Executive Summary

Introduction

This report presents the results of the Operable Unit 1 (OU1) Groundwater Pre-Design Summary Investigation. OU1 is located at Hill Air Force Base (HAFB), Utah. The purpose of the pre-design investigation is to acquire data to design remediation systems and to assess the nature and extent of Non-Source Area groundwater contamination. The proposed and preferred remedial action alternatives are presented in the *Final Record of Decision for Operable Unit 1* (CH2M HILL, 1998). The investigation was divided into two phases: The Phase I groundwater investigation was conducted from May until September 1997. The Phase II investigation was conducted from September 1997 until April 1998. A phased approach was used to allow information obtained in the first phase to help focus the second phase of the investigation.

Objectives

The objectives of the investigation were to:

- Collect data to obtain a more complete understanding of Source Area groundwater flow and contaminant concentrations, and to assess Non-Source Area groundwater flow and contaminant concentrations in order to acquire the data necessary to design remediation systems.
- Determine the constructability of the alternative groundwater containment and associated remediation systems, as defined in the *Final Feasibility Study Report for Operable Unit 1* (CH2M HILL, 1998d).
- Acquire data necessary to design the Source Area groundwater containment and associated remedial systems.
- Acquire baseline information for Non-Source Area remedial action alternatives.
- Evaluate the effect of leakage from the Davis-Weber Canal on the nearby hydrogeologic conditions.
- Assess the impact of Pond 10 on the stability of the adjacent hillside and evaluate the source of water in Pond 10.
- Evaluate groundwater conditions in the deep drinking water aquifer.
- Assess the source of groundwater that may be captured by Source Area remediation systems.

Scope of Work

To accomplish these objectives, a geophysical investigation to map the locations of highly transmissive groundwater flow paths, cone penetration testing, excavation of shallow soil borings, driving of hydraulic probe borings, and the installation of monitoring wells was performed. Eighty-four Cone Penetration Test exploration points were driven to depths as great as 94 feet below the ground surface (bgs), thirty-six soil borings were excavated to depths as great as 77 feet bgs, and 20 hydraulic probe borings were excavated to depths as great as 30 feet bgs. In addition, 35 monitoring wells and 11 piezometers were installed.

Site Background

The OU1 Source Areas consist of Chemical Disposal Pits (CDPs) 1 and 2, Landfills 3 and 4, Fire Training Areas (FTAs) 1 and 2, the Waste Phenol/Oil Pit (WPOP), the Waste Oil Storage Tanks (WOST), the LNAPL Plume, and the contaminated groundwater below the Source Areas. CDPs 1 and 2 were used for disposal and periodic burning of liquid wastes (principally petroleum hydrocarbons and spent solvents) from the 1950s through 1973. Light Non-Aqueous Phase Liquids (LNAPL) emanate from the CDPs. The CDPs were covered with fill materials and capped with low-permeability materials in the mid-1980s. The OU1 Source and Non-Source Areas are presented in Figure ES-1.

Landfill 3 is located in the northeast corner of HAFB. The landfill was in operation from the early 1940s to the mid-1970s and accepted residential and industrial wastes from HAFB. The wastes deposited in the landfill were burned until the mid-1960s. A low-permeability cap was constructed over the surface of the landfill in 1985 to limit infiltration of surface water. Landfill 4 is located in the northeast corner of HAFB, southeast of Landfill 3. Landfill 4 was designated as a sanitary landfill in 1967, when open burning at Landfill 3 was terminated. The landfill operated as a "trench and cover" landfill from 1970 until July 1973. The landfill received solid waste, including: scrap metal, construction debris, domestic refuse, industrial refuse, small amounts of industrial waste consisting of sludge from the Industrial Wastewater Treatment Plan (IWTP) drying beds, sulfuric acid, chromic acid, phenol, and methyl ethyl ketone. A low-permeability cap was constructed over the surface of the landfill in 1985 to limit infiltration of surface water.

FTA 1 was located in the southern part of Landfill 3 and was used by the HAFB Fire Department from approximately the mid-1950s through 1973 as a practice area to extinguish simulated aircraft fires. Soils below FTA 1 are contaminated to the water table at 28 feet bgs. A LNAPL plume from the fuels used during fire training exercises has been observed downgradient (north) of FTA 1. FTA 2 is located along Perimeter Road and has been used by the HAFB Fire Department since approximately mid-1973 as a practice area to extinguish simulated aircraft fires. Soils in this area were contaminated with fuel compounds. A bioventing treatability study preformed at FTA 1 has removed a majority of the soil contamination.

