Ground-Water Monitoring in the area of Operable Unit 4, Hill Air Force Base, Utah, 1991-94, Volume I

EXECUTIVE SUMMARY

Introduction

During March 1991, the U.S. Geological Survey (USGS), in cooperation with Hill Air Force Base (AFB), began a monitoring program to determine the spatial and temporal changes in concentrations of contaminants detected in the shallow ground water in the area of Operable Unit 4 (OU 4) on the north side of Hill Air Force Base. The need for the monitoring program was recognized during a Remedial Investigation (RI) of contamination in the area of OU 4 during 1988-92 by the USGS. The monitoring program was planned for an indefinite period depending on the behavior of the contaminants during and following remediation.

Hill AFB is located in northern Utah, about 25 mi north of Salt Lake City and about 5 mi south of Ogden (fig. ES-1). Hill AFB covers about 6,700 acres and is located on the Weber Delta, a terrace about 300 ft above the valley floor in Weber and Davis Counties. Landfills 1 and 2, the north gate dump sites, munitions dump, and spoils area are in OU 4 (fig. ES-2). The area of study includes these sites and the area immediately surrounding these sites. Evaluations of data collected during 1988-92, contained in the Remedial Investigation Report for Operable Unit 4 (vol. 1, 1992) and the Addendum to the Remedial Investigation Report for Operable Unit 4 (vol. 11, 1993), indicated that landfill 1, which covers about 5 acres, was the most probable source area for trichloroethylene (TCE) and other contaminants found at the site.

Problem

During the RI, 13 volatile organic compounds (VOCs), suspected inorganic contaminants, sulfate and nitrate, and 14 trace elements were detected in shallow ground water at OU 4. TCE was the VOC detected most frequently and in the highest concentrations (vol. 11). TCE exceeded the 5 µg/L primary maximum contaminant level (PMCL) in water from 24 wells and 3 seeps. Trans-1,2-dichloroethylene exceeded the 100 µg/L PMCL in water from two wells and benzene exceeded the 5 µg/L PMCL in water from one well.

Sulfate and nitrate were suspected contaminants because the concentrations were higher in ground water that also was contaminated by TCE than in nearby areas where there was no TCE contamination. Arsenic exceeded the maximum contaminant level (MCL) of 0.05 mg/L in water from two wells, nickel exceeded the MCL of 0.10 mg/L in water from four wells, and selenium exceeded the MCL of 0.05 mg/L in water from one well.

During the RI, plumes of TCE and sulfate were detected in the shallow ground water throughout a large part of OU 4. No contamination was detected in the underlying aquifers used for public water supply. OU 4 is adjacent to several residences that use water from aquifers underlying the contaminated shallow ground water.

Remediation was begun in July and August 1993 by installing horizontal drains and treating the outflow to remove the TCE (fig. ES-2). The horizontal drains were placed within the most contaminated parts of the TCE plume. Determining the effects of remediation on contaminant behavior at OU 4 was complicated by climatic variations and by the relining of the Davis-Weber Canal, both of which affect recharge to the shallow ground-water system. Water-quality monitoring is needed to maintain a current assessment of the nature and extent of contamination and to evaluate the effects of remediation procedures.

Purpose and Scope

This report evaluates and describes the spatial occurrence and temporal behavior during 1991-94 of the chemicals of concern, including the plumes of TCE and sulfate, which were discussed in the "Problem" section. Changes in contaminant concentrations are discussed in relation to structural and climatic changes that affected the ground-water hydrology. Selected data collected as part of the monitoring program, as well as previous historical data, are tabulated in appendixes A-D of this report.

Ground-Water Quality

The water-quality data collected during September 1992 through August 1994 were examined to determine (1) if previously undetected contaminants were

