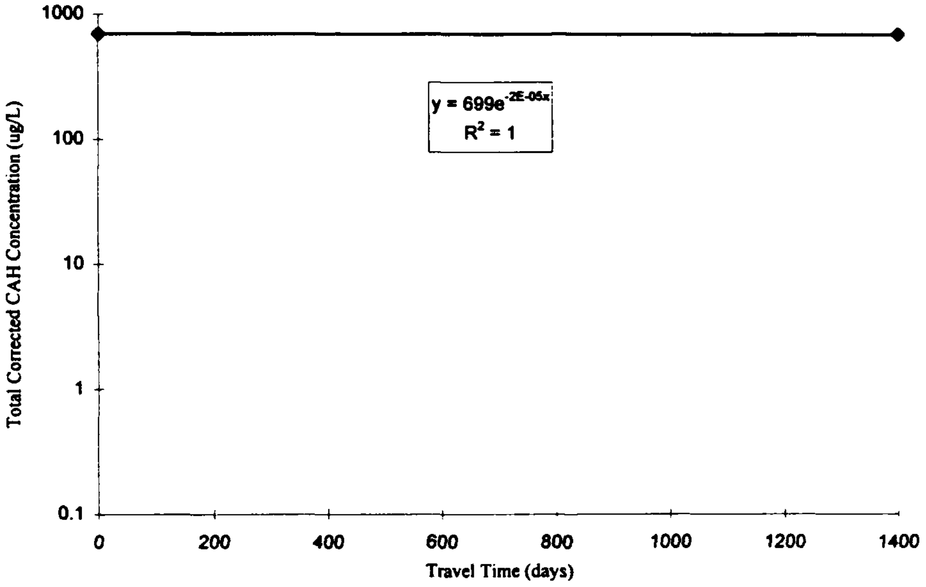
REDUCTIVE DECHLORINATION RATE
USING THE METHOD OF MOUTOUX (1996)
OU5 RNA TS
HILL AFB, UTAH

		Oct-95
	Travel Time	Corrected Total CAH
Point	(days)	Concentration (ug/L)
MW154	0	699
MW132	1400	676

PLOT OF TOTAL CORRECTED CAH CONCENTRATION VERSUS TRAVEL TIME



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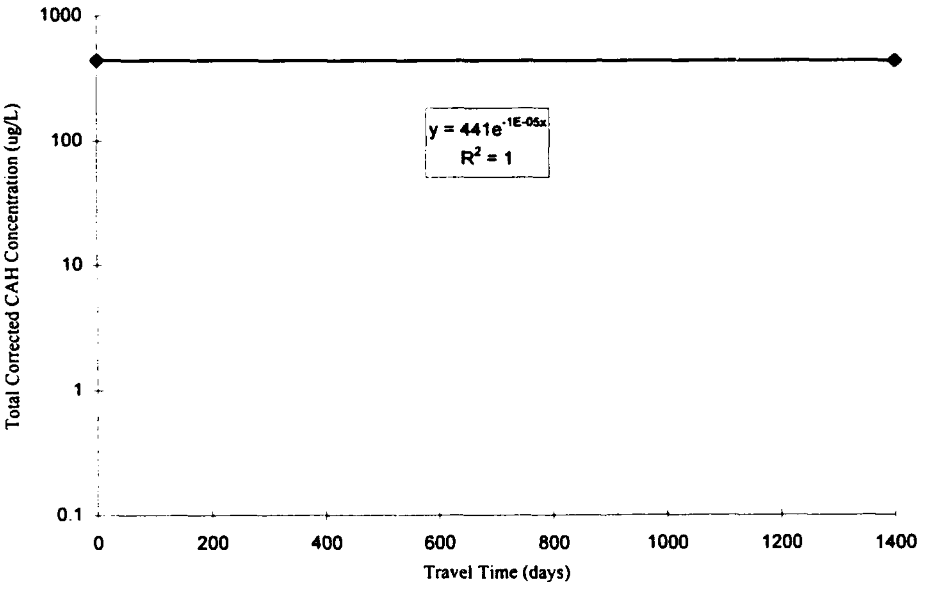
REDUCTIVE DECHLORINATION RATE
USING THE METHOD OF MOUTOUX (1996)
OU5 RNA TS
HILL AFB, UTAH

		Oct-95
Point	Travel Time (days)	Corrected Total CAH Concentration (ug/L)
MW154	0	441
MW132	1400	435

PLOT OF TOTAL CORRECTED CAH CONCENTRATION VERSUS TRAVEL TIME



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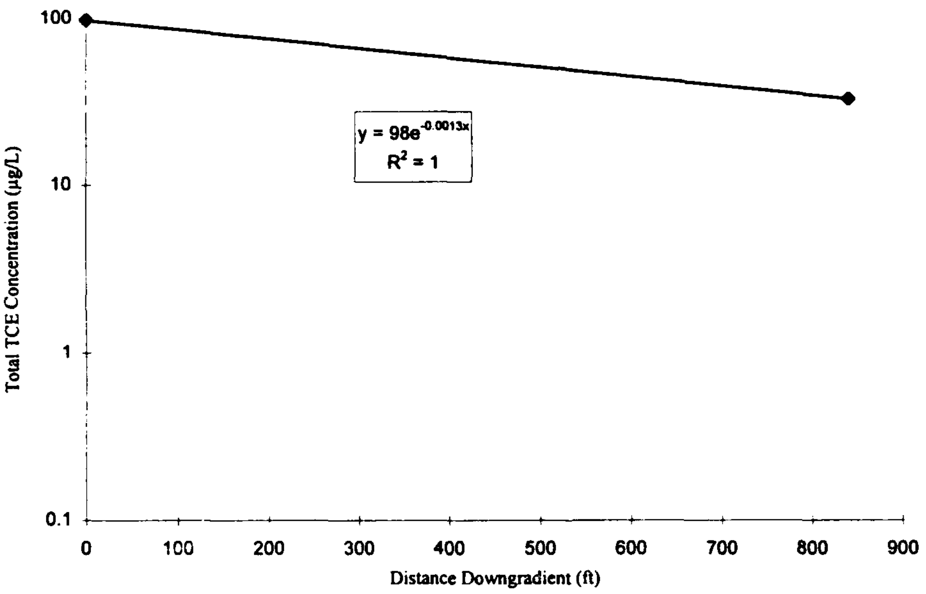
FIRST-ORDER RATE CONSTANT CALCULATION USING THE METHOD OF BUSCHECK AND ALCANTAR (1995)

OU5 RNA TS

HILL AFB, UTAH

Point	Distance Downgradient	TCE spring 1996
MW143	0	98
MW163	840	33

PLOT OF TOTAL TCE CONCENTRATION VERSUS DISTANCE



$\lambda = v_c/4\alpha_x([1+2\alpha_x(k/v_x)]^2-1)$

where $v_c = 0.24$ ft/day

$\alpha_x = 84$ feet

$k/v = 0.0013$

therefore $\lambda = 3.46E-04$

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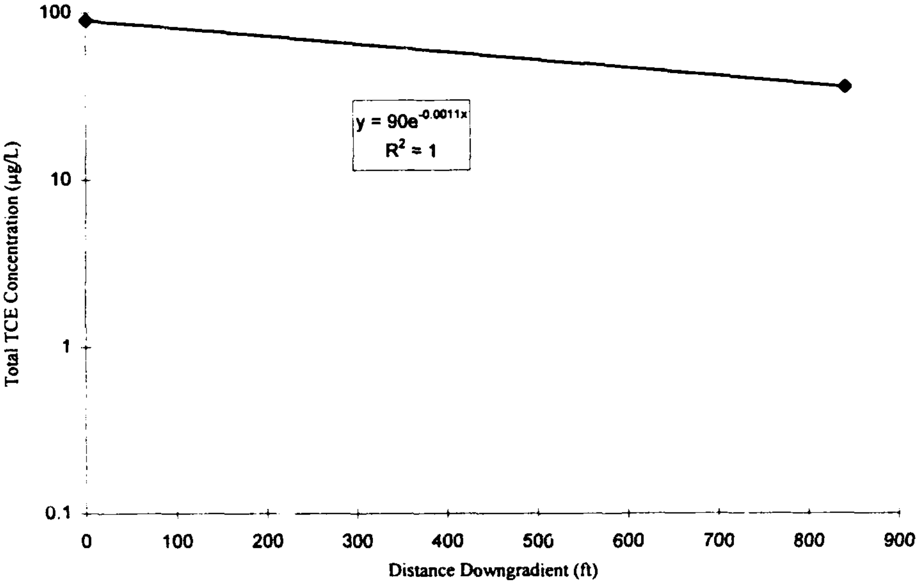
FIRST-ORDER RATE CONSTANT CALCULATION
USING THE METHOD OF BUSCHECK AND ALCANTAR (1995)
OU5 RNA TS
HILL AFB, UTAH

Point	Distance Downgradient	TCE Aug-96
MW143	0	90
MW163	840	36

PLOT OF TOTAL TCE CONCENTRATION VERSUS DISTANCE



$$\lambda = v_c/4\alpha_x([1+2\alpha_x(k/v_x)]^2-1)$$

where v_c = 0.24 ft/day

α_x = 84 feet

k/v = 0.0011

therefore λ = 2.88E-04

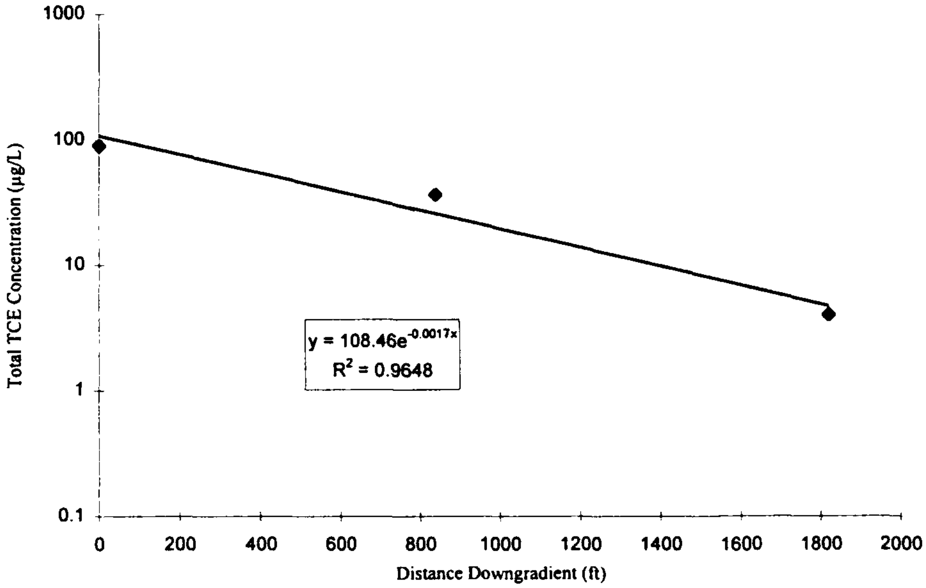
FIRST-ORDER RATE CONSTANT CALCULATION USING THE METHOD OF BUSCHECK AND ALCANTAR (1995)

OU5 RNA TS

HILL AFB, UTAH

Point	Distance Downgradient	TCE Aug-96
MW143	0	90
MW163	840	36
MP7	1820	4

PLOT OF TOTAL TCE CONCENTRATION VERSUS DISTANCE



$\lambda = v_c/4\alpha_x([1+2\alpha_x(k/v_x)]^2-1)$

where v_c = 0.24 ft/day

α_x = 182 feet

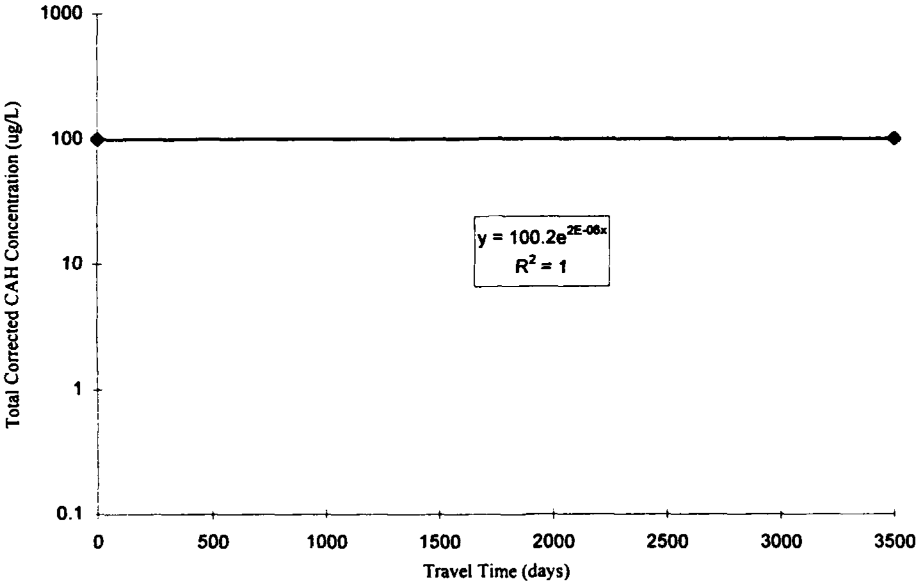
k/v = 0.0017

therefore λ = 5.34E-04

REDUCTIVE DECHLORINATION RATE
USING THE METHOD OF MOUTOUX (1996)
OU5 RNA TS
HILL AFB, UTAH

		Spring 1996
	Travel Time	Corrected Total CAH
Point	(days)	Concentration (ug/L)
MW143	0	100.2
MW163	3500	100.8