The WPOP, also referred to as the "brick-lined burn pit," was used periodically to dispose of waste oil and phenol from approximately 1954 through 1965. After use of the WPOP stopped, the waste oils were disposed of in the CDPs. When the WPOP was removed in 1986 during the excavation of Pond 10, visibly stained soils associated with the WPOP are

disposed of in Landfill 3. The WOST consisted of four aboveground storage tanks located southeast of the CDPs and at the southwest corner of Landfill 3. The tanks were removed in 1985. An LNAPL layer on the shallow groundwater table extends northwest from FTA 1 and westward from the CDP areas. The LNAPL is composed primarily of jet fuel. Other contaminants have been detected in the LNAPL, such as chlorinated solvents, base, neutral, and acid extractable compounds; dioxins; furans, and polychlorinated biphenyls.

Contamination in the Non-Source Areas consists of groundwater contamination emanating from OU1 Source Areas. Two major contaminated groundwater plumes have been observed at OU1. The plumes have been identified as the Off-Base Plume and the Western Plume. The primary contaminant of concern in the Non-Source Area plumes is cis 1,2-dichloroethene (DCE).

Geology and Hydrogeology

Geology

A majority of the investigation focused on the evaluation of the geology and hydrogeology of the OU1 area in consideration of the proposed remediation systems. The description of the geology and hydrogeology is slightly modified from the *Final Comprehensive Remedial Investigation Report for Operable Unit 1* (MW, 1995). The geologic units underlying OU1 consist of landfill materials, landslide debris, terrace deposits, the Provo Formation, the Alpine Formation, an Unnamed Formation, and the Groundwater Aquifer. The Alpine Formation has been subdivided into five lithologic units. Six water-bearing zones have been identified within the Alpine Formation. The division of the Alpine Formation and identification of the various water-bearing zones were necessary due to the differing soil types and the variation in groundwater contamination levels. Figure ES-2 presents a generalized geologic cross-section showing the relationship of the geologic units identified at OU1.

The geology underlying OU1 consists of sand and gravels of the Provo Formation. Underlying the Provo Formation is the Alpine Formation. The Alpine Formation was been divided into the following units: upper clay unit, lower clay unit, sand unit, sand/clay unit, and basal clay unit. The total thickness of the Alpine Formation is approximately 500 feet. An Unnamed Formation and the Groundwater Aquifer underlie the Alpine Formation. The Unnamed Formation and the Groundwater Aquifer are composed of gravels with silty sand interbeds. Other geologic units identified at OU1 include the recent terrace deposits, landslide debris. Artificial fill units include landfill cap materials, landfill cover materials and landfill debris. The recent terrace deposits are found in the Weber River Valley. Landslide debris are observed on the slope between HAFB and the Weber River Valley. Landfill cap materials, landfill cover materials and landfill debris are found in the Source Areas within the Provo Formation.

Continuity of Clay Materials Under the Landfills

The top of the Alpine Formation was mapped to evaluate the continuity of the clay materials. Numerous exploration points were excavated to the clay surface, clay materials of the Alpine Formation appear to be continuous under the Source Areas. In addition, the

depth to the clay surface is fairly consistent under the landfills. A consistent depth of materials allows a confident extrapolation of the depth of clay materials between exploration points and provides evidence of the continuity of the clay surface. The vertical permeability of the clay materials, as measured in a tri-axial cell, ranged from 2.8×10^{-7} centimeters per second (cm/sec) to 8.8×10^{-8} cm/sec.

Hydrogeology

Seven different water-bearing zones were identified underlying OU1 between the ground surface and the groundwater aquifer. Water-bearing zones were identified along the Provo/Alpine Formation contact, just below the Provo/Alpine Formation within the upper clay unit of the Alpine Formation, within the lower clay unit of the Alpine Formation at 4,720 to 4,700 feet Mean Sea Level (MSL), and at the base of the sand unit. The sand unit is connected to the recent terrace deposits. Three additional water-bearing units exist below the sand unit in the sand/clay unit at approximate elevations of 4,430, 4,410 and 4,360 MSL. The water-bearing zones in the Provo Formation and sand unit of the Alpine Formation/recent terrace deposits are unconfined. The other water-bearing zones are confined or partially confined. Monitoring wells and piezometers were installed in each water-bearing unit to evaluate groundwater elevations and contamination levels. Figure ES-2 presents a generalized geologic cross-section showing the relationship of the hydrogeologic units identified at OU1.