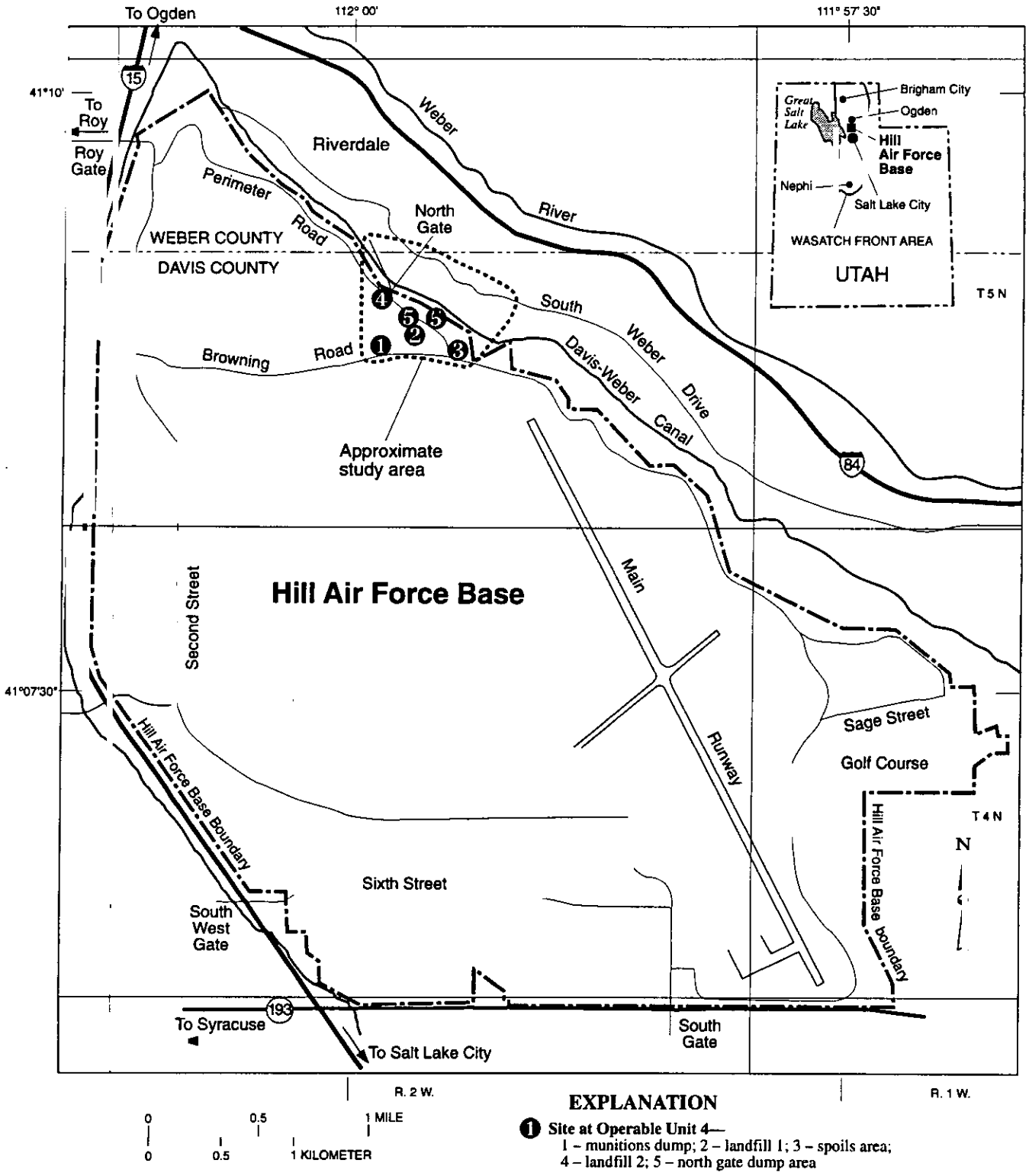


Figure ES-1. Location of Operable Unit 4 at Hill Air Force Base, Utah. (Modified from Radian Corporation, 1988, figure 1.6-1.)