PLOT OF TOTAL CORRECTED CAH CONCENTRATION VERSUS TRAVEL TIME



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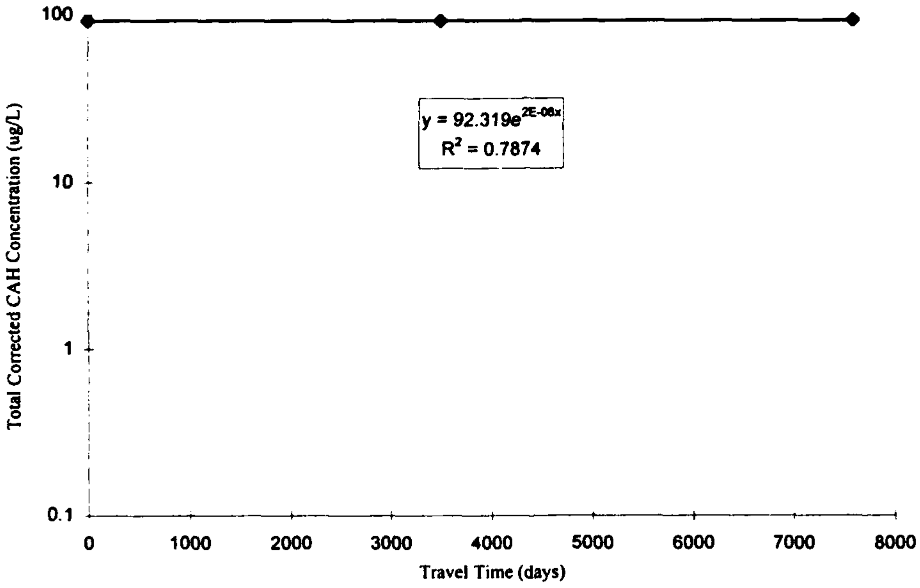
Computation of Corrected CAH Concentrations using the method of Moutoux (1995)									
Spring 1996 data from Radian									
Step 1: Enter Data									
Well	PCE	TCE	DCE	VC	Ethene	Total CAHs	Distance From Source (ft)	CAH velocity (ft/day)	CAH Travel Time (day)
MW143	0	98	2.2	0	0	100.2	0	0.24	0
MW163	0	33	0.3	0	0	33.3	840	0.24	3500
Step 2: Compute Molar Concentrations (micromoles/Liter)									
	PCE	TCE	DCE	VC	Ethene	Total CAHs			
MW143	0	0.753846	0.022917	0	0	0.77676282			
MW163	0	0.253846	0.003125	0	0	0.25697115			
Step 3: Compute Carbon Equivalents				Step 4: Compute Chlorine Equivalents					
MW143	1.553526			2.307372					
MW163	0.513942			0.767788					
Step 5: Compute Corrected CAH Concentrations									
	C(i-1,corr)	C(i)/C(i-1)	T(i-1)/T(i)	Ci (corr)					
MW143	100.2			100.2					
MW163	100.2	0.332755	3.022763	100.8					

REDUCTIVE DECHLORINATION RATE
USING THE METHOD OF MOUTOUX (1996)
OU5 RNA TS
HILL AFB, UTAH

		Aug-96
Point	Travel Time (days)	Corrected Total CAH Concentration (ug/L)
MW143	0	92.5
MW163	3500	92.5
MP7	7583	93.6

PLOT OF TOTAL CORRECTED CAH CONCENTRATION VERSUS TRAVEL TIME



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Computation of Corrected CAH Concentrations using the method of Moutoux (1995)									
August 1996 data									
Step 1: Enter Data									
Well	PCE	TCE	DCE	VC	Ethene	Total CAHs	Distance From Source (ft)	CAH velocity (ft/day)	CAH Travel Time (day)
MW143	0	90	2.5	0	0	92.5	0	0.24	0
MW163	0	36	1	0	0	37	840	0.24	3500
MP7	0	4	0	0	0	4	1820	0.24	7583
Step 2: Compute Molar Concentrations (micromoles/Liter)									
	PCE	TCE	DCE	VC	Ethene	Total CAHs			
MW143	0	0.692308	0.026042	0	0	0.71834936			
MW163	0	0.276923	0.010417	0	0	0.28733974			
MP7	0	0.030769	0	0	0	0.03076923			
Step 3: Compute Carbon Equivalents				**Step 4: Compute Chlorine Equivalents**					
MW143	1.436699			2.129006					
MW163	0.574679			0.851603					
MP7	0.061538			0.092308					
Step 5: Compute Corrected CAH Concentrations									
	C(i-1,corr)	C(i)/C(i-1)	T(i-1)/T(i)	Ci (corr)					
MW143	92.5			92.5					
MW163	92.5	0.4	2.5	92.5					
MP7	92.5	0.108393	9.338542	93.6					

RUN OU5-35.VMF : FINAL CALIBRATED MODEL RUN
SOURCE AREA RECHARGE CONCENTRATIONS
SITE OU5
INTRINSIC REMEDIATION

DATE (year)	START TIME (days)	STOP TIME (days)	POINT RECHARGE RATE (inches)	POINT SOURCE RECHARGE CONCENTRATION (ug/L)	SECOND RECHARGE RATE (inches)	SECONDARY RECHARGE CONCENTRATION (ug/L)	RECHARGE RATE (inches)	NORTH PLUME RECHARGE CONCENTRATION (ug/L)
1949	0							
1952	0	1095	8	12,100	4	12,100	3	0
1955	1095	2190	8	12,100	4	12,100	3	0
1958	2190	3285	8	12,100	4	12,100	3	0
1961	3285	4380	8	12,100	4	12,100	3	0
1964	4380	5475	8	12,100	4	12,100	3	0
1966	5475	6205	8	11,400	4	11,400	3	0
1968	6205	6935	8	10,700	4	10,700	3	0
1970	6935	7665	8	10,000	4	10,000	3	0
1972	7665	8395	8	9,300	4	9,300	3	0
1974	8395	9125	8	8,600	4	8,600	3	0
1976	9125	9855	8	7,900	4	7,900	3	0
1978	9855	10585	8	7,200	4	7,200	3	0
1980	10585	11315	8	6,500	4	6,500	3	0
1982	11315	12045	8	5,800	4	5,800	3	0
1984	12045	12775	8	5,100	4	5,100	3	0
1986	12775	13505	8	4,400	4	4,400	3	0
1988	13505	14235	8	3,700	4	3,700	3	500
1990	14235	14965	8	3,000	4	3,000	3	2000
1992	14965	15695	8	2,300	4	2,300	3	4000
1994	15695	16425	8	1,600	4	1,600	3	5500
1996	16425	17155	8	900	4	900	3	5500

INPUT PARAMETERS

RUN: OU5-35.VMF
DI: 240
DI:Dh: 3.3:1
Decay GW: 0.000006 /day ($6X10^{-6}$/day)
Decay Sorbed 0.000003 /day (0.5*GW Decay)
Bulk Density: 46.73 Kg/ft3 (1.65 g/cm3)
Sorption (R): 0.0024 ft3/Kg (R=1.57)
Effective Porosity: 0.2

RUN CHECKLIST

Transient: X
Advection: X
Mod. MMOC: X
4th-Runge/Kutta
w/ Sink Mods: X
Output Time: 17155

RESULTS

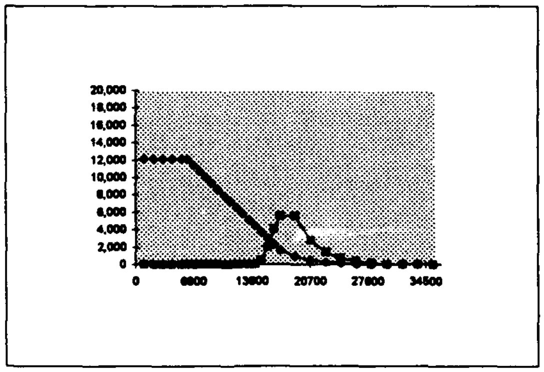
Max. Conc.: 670
Conc. RMS: 65
Flow RMS: 4.66

Number of Recharge Cells: 7

NOTE: Saturated Thickness set to 30-25- 20 feet

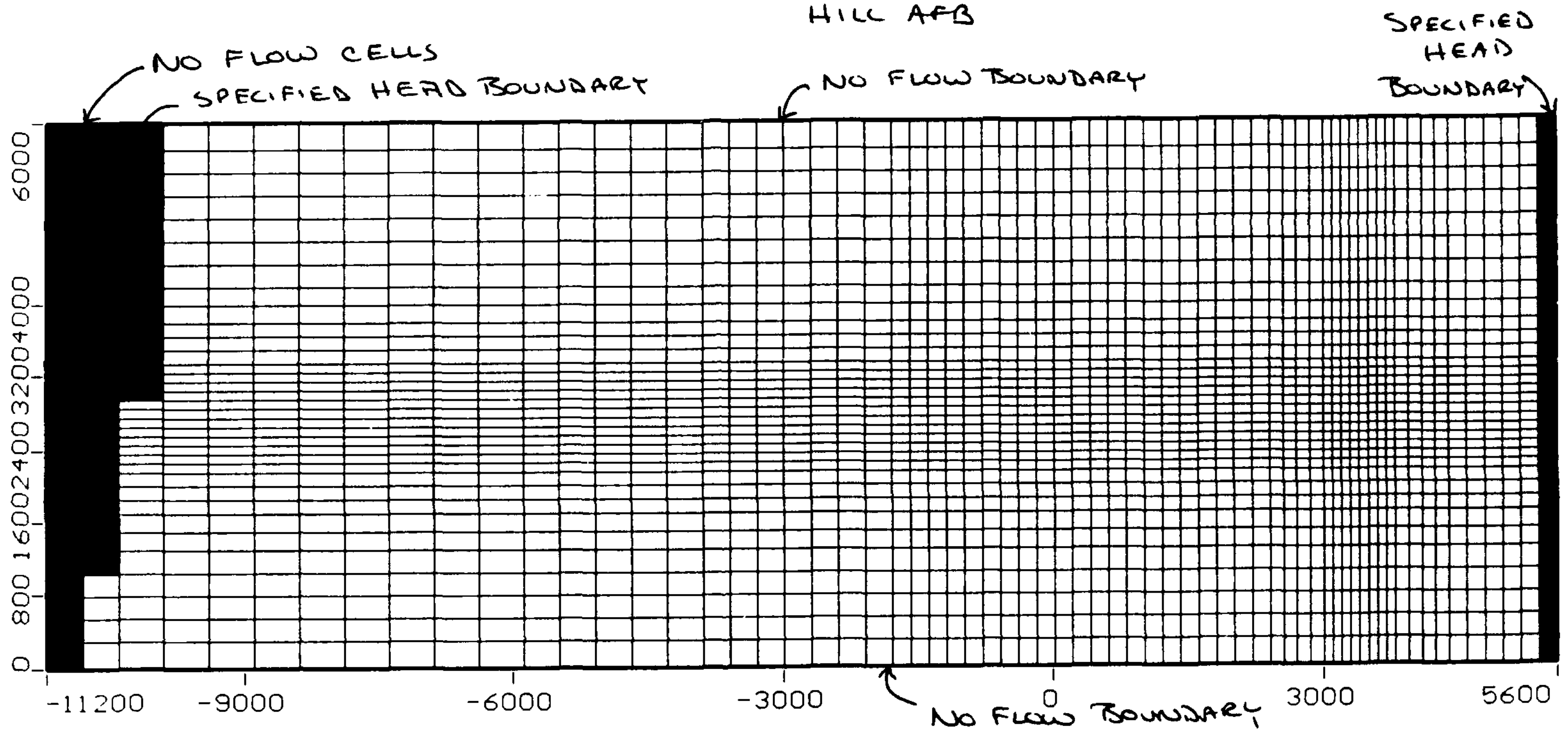
NOTE: Ne/Ss/Se can be assigned to individual cells
Advection can be assigned to individual cells