The top of the Unnamed Formation and the Groundwater Aquifer were observed at elevations of 4,130 and 4,260 feet, MSL, respectively. The Unnamed Formation and the groundwater aquifer are highly permeable and contain significant quantities of water. Groundwater from the Groundwater Aquifer is used as a source of drinking water in the area.

A considerable permeability difference exists between the Provo Formation and the upper clay unit of the Alpine Formation. During the deposition of the Provo Formation, the top of the Alpine Formation was significantly eroded and channels were cut into the formation. The channels control groundwater flow in the Source Areas. A significant permeability contrast also exists between the sand unit and sand/clay unit of the Alpine Formation. Based on horizontal groundwater gradient maps, most of the water-bearing zones do not appear to be connected. Because of the numerous low-permeability layers between the contaminated water-bearing zones and the Groundwater Aquifer, the lower water-bearing zones and Groundwater Aquifer are not affected by contamination from the Source Areas.

Davis-Weber Canal Leakage Assessment

In the off-Base, Non-Source Areas, leakage from the Davis-Weber Canal has been thought to be a source of groundwater recharge to the Weber River Valley. As groundwater contamination emanates from on-Base Source Areas and migrates to the canal area, leakage from the canal enhances the movement of the groundwater contamination into Weber River Valley. Groundwater is found approximately 90 feet below the canal. Contaminated groundwater does not flow into the canal. Groundwater levels in off-Base monitoring wells were analyzed to evaluate the possible leakage from the canal. Hydrographs show the groundwater levels rise in the off-Base plume area during the period the canal is in operation providing evidence that canal leakage contributes to groundwater recharge in the

off-Base area. Canal leakage enhances the natural attenuation of contamination in the off-Base area.

Groundwater Source Areas

Geophysical analysis was performed to evaluate the source of groundwater in the OU1 Source Areas. Identification of the source of groundwater could enable the design of a clean water extraction system that may limit the amount of groundwater required to the extracted by the groundwater remediation system. The results of the investigation indicate that precipitation in the areas south of OU1 are a significant source of recharge. An overflow basin for the Base water supply reservoir/storm water run-off pond and irrigation from the Base Golf Course may also be a source of groundwater. The groundwater was found to flow over a large area and an upgradient, clean water extraction system may not be cost effective. Groundwater from areas to the south of OU1 that flows toward the hillside area along the east side of OU1 is collected prior to reaching the hillside area by the existing extraction system.

Pond 10 Evaluation

Pond 10 is currently used as a surface water catch basin for surface flow from Landfills 3 and 4 and the area west of CDPs 1 and 2. The pond collects surface water through a series of ditches. Depending on the amount of precipitation, Pond 10 generally fills with 2 to 4 feet of water during the winter and early spring. The water evaporates by summer. A majority of the groundwater in Pond 10 is assumed to be from surface-water run-off. Additional investigation was performed to evaluate if groundwater contributes to the water in Pond 10. An approximate 10-foot difference exists between the elevation of the surface water in Pond 10 and the groundwater in the upper clay unit of the Alpine Formation water-bearing zone. Based on the observation that the surface water in the Pond 10 persists into mid-summer in most years, there appears to be only a limited connection between the surface water and groundwater. Geophysical analysis was performed to evaluate if a connection between the Pond 10 and springs located on the hillside below Pond 10 exists. A hydrogeological connection between Pond 10 and hillside springs could not be established.

Groundwater Contamination

The investigation evaluated groundwater contamination by collecting groundwater samples for analytical testing. The results of the testing provided an indication of the type and concentration of chemical contamination in the groundwater. Figure ES-2 presents a generalized geologic cross-section showing the approximate location of groundwater contamination at OU1.

Groundwater contamination underlying OU1 was mapped on the basis of the water-bearing zones identified below OU1. Contamination was observed in the Provo Formation and upper clay, lower clay, sand unit, and the upper two water-bearing zones of the sand/clay unit of the Alpine Formation. Contamination was not observed in the lower water-bearing zone of the sand/clay unit of the Alpine Formation or the groundwater aquifer. The Provo Formation water-bearing zone was found to be the most contaminated. The majority of the groundwater contamination consists of chlorinated hydrocarbons, fuel hydrocarbons, and

metals. Minor levels of pesticides and herbicides were also detected. DCE and vinyl chloride are the most widespread contaminants and were used to identify the extent of groundwater contamination. The type of contamination in the upper clay unit of the Alpine Formation is similar to contamination found in the overlying Provo Formation water-bearing zone. The levels of contamination are significantly lower. The two water-bearing zones appear to be partially connected and the source of contamination appears to be the overlying Provo Formation water-bearing zone.