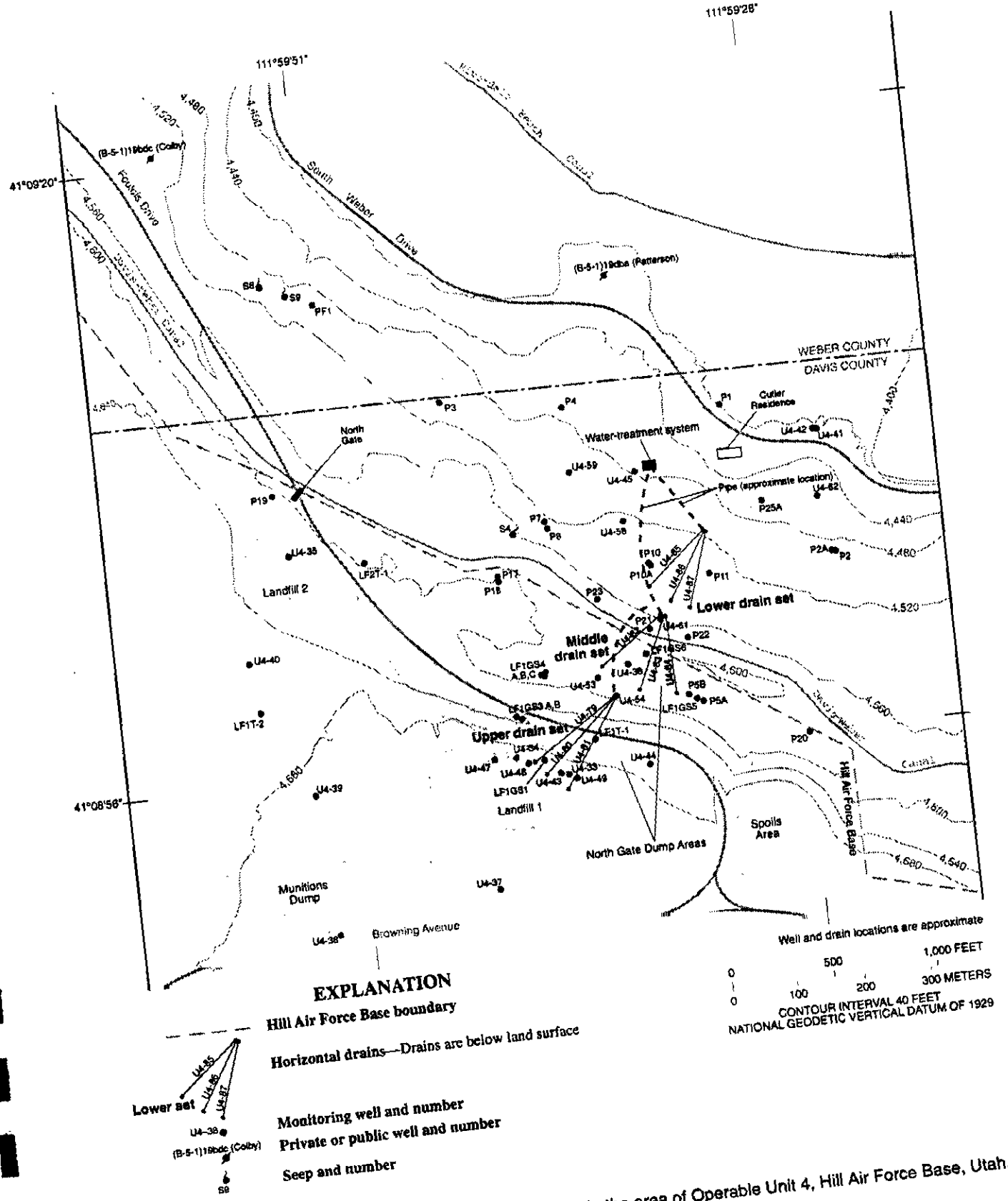


Figure ES-2. Location of monitoring wells and horizontal drains in the area of Operable Unit 4, Hill Air Force Base, Utah.

present in water from any of the wells, and (2) the spatial and temporal behavior of contaminants that had been previously identified in the RI and Addendum reports. Water-quality data for the monitoring wells included VOCs, major inorganic ions, and selected trace elements.

During September 1992 through August 1994, TCE, trans-1,2-dichloroethylene, and acetone were the only VOCs detected in water samples from the monitoring wells. The three VOCs detected were among those reported during studies prior to September 1992; no new VOCs were detected. During September 1992 through August 1994, water from a subset of 26 of the 38 wells sampled prior to September 1992 was resampled and analyzed at least once for TCE. This subset included water from 18 wells in which the TCE concentrations prior to September 1992 exceeded the PMCL and water from 8 wells in which the TCE concentrations were less than the PMCL. Of the 26 wells that were sampled and analyzed at least once for TCE, water from 16 wells continued to have TCE concentrations exceeding the PMCL of 5 µg/L and water from 10 wells did not.

Water from five of the six wells where trans-1,2-dichloroethylene was detected during June 1986 through August 1992 was sampled again at least once during September 1992 through August 1994 (well P21 was excluded). Of the five wells, trans-1,2-dichloroethylene was detected again in water from wells LF2T-1 and P10A but not in water from wells LF1GS3B, LF1GS4B, or LF1GS6.

During September 1992 through August 1994, trans-1,2-dichloroethylene was detected in water from wells LF1GS4A and P22; no detects had been made during prior sampling. P22 was the only well sampled during September 1992 through August 1994 in which water had trans-1,2-dichloroethylene concentrations that exceeded the PMCL.