Start	Stop	Main	North
0	1095	12,100	0
1095	2190	12,100	0
2190	3285	12,100	0
3285	4380	12,100	0
4380	5475	12,100	0
5475	6205	12,100	0
6205	6935	11,400	0
6935	7665	10,700	0
7665	8395	10,000	0
8395	9125	9,300	0
9125	9855	8,600	0
9855	10585	7,900	0
10585	11315	7,200	0
11315	12045	6,500	0
12045	12775	5,800	0
12775	13505	5,100	0
13505	14235	4,400	0
14235	14965	3,700	500
14965	15695	3,000	2000
15695	16425	2,300	4000
16425	17155	1,600	5500
17155	18980	900	5500
18980	20805	500	2750
20805	22630	250	1375
22630	24455	125	690
24455	26280	0	345
26280	28105	0	175
28105	29930	0	0
29930	31755	0	0
31755	33580	0	0
33580	35405	0	0
35405	53655	0	0
53655	54020	0	0



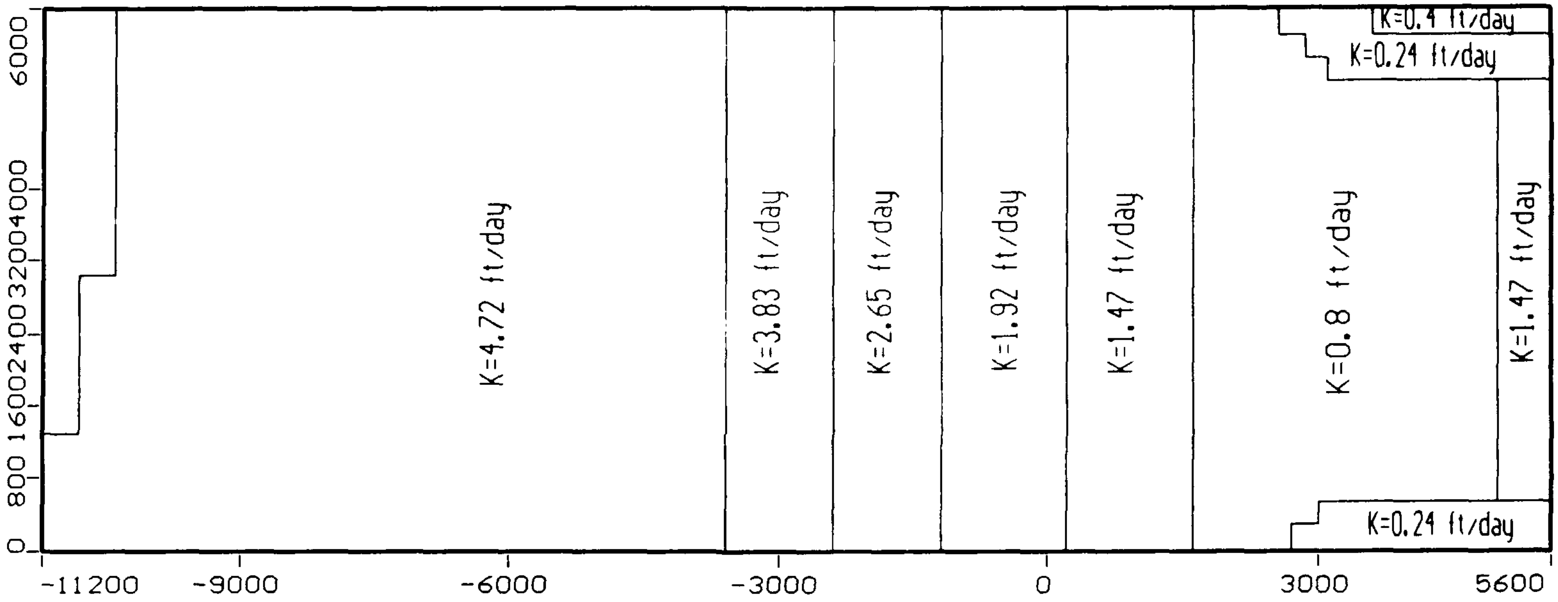
K-Values	ft/day
1	0.24
2	0.80
3	1.92
4	4.72
5	0.40
6	2.65
7	3.83
8	1.47

BOUNDARY CONDITIONS
MODEL OU5-A
HILL AFB

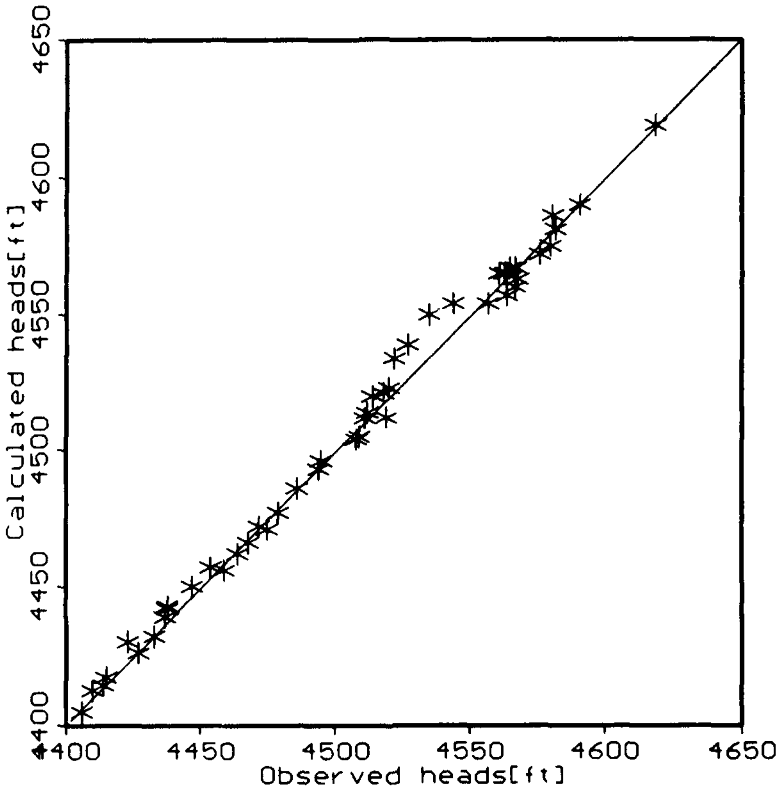


Parsons Eng. Science, Inc. **Project: HILL AFB: OU5-35.VMF** **Description: Boundary Conditions** **Modeller: BMH** **2 May 97**	**Visual MODFLOW v.2.20, (c) 1995** **Waterloo Hydrogeologic Software** **NC: 66 NR: 34 NL: 1** **Current Layer: 1**

DISTRIBUTION OF HYDRAULIC CONDUCTIVITY
MODEL OU5-A
HILL AFB



Parsons Eng. Science, Inc. **Project: HILL AFB: OU5-35.VMF** **Description: Hydraulic Conductivity** **Modeller: BMH** **2 May 97**	**Visual *MODFLOW* v.2.20, (c) 1995** **Waterloo Hydrogeologic Software** **NC: 66 NR: 34 NL: 1** **Current Layer: 1**



Period: 21
Step: 10

Mean error: 0.827749 Mean abs. err:3.57229 RMS error: 4.83233

Parsons Eng. Science, Inc.
Project: HILL AFB: OU5-35.VMF
Description: Flow RMS Error
Modeller: Scenario 1 – 17155 (1996)
25 Apr 97

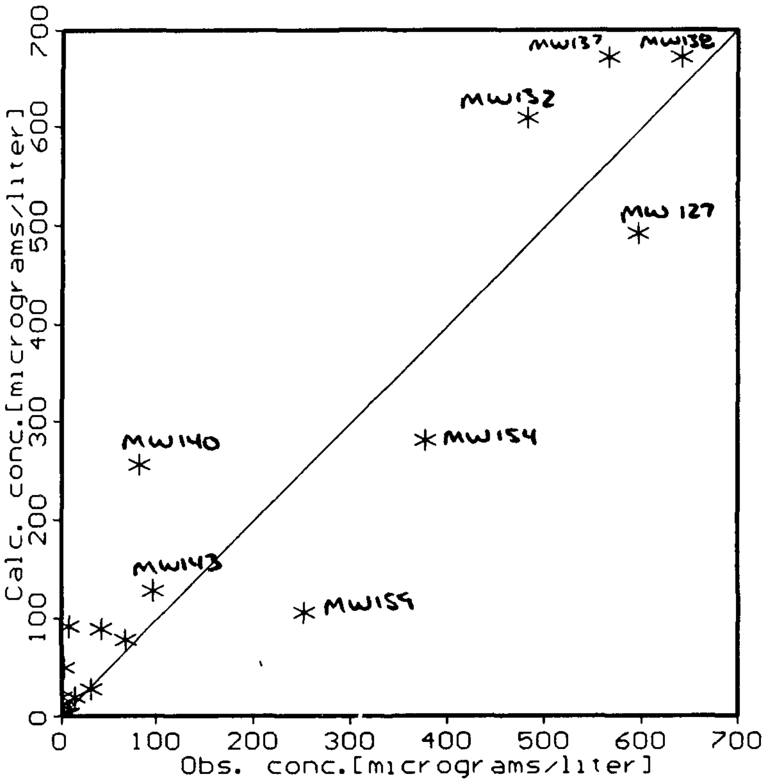
Visual MODFLOW v.2.20, (c) 1995
Waterloo Hydrogeologic Software
NC: 66 NR: 34 NL: 1
Current Layer: 1

GROUNDWATER ELEVATION CALIBRATION DATA

HILL AFB - OU5

AUGUST 1996

Well/Borehole Identification	X	Y	Middle Screen Elevation	Time (days)	Elevation of Water Table Aug-96
MP-1s	3676.6	2673.8	4570.87	17155.00	4575.46
MP-3d	1439.6	2642.8	4466.63	17155.00	4485.96
MP-4s	-367.3	2025.9	4432.59	17155.00	4437.96
MP-5s	-555.7	3208.6	4430.06	17155.00	4437.09
MP-6s	-928.8	2286.3	4425.11	17155.00	4427.21
MP-7s	-1518.3	3036.5	4410.93	17155.00	4414.14
MP-8s	-2078.9	2351.4	4400.29	17155.00	4406.50
MW-121	3588.6	1768.5	4562.16	17155.00	4566.92
MW-122	3464.5	1976.3	4561.16	17155.00	4562.57
MW-124	3135.7	1700.3	4540.35	17155.00	4544.01
MW-125	3332.3	2627.3	4560.01	17155.00	4567.73
MW-126	3173.8	3444.2	4545.71	17155.00	4556.99
MW-127	3186.5	2884.6	4559.10	17155.00	4564.34
MW-129	3100.4	4217.8	4527.45	17155.00	4535.10
MW-130	2951.5	4904.5	4525.39	17155.00	4526.73
MW-133	2604.1	4161.9	4521.49	17155.00	4522.40
MW-134	2044.6	4239.5	4508.39	17155.00	4512.10
MW-135	1879.0	3242.7	4490.42	17155.00	4508.38
MW-136	1928.6	3255.1	4504.59	17155.00	4509.05
MW-137	2207.0	2887.7	4513.33	17155.00	4517.88
MW-139	2123.2	2593.2	4505.34	17155.00	4510.81
MW-140	804.5	2831.9	4466.85	17155.00	4472.32
MW-141	-1734.6	3977.5	4405.43	17155.00	4410.77
MW-142	596.6	3111.0	4461.79	17155.00	4464.11
MW-143	224.4	2794.7	4449.18	17155.00	4454.37
MW-144	1606.8	3484.5	4491.03	17155.00	4494.80
MW-145	2322.6	3416.3	4515.08	17155.00	4520.23
MW-146	2267.9	1601.1	4507.71	17155.00	4514.14
MW-147	-289.8	2630.4	4433.20	17155.00	4437.92
MW-148	4037.3	3515.5	4576.20	17155.00	4581.46
MW-149	4301.3	3138.9	4580.79	17155.00	4590.90
MW-150	3708.8	3101.7	4567.05	17155.00	4579.63
MW-151	3593.7	3847.3	4549.66	17155.00	4561.26
MW-153	5425.5	2145.2	4607.51	17155.00	4619.02
MW-154	3298.2	2779.2	4563.44	17155.00	4566.93
MW-158	1657.3	1546.0	4489.58	17155.00	4494.14
MW-159	1157.3	2475.4	4474.07	17155.00	4479.48
MW-161	398.1	2494.0	4455.11	17155.00	4458.88
MW-162	-8.6	3447.3	4442.66	17155.00	4447.51
MW-163	-615.5	2649.0	4428.71	17155.00	4433.42
MW-164	-996.3	3683.0	4420.22	17155.00	4423.32
MW-165	-1461.6	4295.3	4410.78	17155.00	4415.87
MW-167	941.0	2215.0	4472.15	17155.00	4475.55
MW-168	630.8	2410.3	4466.33	17155.00	4468.53
TAD-1A	4126.5	1974.7	4568.23	17155.00	4580.35
TAD-2	3453.3	2120.4	4564.28	17155.00	4564.17
TAD-3	3523.5	1780.9	4561.11	17155.00	4564.44
TAD-6	2188.4	2125.1	4512.89	17155.00	4518.67