Groundwater contamination was observed in the lower clay unit of the Alpine Formation in the groundwater channels leading off of the Base. The levels of contamination are significantly lower than the upper clay water-bearing zone. Groundwater contamination was also observed in the sand unit/recent terrace deposits and sand/clay unit water-bearing zones. DCE is the main contaminant observed in the groundwater of the sand unit/recent terrace deposits and sand/clay unit water-bearing zones. Contamination levels are significantly lower in the sand/clay water-bearing zone than found in OU1 Source Areas. Groundwater contamination was not observed in the Groundwater Aquifer.

Slope Stability Evaluation

An assessment of the stability of the slope area below Pond 10 with respect to standing water levels in the pond was performed. The slope area below Pond 10 contains numerous recent surficial landslides adjacent to the Davis-Weber Canal. The purpose of this investigation focused on whether the surface water in Pond 10 contributes to slope instability. The slope stability analysis was performed with Pond 10 dry and Pond 10 filled to capacity to compare the stability of the slope. Analyses were performed with the pond empty and with the pond full, acting as an external load. The factor of safety calculated for the empty and full pond configurations were both 1.78. The external loading of Pond 10 filled to capacity does not affect the overall stability of the slope.

During the spring of 1998, a series of surficial landslides occurred on the hillside area of OU1. The landslides were significant enough to concern HAFB and the adjoining landowners as to the cause and potential extent of the landslides. As part of this investigation, an investigation was performed to determine the cause of the landslides. The results of this investigation indicate that the landsliding is the result of the oversteeping of the slope above the Davis-Weber Canal that occurred when the canal was relined and heavier than normal precipitation occurred during the winter and spring of 1998. The heavier than normal precipitation saturated surficial soils in the area. These factors combined to cause the landsliding. Groundwater from the Source Areas is not the cause of landsliding.

Source Area Remedial Action

The Source Area remedial action consists of two aspects: (1) construction of groundwater extraction trenches and integration of portions of the existing groundwater extraction system to treat contaminated groundwater and (2) the repair of the low-permeability caps. The planned groundwater extraction trench system consists of a series of four groundwater extraction trenches that will be used to extract shallow contaminated groundwater before it

flows to Non-Source Areas. Portions of the existing system will be incorporated into the extraction. The location of the Source Area remediation system is presented in Figure ES-3.

Extraction Trenches

Trench A is proposed to be located west of the CDPs through the center of the LNAPL area. The trench will be located parallel to a groundwater channel eroded into the Alpine Formation thorough the LNAPL area. The purpose of Trench A is to dewater the Provo Formation in this area by extracting contaminated groundwater. The trench will extract groundwater and LNAPLs. The trench will consist of 3 segments.

Trench B is proposed to be located east of the CDPs through the western end of Landfill 3. The trench will be located parallel to a groundwater channel eroded into the Alpine Formation in the Landfill 3 area. The purpose of Trench B is to dewater the Provo Formation by extracting contaminated groundwater from the area east of the main source of contamination at OU1, the CDPs and the FTA 1. The trench is not expected to extract LNAPLs. The trench will consist of a single segment.

Trench C is proposed to be located along the northern side of the CDPs, within the LNAPL area emanating from the CDPs. The purpose of the trench is to remove LNAPL from the CDP area. The trench is not located in a main groundwater flow channel. The trench will consist of a single segment.

Trench D is proposed to be located along the downgradient perimeter of the OU1 Source Areas, perpendicular to groundwater channels eroded into the Alpine Formation. The trench will collect groundwater from the main groundwater flow channels to the Off-Base and Western Plumes. The trench will also collect groundwater from the Alpine Formation. The purpose of the trench will be to limit flow to the Off-Base Plume, the Western Plume, and Springs U1-303 and U1-304. By limiting the flow of contamination to the plumes, the natural attenuation of contamination in the Off-Base and Western Plumes will be enhanced.