During June 1986 through August 1992, acetone was detected in water from wells LF1T-1 and P21. During September 1992 through August 1994, acetone was not detected in water from wells LF1T-1 or P21 but was detected in water from well P10A at a concentration of 160 µg/L. No MCL had been established for acetone as of August 1994.

A plume of TCE was defined during the RI based on maximum concentrations determined from data collected during 1986-92 (vol. 11, fig. 4.7.2.1-3). Within the boundary of the plume, however, change in TCE concentration has occurred. Most of the change is believed to be a result of the drains installed during July and August 1993, as part of remediation, and to a lesser extent by variations in precipitation and relining of the Davis-Weber Canal (fig. ES-3).

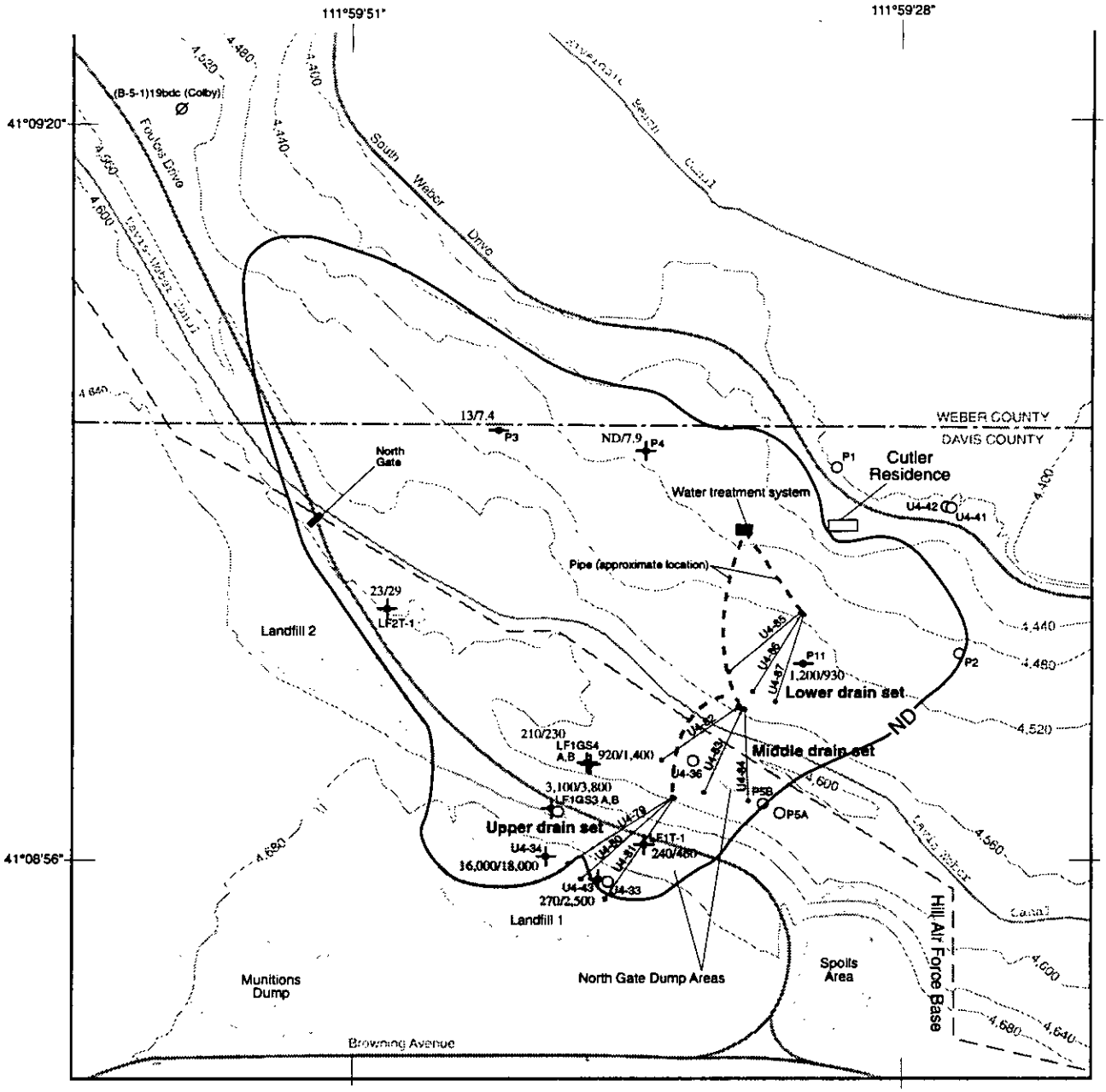
Four sets of clustered wells were included in the monitoring program to determine if TCE or other contaminants were migrating deeper into the ground-water system. The clusters selected for monitoring include wells LF1GS3B and LF1GS3A, LF1GS4B and LF1GS4A, LF1GS6 and U4-36, and U4-33 and U4-43 (fig. ES-3). Data for the clustered wells LF1GS4A and LF1GS4B show evidence of deeper migration of TCE into the ground-water system. In December 1992, the concentration in water from the deeper well, LF1GS4A, began increasing and reached a maximum concentration of about 230 µg/L in November 1993. Comparison of the boundary of the plume in August 1994 with the boundary defined using data from 1986-92 indicates that the areal extent of contamination has not changed since 1992.