Period: 21
Step: 10

Mean error: 14.0707 Mean abs. err:40.3353 RMS error: 66.2286

Parsons Eng. Science, Inc. Project: HILL AFB: OU5-35.VMF Description: Concentration Calibration Modeller: BMH 2 May 97	Visual MODFLOW v.2.20, (c) 1995 Waterloo Hydrogeologic Software NC: 66 NR: 34 NL: 1 Current Layer: 1

TCE CALIBRATION DATA

HILL AFB - OU5

MARCH 1996

WELL	X	Y	Elevation	Time (day)	Concentration
MW-127	3186.5	2884.6	4559.1	17155	597
MW-129	3100.4	4217.8	4527.45	17155	68.3
MW-132	2868.9	2893.9	4542.45	17155	484
MW-136	1928.6	3255.1	4504.59	17155	43.3
MW-137	2207	2887.7	4513.33	17155	567
MW-138	2253.5	2903.2	4490.13	17155	643
MW-140	804.5	2831.9	4466.85	17155	83.3
MW-142	596.6	3111	4461.79	17155	10.6
MW-143	224.4	2794.7	4449.18	17155	97.6
MW-144	1606.8	3484.5	4491.03	17155	16
MW-146	2267.9	1601.1	4507.71	17155	1.9
MW-153	5425.5	2145.2	4607.51	17155	0.1
MW-154	3298.2	2779.2	4563.44	17155	379
MW-156	2903	2215	4537.15	17155	2.1
MW-158	1657.3	1546	4489.58	17155	3.1
MW-159	1157.3	2475.4	4474.07	17155	253
MW-160	1231.5	3630.2	4479.08	17155	2.2
MW-161	398.1	2494	4455.11	17155	5.2
MW-162	-8.6	3447.3	4442.66	17155	5.8
MW-163	-615.5	2649	4428.71	17155	33
MW-164	-996.3	3683	4420.22	17155	0.5
MW-165	-1461.6	4295.3	4410.78	17155	9.7
MW-167	941	2215	4472.15	17155	0.4
MW-168	630.8	2410.3	4466.33	17155	1.1
MW-169	-1298	2583.9	4416.12	17155	0.9

CALCULATION OF RETARDATION COEFFICIENTS
MODEL INPUT FOR OU5 RNA TS
HILL AFB, UTAH

Compound	K_{oc} (L/kg [a])	Maximum Fraction Organic Carbon [b]	Minimum Fraction Organic Carbon [b]	Average Fraction Organic Carbon [b]	Distribution Coefficient K_d (L/kg)			Bulk Density (kg/L)[d]	Effective Porosity [e]	Coefficient of Retardation		
					Maximum[c1]	Minimum[c2]	Average[c3]			Maximum	Minimum	Average
TCE	87	0.0029	0.00026	0.00079	0.252	0.023	0.069	1.65	0.20	3.08	1.19	1.57

K_{oc} (ft^3/kg [a])
3.071

Distribution Coefficient K_d (ft^3/kg)			Bulk Density (kg/ft^3)[d]
Maximum[c1]	Minimum[c2]	Average[c3]	
0.009	0.001	0.002	46.73

Distribution Coefficient K_d (ft^3/kg)	Bulk Density (kg/ft^3)[d]	Effective Porosity [e]	Coefficient of Retardation
0.0000	46.73	0.20	1.00
0.0008	46.73	0.20	1.19
0.0024	46.73	0.20	1.57
0.0043	46.73	0.20	2.00
0.0089	46.73	0.20	3.08

NOTES:

[a] From technical protocol (Wiedemeier *et al.*, 1996)

[b] From laboratory analyses of site soil samples

[c1] K_d = Maximum Fraction Organic Carbon x K_{oc}

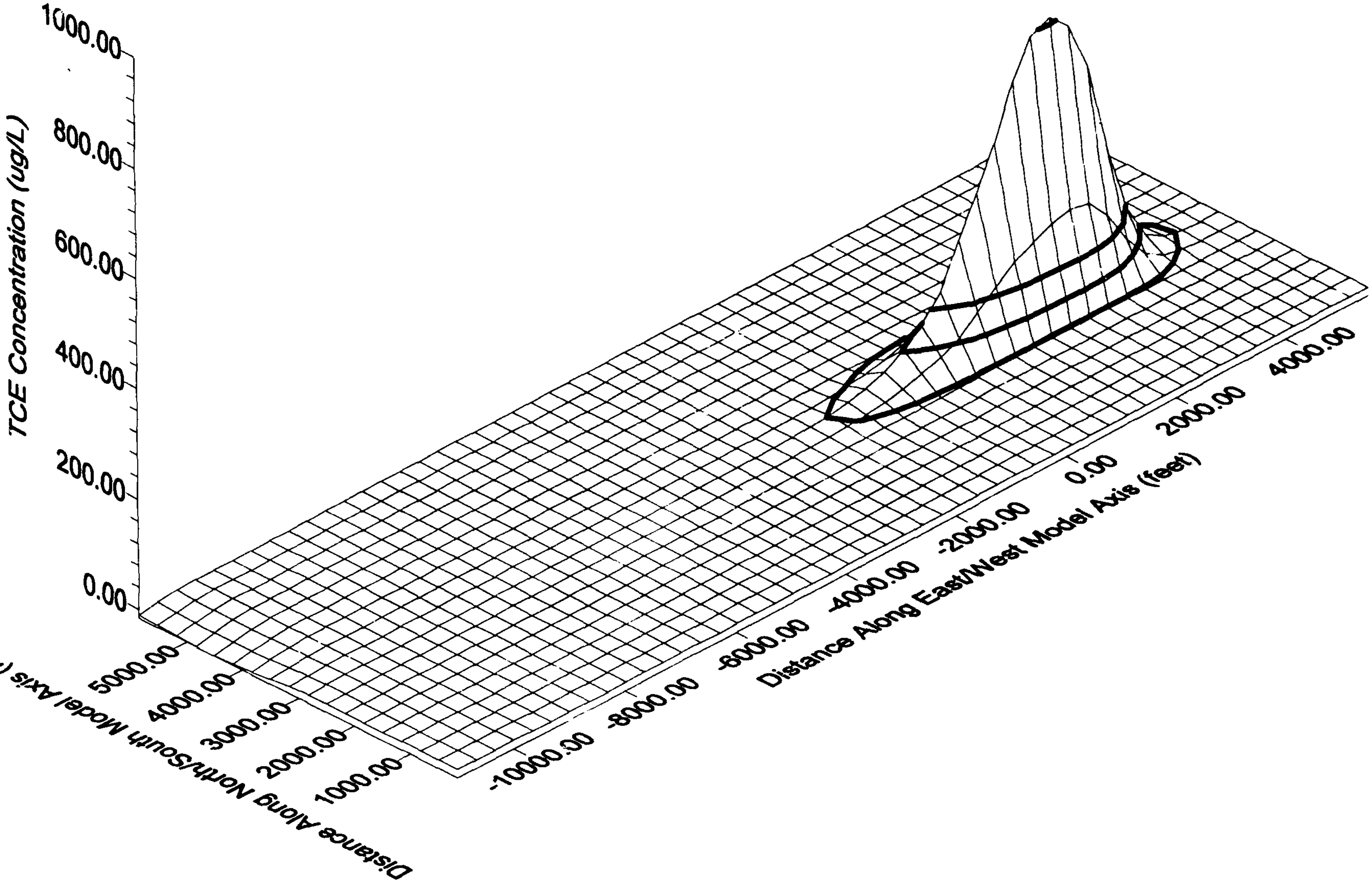
[c2] K_d = Minimum Fraction Organic Carbon x K_{oc}

[c3] K_d = Average Fraction Organic Carbon x K_{oc}

[d] Estimated Value.

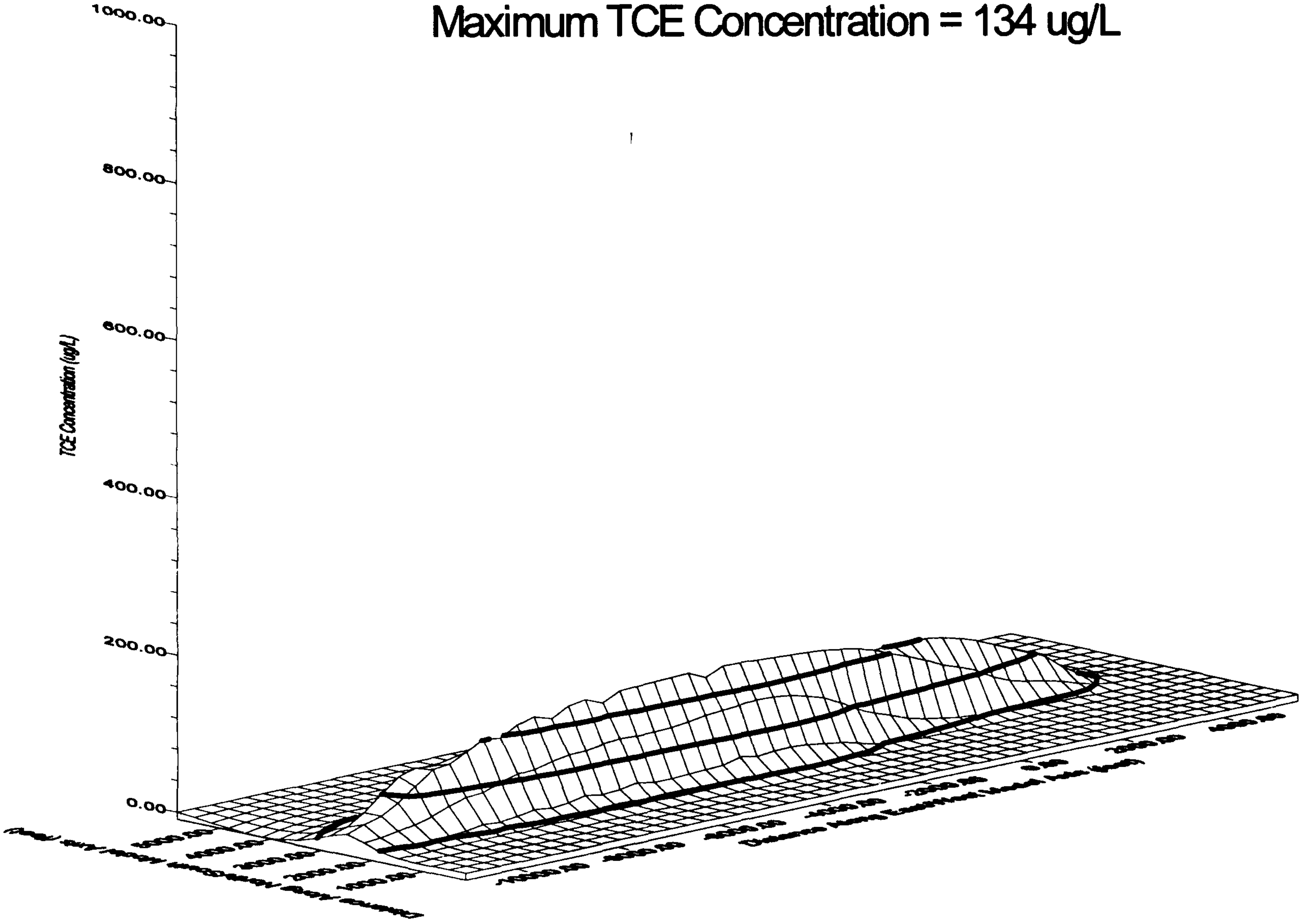
[e] Estimated Value.