The existing Source Area dewatering system consists of a 1,500-foot-long dewatering trench located along the north side of Landfill 3 and the CDPs, seven dewatering wells, a slurry wall, and spring water extraction systems at Springs U1-303, U1-304, and U1-307. The dewatering trench and the three spring extraction systems were found to be effective in extracting groundwater and are recommended to be incorporated into the proposed extraction system. The spring extraction systems at Springs U1-303 and U1-304 are expected to cease to flow upon operation of the groundwater extraction trenches. The seven dewatering wells and the slurry wall were found to be ineffective remediation systems. The dewatering wells are recommended to be abandoned. The slurry wall will not be maintained.

The quantity of groundwater that may be extracted by the extraction system was estimated to determine potential flows into the proposed trench segments. This data will be used to determine the size of pumping, conveyance, and treatment systems. Contamination levels that may be extracted by the groundwater extraction system were estimated to evaluate the levels of contamination that will need to be treated by the treatment facility. The groundwater extracted will be treated at the HAFB IWTP or OU2 Air Stripper Treatment Plant (ASTP). The results of the evaluation indicated that the IWTP or the OU2 ASTP is

capable of treating the quantity and contamination concentrations in groundwater that may be extracted by the extraction trenches.

The soils excavated above the groundwater table along a majority of the trench alignments is expected to be uncontaminated. The only exception are the soils excavated along Trenches A and C in the area of the CDPs. Projected soil contamination levels were calculated for each trench. Pockets of significant soil contamination could be observed along any of the trench alignments. Contamination levels were calculated by identifying the soil samples obtained from exploration points along the segment alignment.

LNAPLs are projected to be extracted by Trenches A and C. An investigation was performed to evaluate the physical properties of the LNAPL and project the rate of extraction. Based on this evaluation, skimmer pumps are recommended to be used to extract the LNAPL from the trench sumps. The LNAPLs will be stored onsite until a sufficient quantity has been extracted and disposed of off-site. The groundwater extracted from Trenches A, B, and C will be passed through an oil/water separator prior to being treated at the IWTP or OU2 ASTP to remove any residual LNAPLs.

Landfill Cap Repair

The repair of the landfill cap consists of filling areas of differential settlement, grading the landfill cap to drain, repair of drainage surface courses within the landfill caps, construction of a new portion of the landfill cap over the CDP area, and repair of the cap areas where disturbed by construction of the groundwater extraction trenches. Gas vents are recommended to be repaired where disturbed by construction and a new vent system be constructed under the portions of the new cap. Fences are recommended to be constructed surrounding Landfill 3 and the LNAPL cap to limit future damage to the caps.

Non-Source Area Remedial Action

The Non-Source Area remedial action consists of two aspects: (1) monitored natural attenuation of groundwater contamination in the Off-Base and Western Groundwater Plumes and (2) the remediation of spring areas. The Non-Source Area comprises the Off-Base and Western Groundwater Plumes.

Natural Attenuation

An assessment of natural attenuation mechanisms and the potential for off-Base contamination to naturally attenuate were documented in the *Draft Remediation by Natural Attenuation Treatability Study for Operable Unit 1* (Parsons, 1998). This study documented that natural attenuation of contamination is occurring in the Off-Base Plume and modeled the rate of natural attenuation. The report focused on the off-Base areas, although conditions in the Western Plume are similar to conditions in the Off-Base Plume. Conclusions made for the Off-Base Plume are applicable to the Western Plume. Natural attenuation appears to be occurring without the removal of contaminated groundwater from OU1 Source Areas.

Monitoring wells were installed in the Off-Base and Western Plume areas to assess groundwater contamination levels in areas not previously monitored. The monitoring wells may be used for long-term monitoring of the groundwater contamination plume in these

areas. Twenty-six additional monitoring wells were installed in the Off-Base and Western Plume areas.

Spring Remediation Systems

As part of the remedial design for OU1, springs with contamination levels above Maximum Contaminant Levels and springs with significant quantities of arsenic in the soil will be remediated. Treatment of contaminated groundwater emanating from the springs is the preferred method to remediate groundwater. Soils with arsenic levels above background levels will be removed and disposed of offsite. The remediation of the springs will be performed during the second phase of the remedial design. The remediation is being deferred to allow the groundwater extraction trenches to operate and mitigate flow to the springs. Most of the springs that will require treatment of groundwater are located adjacent to Source Areas that will be dewatered by the extraction trenches. If the groundwater extraction trenches cause spring flow to cease, the design and construction of a treatment system will not be necessary. The removal of arsenic contaminated soils will also be deferred to determine if the Source Area groundwater extraction trenches cause spring flow to cease. Spring flows will continue to deposit arsenic until the flow is stopped or treated.