The maximum concentrations of TCE for the 1993 water year were compared with those of the 1994 water year to determine if significant changes have occurred since the drains were installed. The most significant changes are:

1. Six of the eight wells with water containing increased concentrations of TCE were located near the drains and the largest increases were in water from wells near the upper set of drains. Increased concentration may be a result of the enhancement of the hydraulic connection by the drains between the source of TCE in the landfill and the nearby wells.
2. The largest decrease in concentration was in water from well P11 near the most downgradient set of drains. This decrease may be caused by the removal of water containing higher concentrations of TCE through the upper two sets of drains, which are located near the upgradient source area (landfill 1) (fig. ES-3).

Evaluating the effect of the drains on the concentration of TCE in the plume defined by sampling during 1993-94 is difficult because of several climatic and hydrologic factors that changed about the same time the drains were installed. Upgradient from the canal, most of the ground-water recharge is from precipitation. During the 1993 water year, precipitation was about 32 percent greater than average for 1979-94, and during the 1994 water year, precipitation was about 22 percent less than the 1979-94 average. Thus, recharge upgradient from the canal was probably considerably less during 1994 than during 1993. After the canal was relined during the 1992 water year, there was probably little or no recharge from the canal to the area downgradient of the canal.

During January 1989 through August 1994, water samples were collected and analyzed for selected trace elements. The trace elements, detection limits,



Well and drain locations are approximate

EXPLANATION

ND — **Line of trichloroethylene concentration not detected, September 1992 to August 1994**

Hill Air Force Base boundary

0 500 1,000 FEET
0 100 200 300 METERS
CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Upper set U4-79 U4-80 U4-81 — **Horizontal drains**—Drains are below land surface

Wells and seeps—Change in trichloroethylene concentrations from October 1992 – September 1993 to October 1993 – September 1994

Monitoring well and number. Maximum trichloroethylene concentration in water year 1993/ maximum trichloroethylene concentration in water year 1994. ND – Not detected, reporting limit is 5 micrograms per liter

LF1T-1 240/460 Increase U4-33 No change P11 1,200/930 Decrease

Private or public well and number
(B-5-1)19bdc (Colby) Ø No change

Figure ES-3. Monitoring wells showing an increase, no change, or decrease in maximum trichloroethylene concentrations in the area of Operable Unit 4, Hill Air Force Base, Utah, during water years 1993-94.

concentrations, and MCLs are listed in appendix C. The concentrations of trace elements that exceeded MCLs in water during January 1989 through August 1994 are listed in table ES-1. Comparisons were made of trace-element concentrations in water from wells for January 1989 through August 1992 and September 1992 through August 1994. In this report, January 1989 through August 1992 is referred to as the first time period, and September 1992 through August 1994 is referred to as the second time period.

During the first time period, ground-water samples were collected from 28 wells and were analyzed for arsenic (appendix C). Concentrations in water from wells U4-35 and U4-42 exceeded the MCL of 0.05 mg/L (table ES-1). During the second time period, water from 9 of the 28 wells was sampled again. Concentrations of arsenic in water from well U4-35 did not exceed the MCL, but concentrations in water from well U4-42 continued to exceed the MCL. Arsenic concentrations in water from well U4-41 did not exceed the MCL during the first time period but exceeded it during the second time period.

Arsenic has exceeded the MCL in water from only one well upgradient from the flood plain, and very little, if any, of the upgradient ground water enters the flood plain. Therefore, it is more probable that the arsenic detected in water from wells U4-41 and U4-42 originates within the flood plain and not from the landfill.