Maximum TCE Concentration = 654 ug/L



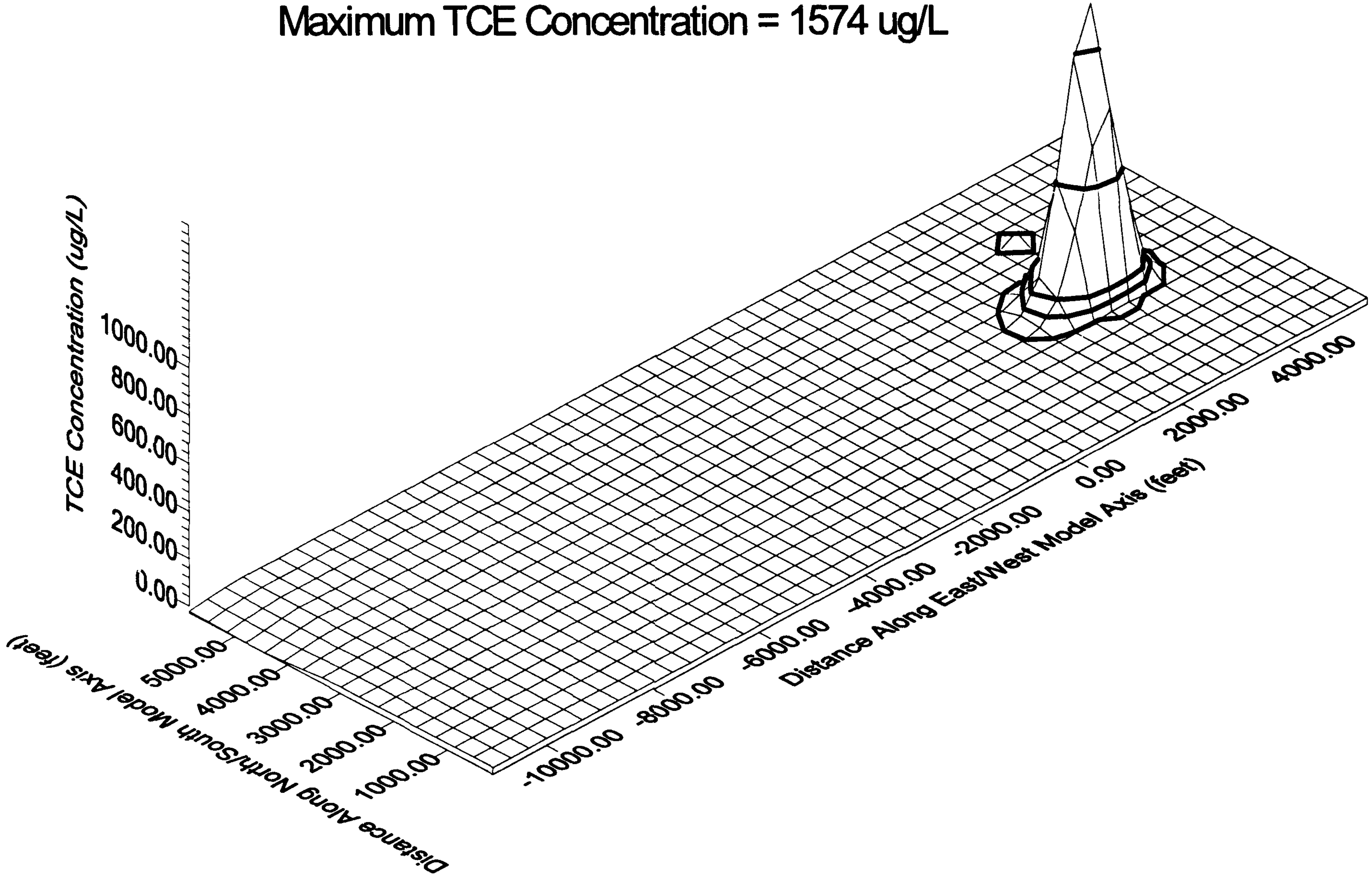
CALIBRATED MODEL

Maximum TCE Concentration = 134 ug/L



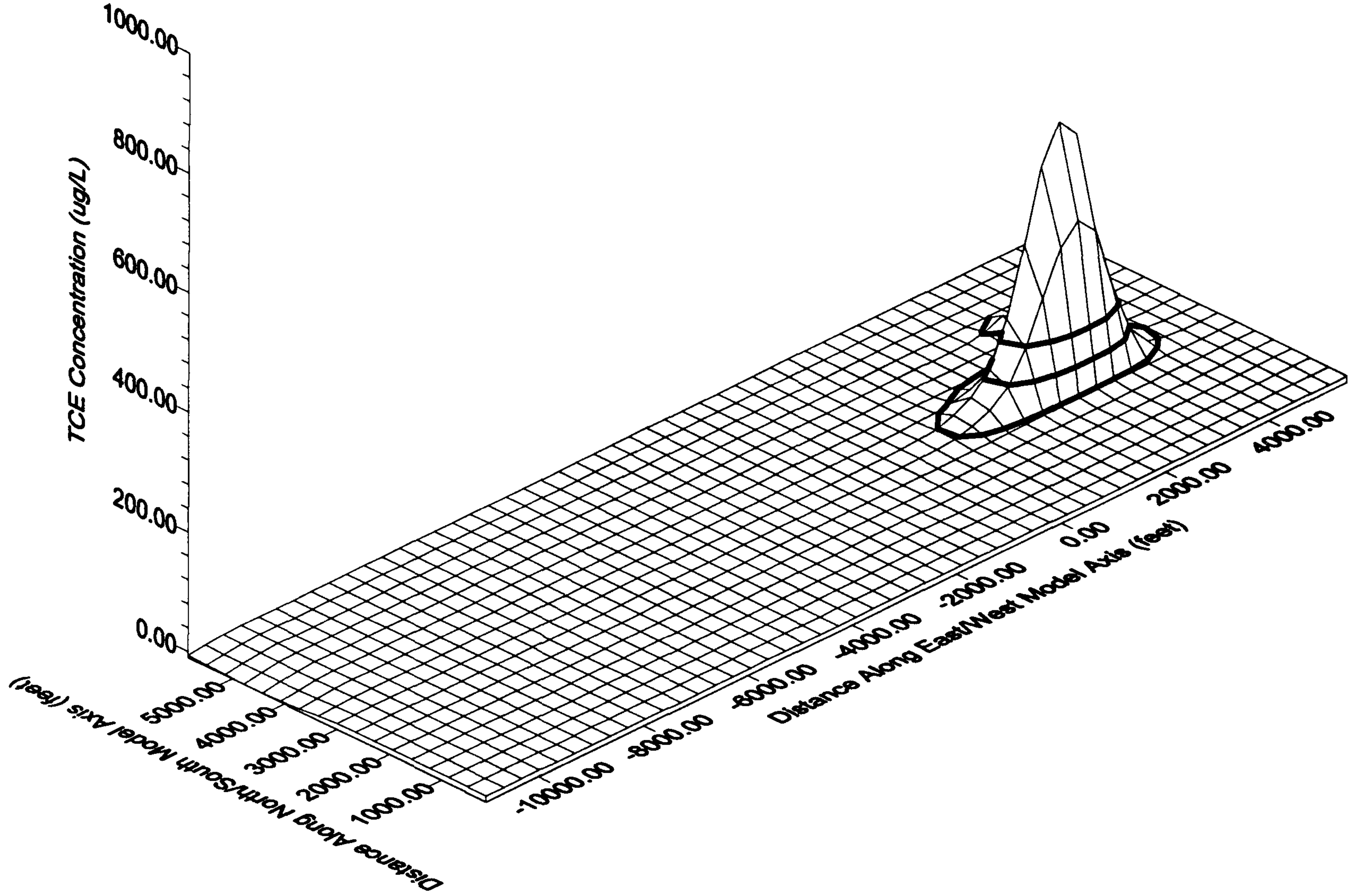
TRANSMISS. .ITY INCREASED BY 5X

Maximum TCE Concentration = 1574 ug/L



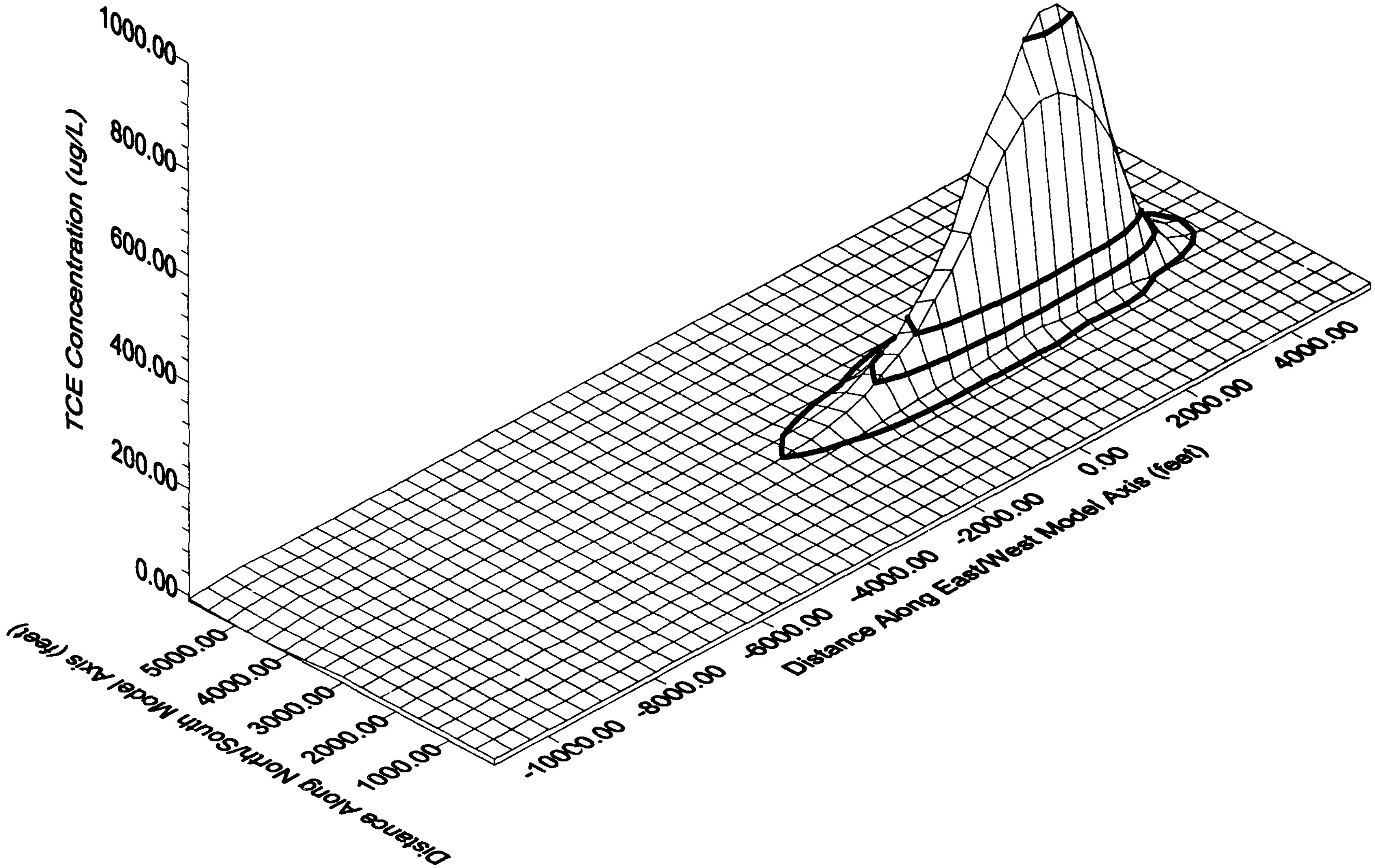
TRANSMISSIVITY DECREASED BY 5X

Maximum TCE Concentration = 560 ug/L



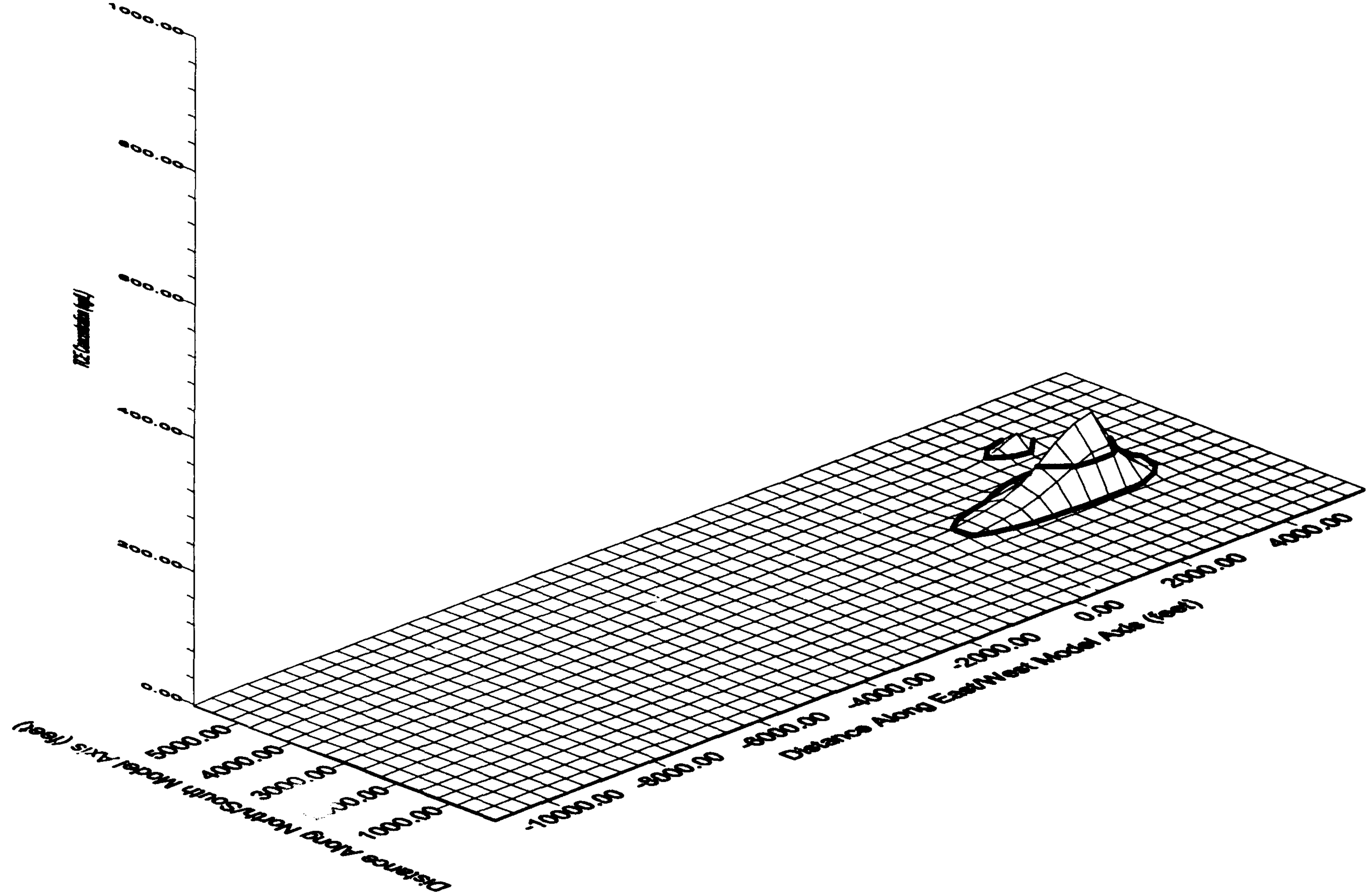
RETARDATION COEFFICIENT INCREASED TO 3.08