During the first time period, ground-water samples were collected from 17 wells and analyzed for boron (appendix C). Concentrations in water from wells LF1T-1 and LF1GS6 exceeded the lifetime health advisory level of 0.6 mg/L (table ES-1). During the second time period, water from 29 wells was sampled, including 15 wells sampled during the first time period and 14 wells not previously sampled. Concentrations of boron in water from wells LF1T-1 and LF1GS6 continued to exceed the lifetime health advisory level. Water from well LF1GS3B, which was sampled during both time periods, exceeded the lifetime health advisory level only during the second time period. Water from wells U4-34 and U4-43, sampled only during the second time period, also exceeded the lifetime health advisory level.

During the first time period, water from 28 wells was sampled and analyzed for nickel (appendix C), and concentrations in water from wells LF1GS3B, LF1GS6, P3, and P18 exceeded the MCL of 0.10 mg/L (table ES-1). During the second time period, water from six wells was sampled, including wells LF1GS3B, P18, and four wells in which concentrations of nickel were previously below the detection limit. Concentrations of nickel did not exceed the MCL in water from well LF1GS3B, continued to exceed the MCL in water from well P18, and were not analyzed in water from wells LF1GS6 and P3. Concentrations did not exceed the MCL in water from the other four wells sampled during the second time period.

During the first time period, water from 28 wells was sampled and analyzed for selenium (appendix C), and concentrations in water from well P18 exceeded the MCL of 0.05 mg/L (table ES-1). During the second time period, water from 5 of the 28 wells, including well P18, was sampled again, and concentrations did not exceed the MCL.

During the first time period, water from 28 wells was sampled and analyzed for lead (appendix C), and concentrations in water did not exceed the action level of 0.015 mg/L. The action level for lead applies to water used for public supply and sampled from a tap. Water from the shallow aquifer, however, is not being used for drinking water. During the second time period, water from 7 of the 28 wells was sampled again and concentrations of lead in water did not exceed the action level, although lead was detected in water from well U4-38 at a concentration equal to the action level of 0.015 mg/L.

A plume of sulfate defined during the RI based on the maximum concentrations that exceeded 100 mg/L was determined from data collected during January 1989 through August 1992 (vol. 11, fig. 4.5.4.2-2). A similar map shows the area where sulfate exceeded 100 mg/L during May and June, 1994 (fig. ES-4). Comparison of the maps of the plumes for 1992 and 1994 indicates that the boundary of the area upgradient from Davis-Weber Canal that contains more than 100 mg/L of sulfate has shifted to the northwest and no longer includes well LF1T-1. The boundary downgradient from the canal has shifted southeast and no longer includes wells P11 and P4 but now includes wells P2A and P2.

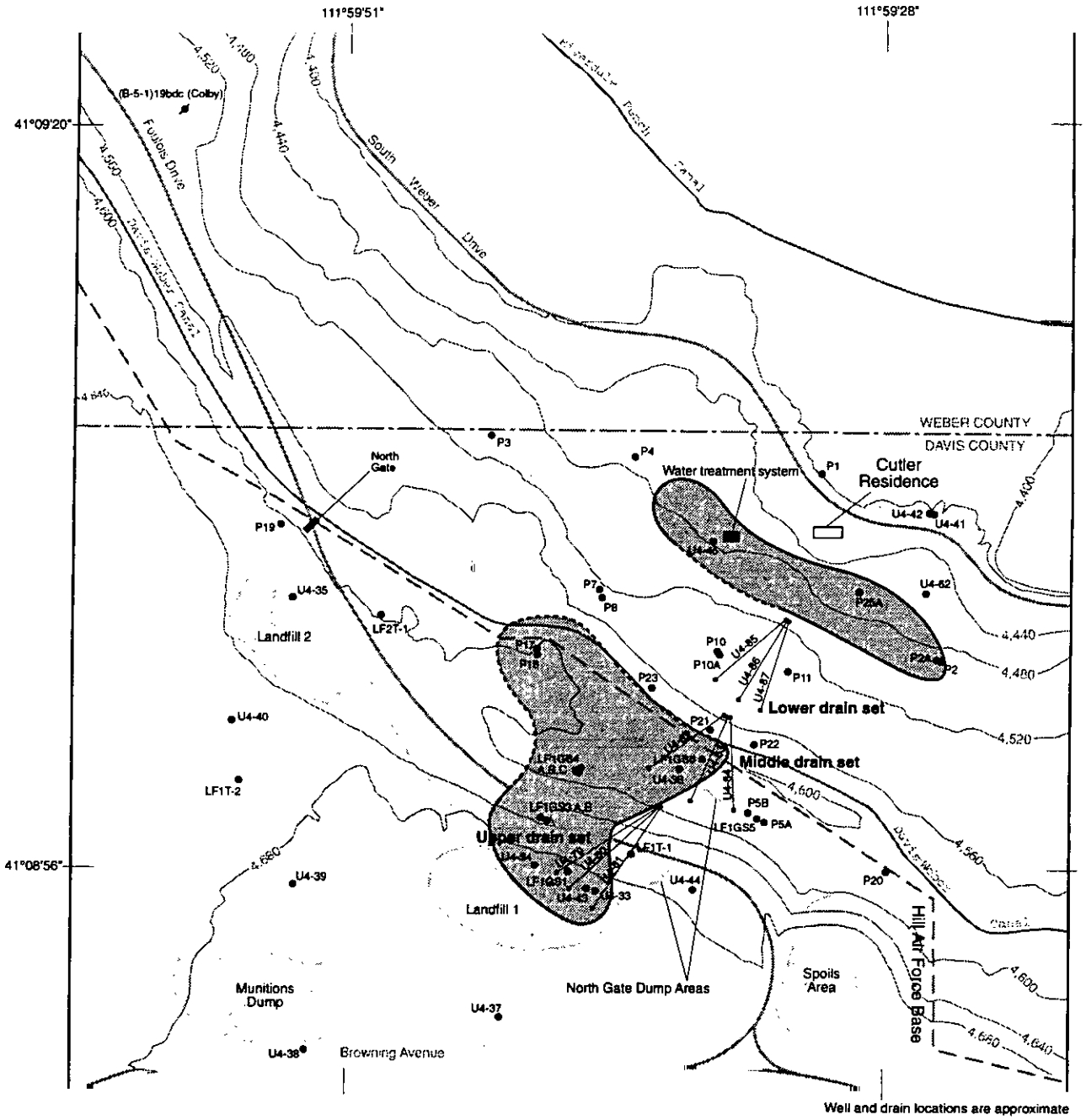
Only one of the four sets of clustered wells selected for monitoring showed evidence of increased sulfate concentration in water from the deeper well. Well U4-33 is screened about 18 ft below the bottom of the screen of the shallower well, U4-43 (fig. ES-4). After the drains were installed, the sulfate concentrations in water from both of these wells more than doubled.

Most of the changes in the areal extent of the sulfate plume are likely caused by the drains that were installed during July and August 1993 as part of remediation and to a lesser extent by variations in precipitation and by the relining of the Davis-Weber Canal. In an effort to evaluate the effects of the drains, the maximum concentrations of sulfate in water from wells for the 1993 water year were compared with maximum concentrations from wells for the 1994 water year; and concentrations increased in water from 8 wells and decreased in water from 10 wells. Except for well LF1GS3B, the largest increases in sulfate concentra-

Table ES-1. Trace elements that exceeded water-quality standards in water from wells in the area of Operable Unit 4, Hill Air Force Base, Utah, 1989-94

[mg/L, milligrams per liter; MCL, maximum contaminant level; LHAL, lifetime health advisory level]

Well	Date	January 1989 to August 1992	September 1992 to August 1994
		Arsenic (mg/L) MCL = 0.05	
U4-35	05/27/92	0.065	
U4-41	10/27/92		.052
	04/20/93		.053
	10/22/93		.33
U4-42	07/13/92	.094	
	10/27/92		.098
	04/20/93		.090
	10/22/93		.19
	05/11/94		.11
		Boron (mg/L) LHAL = 0.6	
LF1T-1	01/26/89	1.8	
	11/07/91	1.3	
	11/18/92		1.5
	04/22/93		1.4
	11/05/93		1.8
	06/03/94		1.7
LF1GS3B	04/21/93		1.7
	06/08/94		.62
LF1GS6	11/13/91	1.5	
	10/28/92		1.7
	05/10/93		2.0
U4-34	10/23/92		1.1
	05/10/93		.74
	11/08/93		1.6
	05/10/94		1.0
U4-43	10/22/92		2.3
	04/20/93		2.3
	11/03/93		1.6
	05/10/94		1.5
		Nickel (mg/L) MCL = 0.10	
LF1GS3B	02/01/89	2.1	
LF1GS6	07/07/92	.46	
P3	04/04/91	.27	
P18	03/28/91	1.7	
	10/17/91	1.4	
	09/22/92		1.2
		Selenium (mg/L) MCL = 0.05	
P18	10/17/91	.053	