Maximum TCE Concentration = 677 ug/L



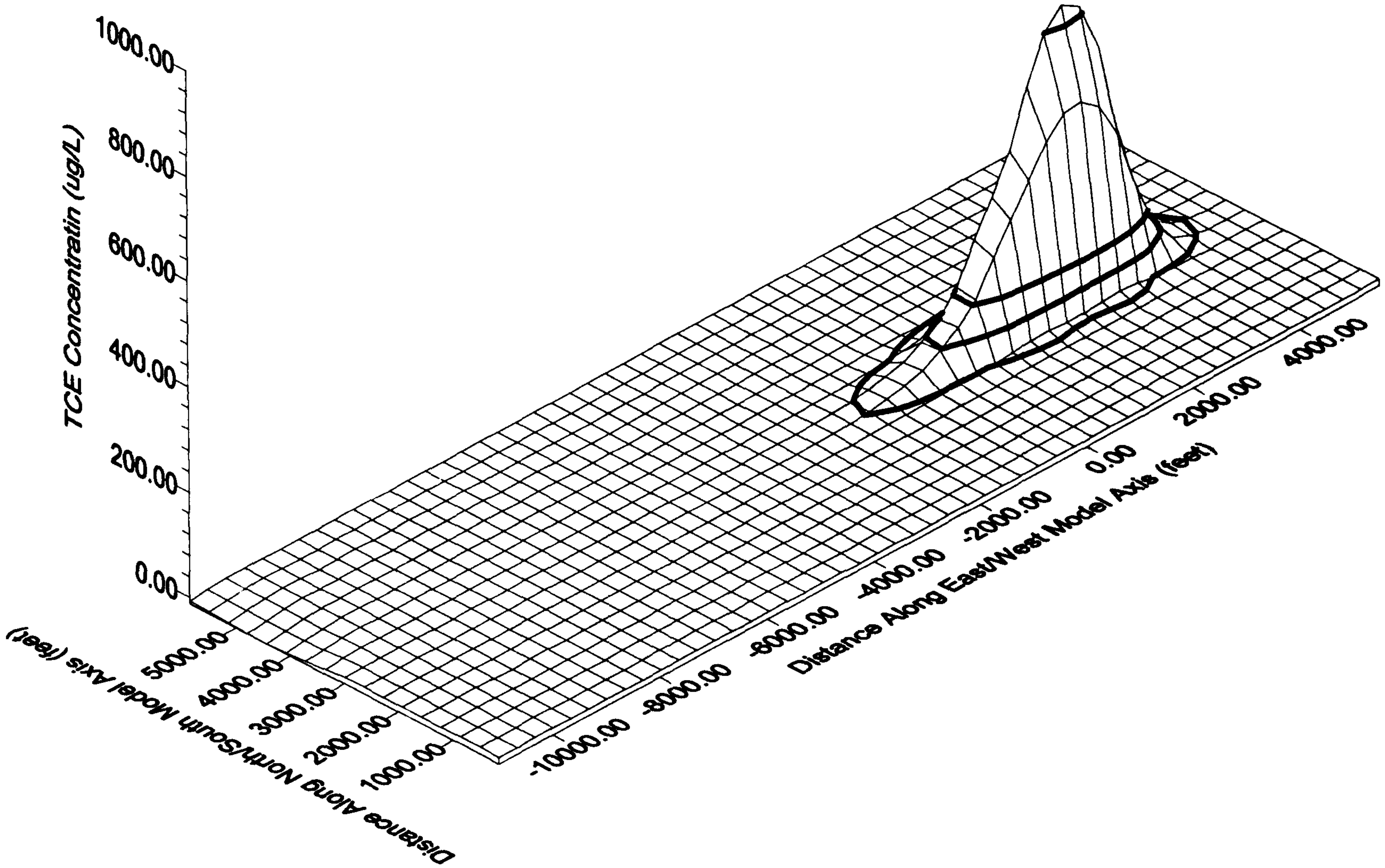
RETARDATION COEFFICIENT DECREASED TO 1.19