EXPLANATION

Area where concentration of sulfate exceeded 100 milligrams per liter, May–June 1994—Dashed where approximately located. At sites with well clusters, the well with the greater concentration of sulfate was used

Hill Air Force Base boundary

Upper set (U4-79, U4-80, U4-81) **Horizontal drains**—Drains are below land surface

U4–38 **Monitoring well and number**

(B-5-1)19bdc (Colby) **Private or public well and number**

0 500 1,000 FEET
0 100 200 300 METERS

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Figure ES-4. Areas where concentrations of sulfate exceeded 100 milligrams per liter in the shallow ground water in the area of Operable Unit 4, Hill Air Force Base, Utah, May-June 1994.

tions were in water from wells near the upper set of drains. The largest increases in concentrations were in wells U4-43 and U4-34, near the upper set of drains and nearest to landfill 1 (fig. ES-4). Increased concentration may be a result of the enhancement of the hydraulic connection between the source of sulfate in the landfills and the nearby wells.

Suggestions for Monitoring

The wells and seep that are suggested for monitoring of water quality and water levels at OU 4 are shown in figure ES-2 and listed in table ES-2. After each round of sampling, the data need to be reviewed to determine if changes have occurred that might necessitate revision of the monitoring program.

Evaluation of the data collected during September 1992 through August 1994 indicates a need to add wells P10A, P18, and P22 and seep S9 to the monitoring program. Addition of wells P10A and P18 will better define the plumes of TCE and sulfate. Well P22 should be sampled only if well LF1GS6 does not have enough water to be sampled. Seep S9 should be sampled and analyzed for VOCs to refine the location of the no-detection boundary for TCE in the northwestern part of the study area.

The frequency of sample collection from well U4-45 should be increased to four times a year to better define the temporal change of TCE near the leading edge of the plume. Nickel has been added to the analytical schedule for wells LF1GS3B, LF1GS6, P3, and P18 because it has exceeded MCLs in water from these wells during past samplings. Selenium has been added to the analytical schedule for well P18 because it has exceeded the MCL during past samplings.

Since installation of the drains in July and August 1993, water levels in wells near the drains have declined about 3 ft upgradient from the Davis-Weber Canal and about 5 ft downgradient from the canal. The upgradient drains and relining of the canal reduce the amount of recharge to the area downgradient from the canal where the lower set of drains is installed. To help evaluate the effect of reduced recharge on seasonal fluctuations of water levels, measurement should continue to be every month. Monthly measurements of water levels by the USGS will be discontinued, and Montgomery Watson, Consulting Engineers, Incorporated will begin measuring the water levels in 1995.

Table ES-2. Wells and a seep suggested for continued monitoring of water quality at quarterly, semiannual, or annual intervals and water levels at monthly intervals in the area of Operable Unit 4, Hill Air Force Base, Utah

[Unless otherwise noted, each sample analysis will include the following schedules: volatile organic compounds (SW8240), common anions (A429 includes chloride, fluoride, sulfate, nitrate, and orthophosphate), total alkalinity (A403), nitrate+nitrite (E353.2), and selected inorganic constituents (SW6010 includes calcium, magnesium, potassium, silica as SiO_2, sodium, boron, and others as requested); Quarterly sampling: summer and winter sampling of these wells will only include analyses of volatile organic compounds]

Quarterly sampling (spring, summer, fall, winter)	Semiannual sampling (spring, fall)	Annual sampling (spring)
	Upgradient from Davis-Weber Canal	
LF1T-1	LF2T-1	P5A
[1] LF1GS3B	LF1GS3A	P5B
LF1GS4B	LF1GS4A	
[1,2] LF1GS6	[1,3] P18	
[4] U4-34	U4-33	
[2,4] U4-43	[5,6] U4-35	
	U4-36	
	Downgradient from Davis-Weber Canal	
P11	[1] P3	[2] P2
P22	P4	P2A
U4-45	P10A	[7] S9
	[2] P25A	
	Colby	
	Weber River flood plain	
	P1	
	[5] U4-41	
	[5] U4-42	

[1] Add nickel (requested in schedule SW6010).

[2] Not enough water in well to collect a sample.

[3] Add selenium (SW7740).

[4] Add lead (SW7421).

[5] Add arsenic (SW7060).

[6] Sample for selected inorganic constituents (SW6010) only.

[7] Sample for volatile organic compounds (SW8240) only.