Maximum TCE Concentration = 134 ug/L

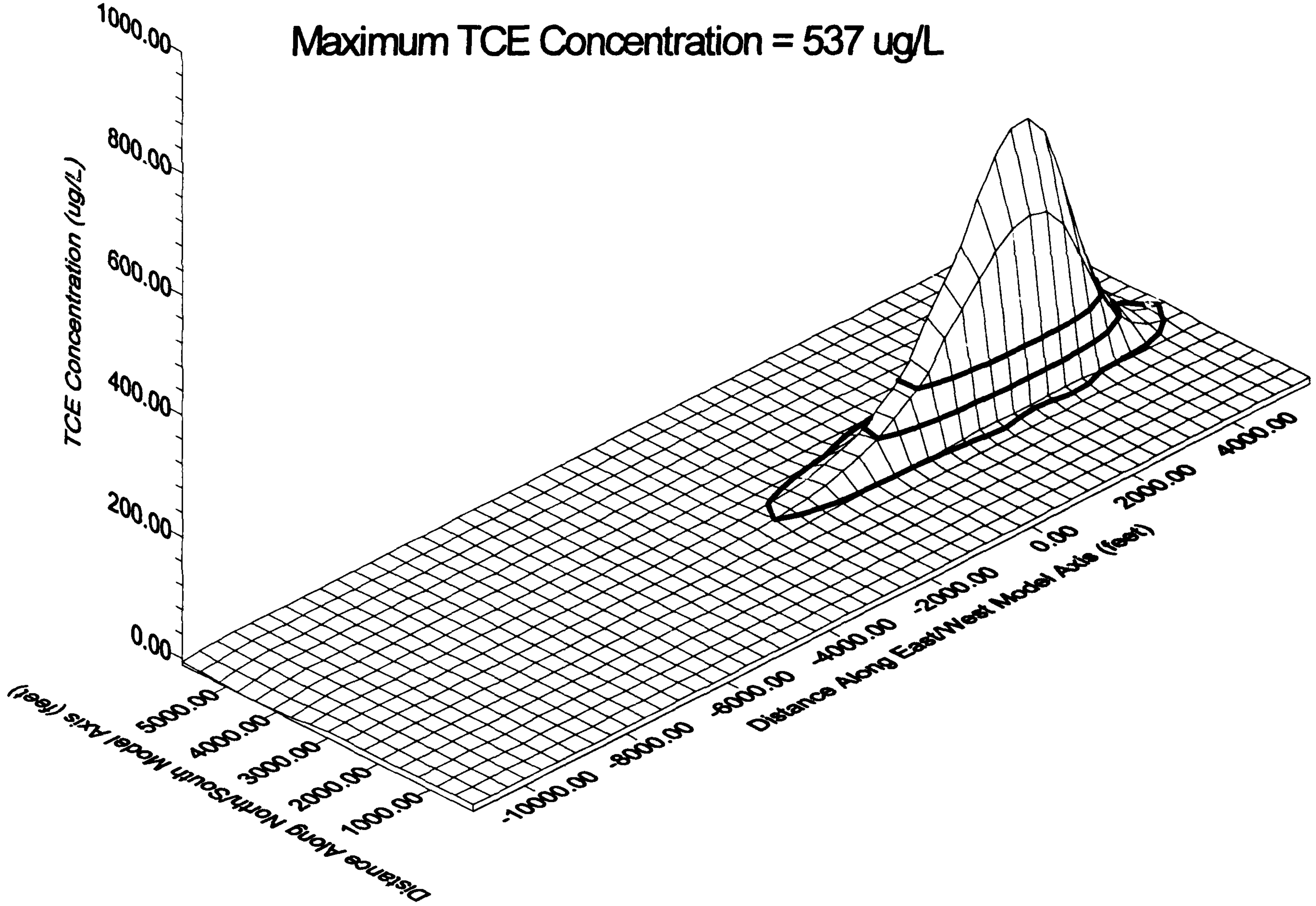


DECAY RATE INCREASED TO 3E-04

Maximum TCE Concentration = 676 ug/L

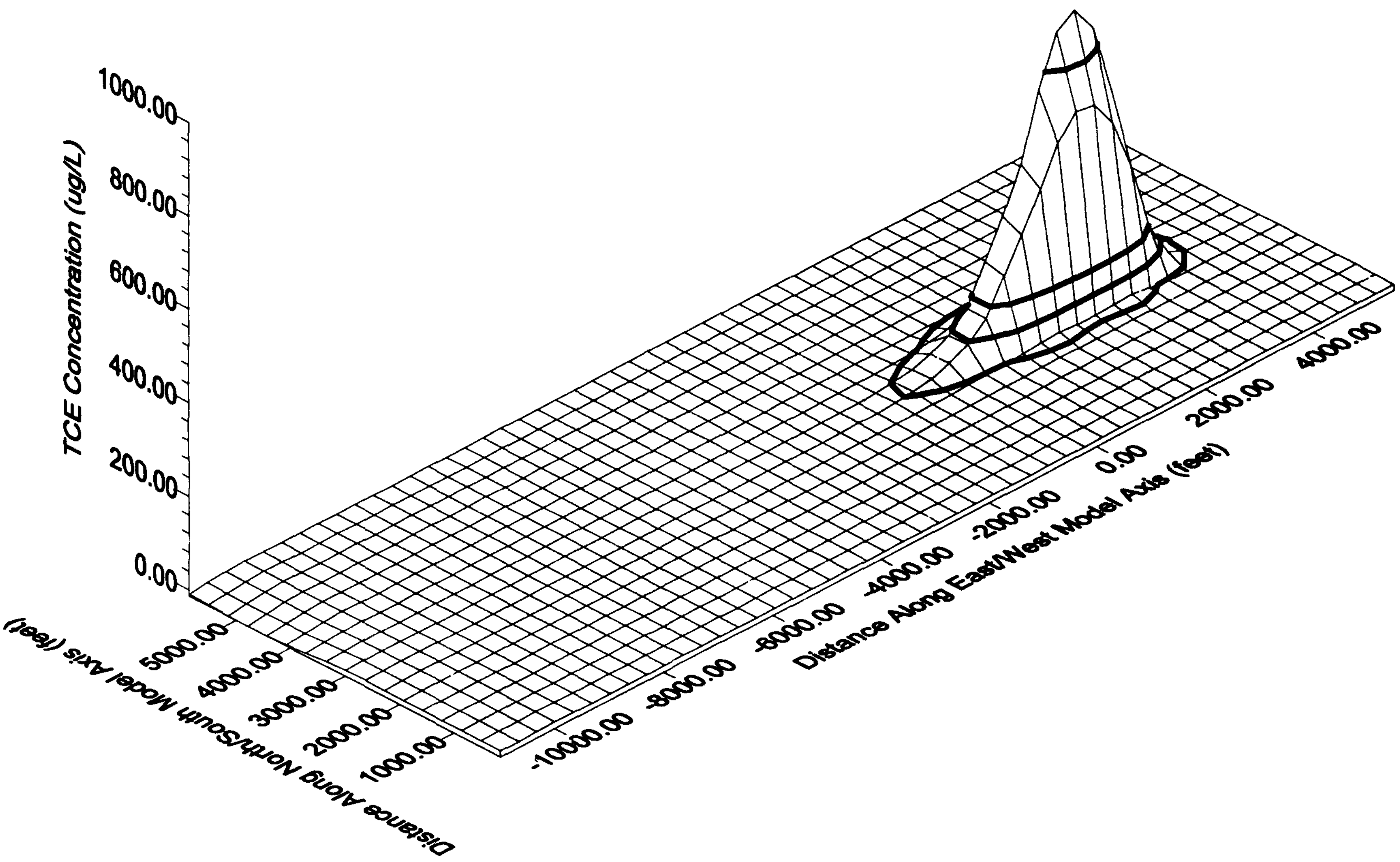


DECAY RATE DECREASED TO 2E-06


Maximum TCE Concentration = 537 ug/L

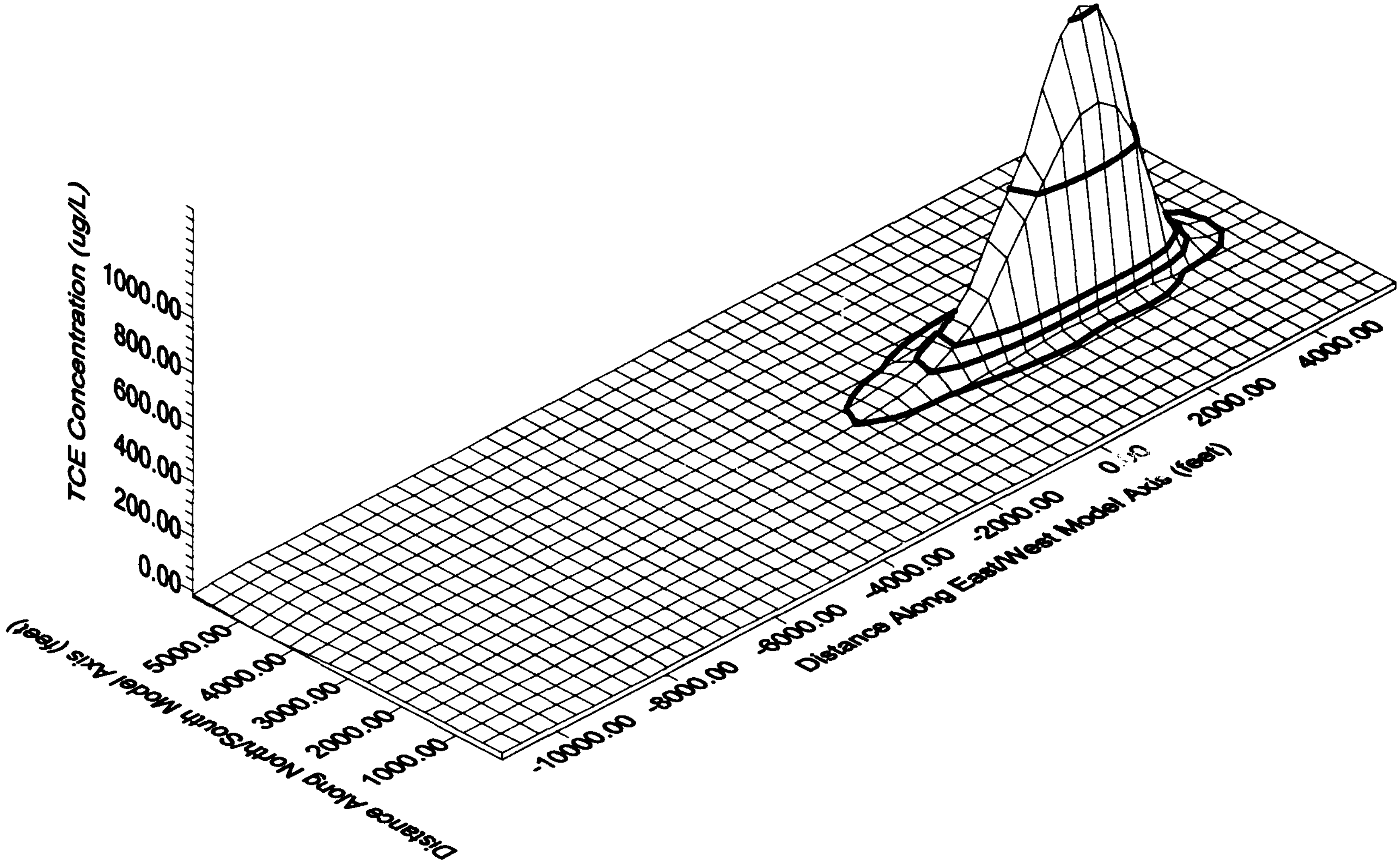
DISPERSIVITY INCREASED TO 480 FT

Maximum TCE Concentration = 761 ug/L



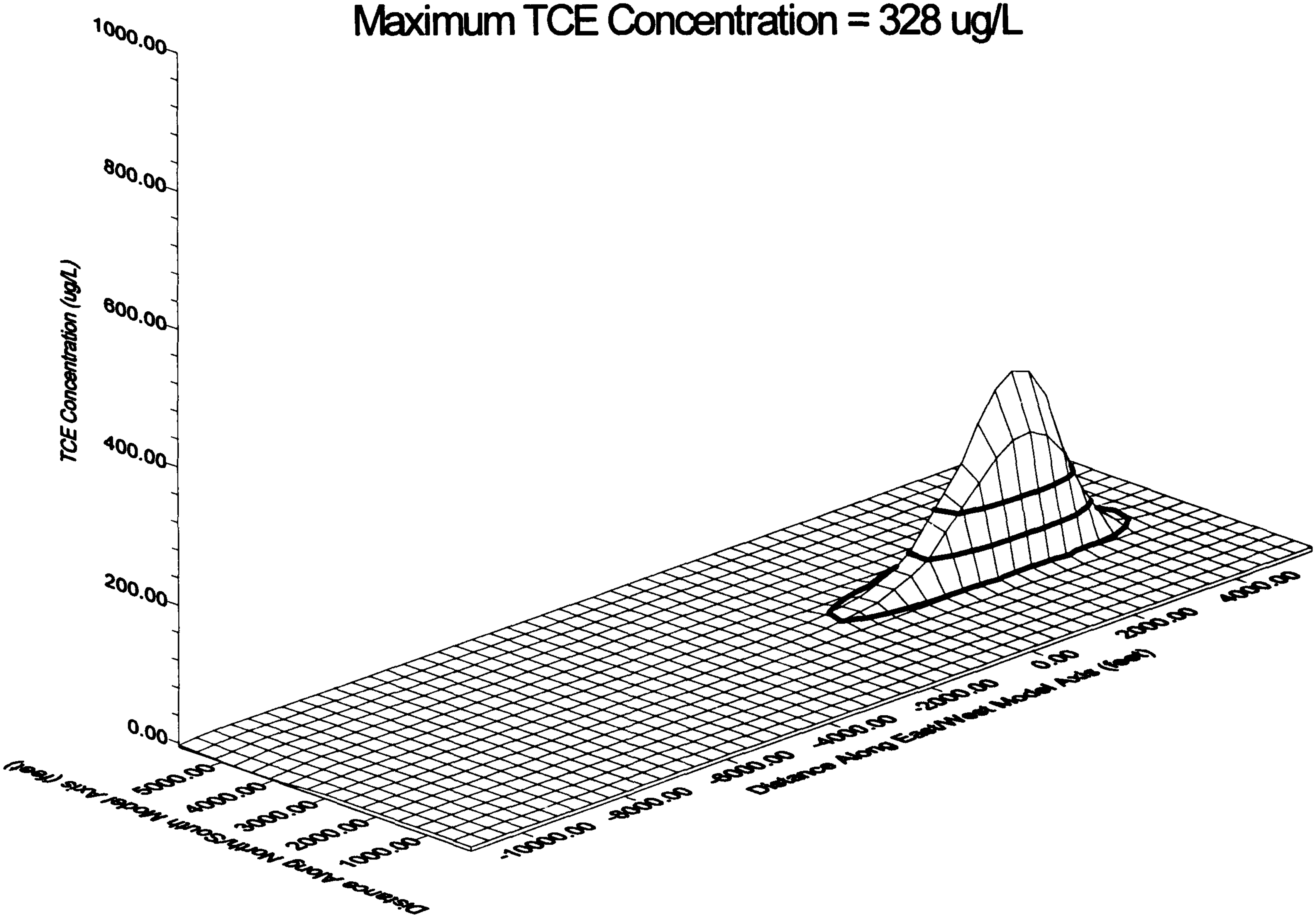
DISPERSIVITY DECREASED TO 120 FT

Maximum TCE Concentration = 1311 ug/L



RECHARGE CONCENTRATIONS INCREASED BY 2X

Maximum TCE Concentration = 328 ug/L



RECHARGE CONCENTRATIONS DECREASED BY 0.5X

APPENDIX F

LONG-TERM MONITORING COST CALCULATIONS

Hill AFB OU5 Backup Calculations

Long-Term Monitoring

Misc calculations

Number of LTM wells:		
Number of wells:	2	
Depth each:	20	ft

Cost calculations

Description	Unit	Qty.	Unit Price	Subtotal	Total	Source (If applicable)
Well Installation					$ 4,900	
Mobilization	ea	1	$ 1,500	$ 1,500		
Well Installation	ln ft	40	$ 80	$ 3,200		
Soil Disposal	drum	2	$ 100	$ 200		

Hill AFB OU5 Backup Calculations

Long-Term Monitoring

Misc calculations

Number of LTM wells:		
Number of wells:	3	
Depth each:	20	ft

Cost calculations

Description	Unit	Qty.	Unit Price	Subtotal	Total	Source (If applicable)
Well Installation					$ 6,600	
Mobilization	ea	1	$ 1,500	$ 1,500		
Well Installation	ln ft	60	$ 80	$ 4,800		
Soil Disposal	drum	3	$ 100	$ 300		

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Design/Construct two LTM wells

Standard Rate Schedule

Billing Category Cost Code/(Billing Category)	Billing Rate	Task 1 (hrs)	Install New LTM/POC Wells ($)	Task 2 (hrs)	Subcontracting ($)	Task 3 (hrs)	Reporting & PM ($)
Word Processor 88/(15)	$30	0	$0	5	$150	5	$150
CADD Operator 58/(25)	$47	0	$0	0	$0	5	$235
Technician 42/(50)	$40	8	$320	0	$0	0	$0
Staff Level 16/(65)	$57	20	$1,140	20	$1,140	15	$855
Project Level 12/(70)	$65	8	$520	12	$780	5	$325
Senior Level 10/(80)	$85	2	$170	2	$170	2	$170
Principal 02/(85)	$97	0	$0	0	$0	0	$0
Total Labor (hrs | $)		38	$2,150	39	$2,240	32	$1,735
ODCs							
Phone			$20		$20		$0
Photocopy			$10		$0		$10
Mail			$0		$10		$20
Computer			$0		$50		$50
CAD			$0		$0		$50
WP			$0		$20		$20
Travel			$100		$0		$0
Per Diem			$0		$0		$0
Eqpt. & Supplies			$200		$0		$0
Total ODCs			$330		$100		$150
Outside Services							
LTM/POC Well Installation Costs			$4,900		$0		$0
Surveying			$400		$0		$0
Other: Maintain Institutional Controls			$0		$0		$0
Total Outside Services			$5,300		$0		$0

Proposal Estimate	Task 1	Task 2	Task 3
Labor	$2,150	$2,240	$1,735
ODC's	$330	$100	$150
Outside Services	$5,300	$0	$0
Total by Task	$7,780	$2,340	$1,885

Total Labor	$6,125
Total ODCs	$580
Total Outside Services	$5,300
Total Project	$12,005

Task 1: Install New LTM/POC Wells

Task 2: Subcontracting/Permitting

Task 3: Reporting/PM per Event.

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Design/Construct 3 LTM Wells

Standard Rate Schedule

Billing Category Cost Code/(Billing Category)		Billing Rate	Task 1 (hrs)	Install New LTM/POC Wells ($)	Task 2 (hrs)	Subcontracting ($)	Task 3 (hrs)	Reporting & PM ($)
Word Processor	88/(15)	$30	0	$0	5	$150	5	$150
CADD Operator	58/(25)	$47	0	$0	0	$0	5	$235
Technician	42/(50)	$40	8	$320	0	$0	0	$0
Staff Level	16/(65)	$57	30	$1,710	20	$1,140	15	$855
Project Level	12/(70)	$65	8	$520	12	$780	5	$325
Senior Level	10/(80)	$85	2	$170	2	$170	2	$170
Principal	02/(85)	$97	0	$0	0	$0	0	$0
Total Labor (hrs|$)			48	$2,720	39	$2,240	32	$1,735
ODCs								
Phone				$20		$20		$0
Photocopy				$10		$0		$10
Mail				$0		$10		$20
Computer				$0		$50		$50
CAD				$0		$0		$50
WP				$0		$20		$20
Travel				$150		$0		$0
Per Diem				$0		$0		$0
Eqpt. & Supplies				$200		$0		$0
Total ODCs				$380		$100		$150
Outside Services								
LTM/POC Well Installation Costs				$6,600		$0		$0
Surveying				$500		$0		$0
Other: Maintain Institutional Controls				$0		$0		$0
Total Outside Services				$7,100		$0		$0

Proposal Estimate	Task 1	Task 2	Task 3
Labor	$2,720	$2,240	$1,735
ODC's	$380	$100	$150
Outside Services	$7,100	$0	$0
Total by Task	$10,200	$2,340	$1,885

Total Labor	$6,695
Total ODCs	$630
Total Outside Services	$7,100
Total Project	$14,425

Task 1: Install New LTM/POC Wells

Task 2: Subcontracting/Permitting

Task 3: Reporting/PM per Event. I:\hill\ou5\tables\cost3.xls

LTM 1 Cost Estimate
Hill AFB OU5
729691.02250

Author: JRH
Date: 5/5/97
Checked by: SH
Date: 5/6/97

Groundwater and Surface Water Sampling - Years 1998-2012--16 wells and 1 spring Sampled Annually

Sampling Labor	60 hours x		$60	/hour	$3,600
16 Long-Term Monitoring Wells					
1 Surface Water Sample					
6 QA/QC					
23 Total Samples					
Analytical Subcontractor					
	23 CAHs		$150	/each	$3,450
	16 Methane/Ethene		$100	/each	$1,600
	16 Field Parameters		$20	/each	$320
Supplies			$600	lump sum	$600
Travel			$30	lump sum	$30
Data Management (40 hr x $60hr)			$2,400		$2,400
Data Validation (17 hr x $60/hr)			$1,020		$1,020
Reporting/Project Management Labor					
Word Processing	10	hours x	$25	/hour	$250
CADD	10	hours x	$50	/hour	$500
Reproduction	8	hours x	$20	/hour	$160
Staff Level	40	hours x	$60	/hour	$2,400
Proj. Manager	10	hours x	$80	/hour	$800
Editor	4	hours x	$60	/hour	$240
Reporting/Project Management ODCs			$300	lump sum	$300
			Total for 1 Sampling Event		$17,670

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LTM Cost Estimate
Hill AFB OU5
729691.02250

Author: JRH
Date: 5/5/97
Checked by: SH
Date: 5/6/97

Groundwater Sampling - Years 2002-2012--3 Wells Sampled Biannually

Sampling Labor	14 hours x		$60	/hour	$840
3 Long-Term Monitoring Wells					
Analytical Subcontractor					
	3 CAHs		$150	/each	$450
	3 Methane/Ethene		$100	/each	$300
	3 Field Parameters		$20	/each	$60
Supplies			$150	lump sum	$150
Travel			$30	lump sum	$30
Data Management			$0		$0
Data Validation (2 hr x $60/hr)			$120		$
Reporting/Project Management Labor					
Word Processing	0	hours x	$25	/hour	$0
CADD	0	hours x	$50	/hour	$0
Reproduction	0	hours x	$20	/hour	$0
Staff Level	0	hours x	$60	/hour	$0
Proj. Manager	0	hours x	$80	/hour	$0
Editor	0	hours x	$60	/hour	$0
Reporting/Project Management ODCs			$0	lump sum	$0
			Total for 1 Sampling Event		$1,950

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LTM 1 Cost Estimate
Hill AFB OU5
729691.02250

Author: JRH
Date: 5/5/97
Checked by: SH
Date: 5/6/97

Groundwater and Surface Water Sampling - Years 2013-2022--22 wells and 5 surface water stations sampled biannuall
Cost per Sampling Event

Sampling Labor	110	hours x	$60	/hour	$6,600
22 Long-Term Monitoring Wells					
5 Surface Water Samples					
9 QA/QC					
36 Total Samples					
Analytical Subcontractor					
	36 CAHs		$150	/each	$5,400
	22 Methane/Ethene		$100	/each	$2,200
	22 Field Parameters		$20	/each	$440
Supplies			$1,000	lump sum	$1,000
Travel			$50	lump sum	$50
Data Management (50 hr x $60/hr)			$3,000	lump sum	$3,000
Data Validation (23 hr x $60/hr)			$1,180	lump sum	$1,180
Reporting/Project Management Labor					
Word Processing	10	hours x	$25	/hour	$250
CADD	10	hours x	$50	/hour	$500
Reproduction	8	hours x	$20	/hour	$160
Staff Level	45	hours x	$60	/hour	$2,700
Proj. Manager	10	hours x	$80	/hour	$800
Editor	4	hours x	$60	/hour	$240
Reporting/Project Management ODCs			$400	lump sum	$400
			Total for 1 Sampling Event		$24,920

LTM 1 Cost Estimate
Hill AFB OU5
729691.02250

Author: JRH
Date: 5/5/97
Checked by: SH
Date: 5/6/97

Groundwater and Surface Water Sampling - Years 2023-2028--25 wells and 5 surface water stations sampled biannuall
Cost per Sampling Event

Sampling Labor	120 hours x		$60	/hour	$7,200
25 Long-Term Monitoring Wells					
5 Surface Water Samples					
9 QA/QC					
39 Total Samples					
Analytical Subcontractor					
	39 CAHs		$150	/each	$5,850
	25 Methane/Ethene		$100	/each	$2,500
	25 Field Parameters		$20	/each	$500
Supplies			$1,000	lump sum	$1,000
Travel			$50	lump sum	$50
Data Management (60 hr x $60/hr)			$3,600	lump sum	$3,600
Data Validation (25 hr x $60/hr)			$1,500	lump sum	$1,500
Reporting/Project Management Labor					
Word Processing	10	hours x	$25	/hour	$250
CADD	12	hours x	$50	/hour	$600
Reproduction	8	hours x	$20	/hour	$160
Staff Level	50	hours x	$60	/hour	$3,000
Proj. Manager	12	hours x	$80	/hour	$960
Editor	5	*hours x*	$60	/hour	$300
Reporting/Project Management ODCs			$400	lump sum	$400
			Total for 1 Sampling Event		$27,870

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LTM 1 Cost Estimate
Hill AFB OU5
729691.02250

Author: JRA
Date: 5/5/97
Checked by: SH
Date: 5/6/97

Summary of Capital and Present Worth Costs

Capital Costs

Design/Construct 2 LTM Wells in 1998		$11,220
	P/F i=7% n=1	
Design/Construct 3 LTM Wells in 2002		$10,285
	P/F i=7% n=5	
Design/Construct 3 LTM Wells in 2012		$5,228
	P/F i=7% n=15	
Design/Construct 3 LTM Wells in 2022		$2,658
	P/F i=7% n=25	

Monitoring Costs

Annual Monitoring of 16 wells and 1 spring, 1998-2012 (15 years)

	Annual Cost	$17,670	
P/A i=7%, n=15	PWF = 9.10791401		
	Present Worth Cost		$160,937

Biannual Monitoring of 3 wells, 2002-2012 (6 events)

Cost per Event	$1,950		
P/A i=7%, n=5	2002	$1,390	
P/A i=7%, n=7	2004	$1,214	
P/A i=7%, n=9	2006	$1,061	
P/A i=7%, n=11	2008	$926	
P/A i=7%, n=13	2010	$809	
P/A i=7%, n=15	2012	$707	
Total Present Worth Cost			$6,108

Biannual Monitoring of 22 wells and 5 surface water stations, 2013-2022 (5 events)

Cost per Event	$24,920		
P/A i=7%, n=17	2014	$7,889	
P/A i=7%, n=19	2016	$6,891	
P/A i=7%, n=21	2018	$6,019	
P/A i=7%, n=23	2020	$5,257	
P/A i=7%, n=25	2022	$4,591	
Total Present Worth Cost			$30,646

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LTM 1 Cost Estimate
Hill AFB OU5
729691.02250

Author: JRH
Date: 5/5/97
Checked by: SH
Date: 5/6/97

Biannual Monitoring of 25 wells and 5 surface water stations, 2023-2028 (3 events)

Cost per Event	$27,870		
P/A i=7%, n=27	2024	$4,485	
P/A i=7%, n=29	2026	$3,917	
P/A i=7%, n=31	2028	$3,422	
	Total Present Worth Cost		$11,824

Site Management every year (30 years)

Annual Cost	$6,000		
P/A i=7% n=30	PWF =	12.4090412	
	Present Worth Cost		$74,454

Total Capital and Present Worth Costs of LTM Program $313,360

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Visual MODFLOW Output Files

After running the model, a number of result files will be generated. Some of the files generated by Visual MODFLOW may be very large (more than 100 Mbytes) especially the .BGT and the .UGN files. These files are typically in ASCII format, but some are in binary format to save disk space. These files are described below. The files marked with an asterisk (*) can get quite large especially with a transient simulation.

General

filename.ASC	Visual MODFLOW output file containing data to be used by plotting programs, such as Surfer (Golden Software) - ASCII format
* *filename*.LST	Visual MODFLOW output file containing the listing information and messages from MODFLOW - ASCII format
filename.PS	Visual MODFLOW output file containing the POSTSCRIPT graphics file - ASCII format
filename.DXF	Visual MODFLOW output file containing the DXF graphic file - ASCII format

MODFLOW

filename.DDN	MODFLOW output file containing drawdown X, Y, Z heads for each node - Binary format
filename.DVT	MODFLOW output file containing drawdown versus time results- Binary format
* *filename*.FLO	MODFLOW output file containing output for input to MT3D cell-by-cell flow terms (See MT3D manual for format) - Binary format
* *filename*.HDS	MODFLOW output file containing equipotential results - Binary format;
filename.HVT	Contains MODFLOW head versus time results - Binary format;

MT3D

* *filename*.OT	MT3D output file containing listing information and messages from MT3D - ASCII format;
* *filename*.UCN	MT3D output file containing unformatted concentration information - Binary format;
* *filename*.MAS	MT3D output file containing mass balance file - ASCII format
* *filename*.CNF	MT3D output file containing model grid configuration file - ASCII format

Translated Inputs for Numerical Models

The following files are generated by Visual MODFLOW during translation:

Translated MODFLOW Files

MODFLOW.IN	List of translated files that Visual MODFLOW creates for MODFLOW.
filename.BAS	Translated MODFLOW file containing data for the BASIC Package.
filename.BCF	Translated MODFLOW file containing data for the Block-Centred Flow Package.
filename.CH	Translated MODFLOW file containing data for the transient constant head package.
filename.DRN	Translated MODFLOW file containing data for the Drain Package.
filename.EVP	Translated MODFLOW file containing data for the Evapotranspiration Package.
filename.GHB	Translated MODFLOW file containing data for the General Head Boundary Package.
filename.OC	Translated MODFLOW file containing data for the output control options.
filename.PCG	Translated MODFLOW file containing data for the PCG2 solver.
filename.RCH	Translated MODFLOW file containing data for the Recharge Package.
filename.RIV	Translated MODFLOW file containing data for the River Package.
filename.SIP	Translated MODFLOW file containing data for the SIP solver.
filename.SOR	Translated MODFLOW file containing data for the SOR solver.
filename.WAL	Translated MODFLOW file containing data for the Horizontal Flow Boundary Package.
filename.WEL	Translated MODFLOW file containing data for the Well Package.
filename.WHS	Translated MODFLOW file containing data for the WHS Solver.

Translated MT3D Files

filename.AD3	Translated MT3D file containing Advection data
filename.BT3	Translated MT3D file containing Basic Transport data
filename.DP3	Translated MT3D file containing Dispersion data
filename.RC3	Translated MT3D file containing Chemical Reaction data
filename.SS3	Translated MT3D file containing Source / Sink data
MT3D.IN	Translated MT3D file containing the list of files that Visual MODFLOW creates for use in MT3D

APPENDIX E
MODFLOW/MT3D MODEL
INPUT AND OUTPUT FILES

File:	
OU5-A-IN.ZIP	Model OU5-A Input Files
OU5A-OUT.ZIP	Model OU5-A Output Files
OU5-B-IN.ZIP	Model OU5-B Input Files
OU5B-OUT.ZIP	Model OU5-B Output Files
OU5-C-IN.ZIP	Model OU5-C Input Files
OU5C-OUT.ZIP	Model OU5-C Output Files

To decompress these files, type the following at the c:\> prompt:

```
a:\pkunzip a:\*.zip c:\
```

This will create the input and output files for each model run in uncompressed ASCII format. The model files generated and the data contained therein are listed on the attached pages. All applicable input files are included. Only the general MODFLOW *.LST, and the MT3D *.OT and *.MAS output files are included.

APPENDIX E

MODEL INPUT AND OUTPUT FILES