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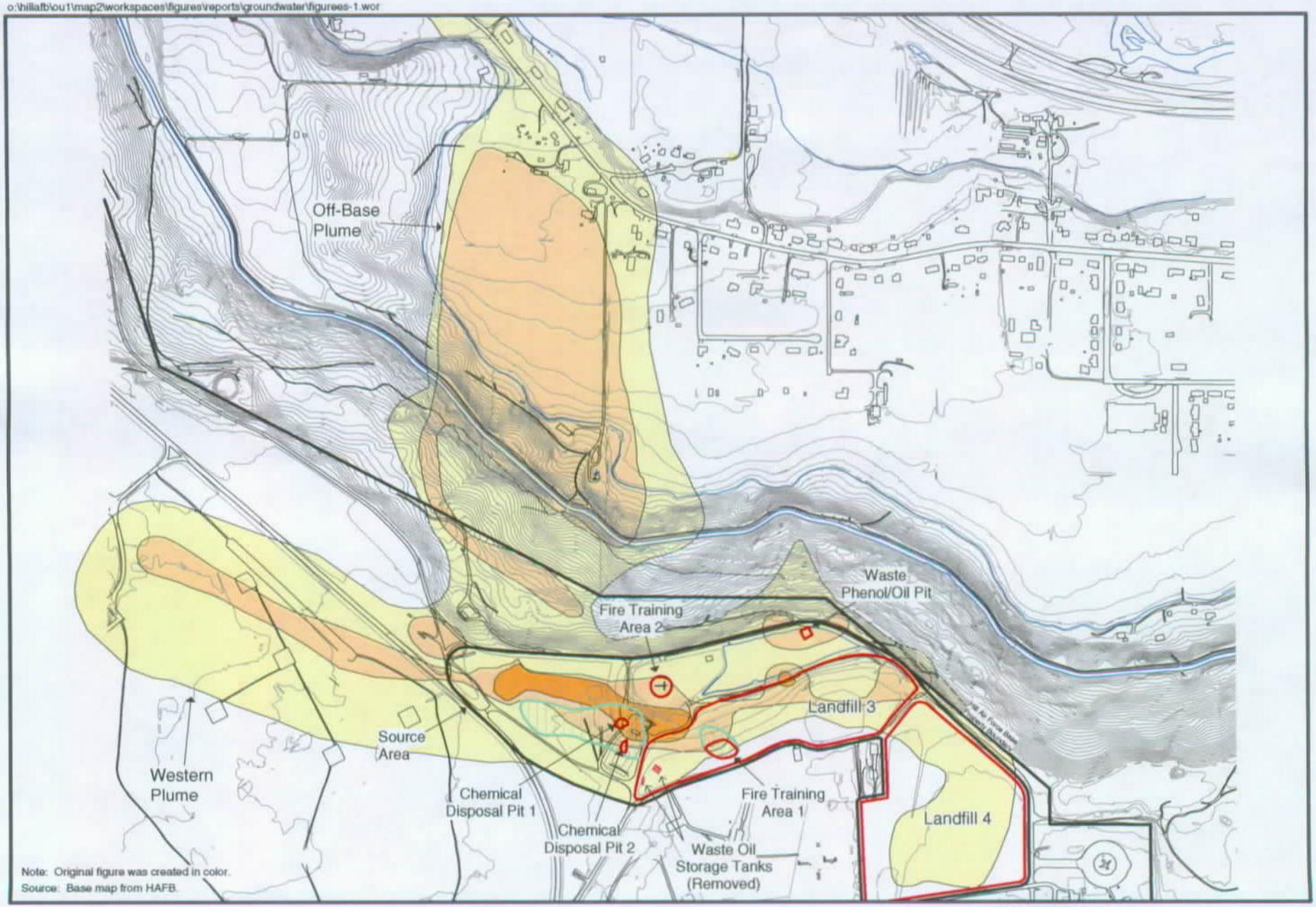

N

0 400 800

1 inch = 800 feet

LEGEND

- LNAPL Plume (1996)
- DCE Contamination, 0 - 70 ppb
- DCE Contamination, 70 - 1000 ppb
- DCE Contamination, greater than 1000 ppb

FIGURE ES-1
SOURCE AREA & NON-SOURCE AREA LOCATION MAP
OPERABLE UNIT 1
HILL AIR FORCE BASE, UTAH

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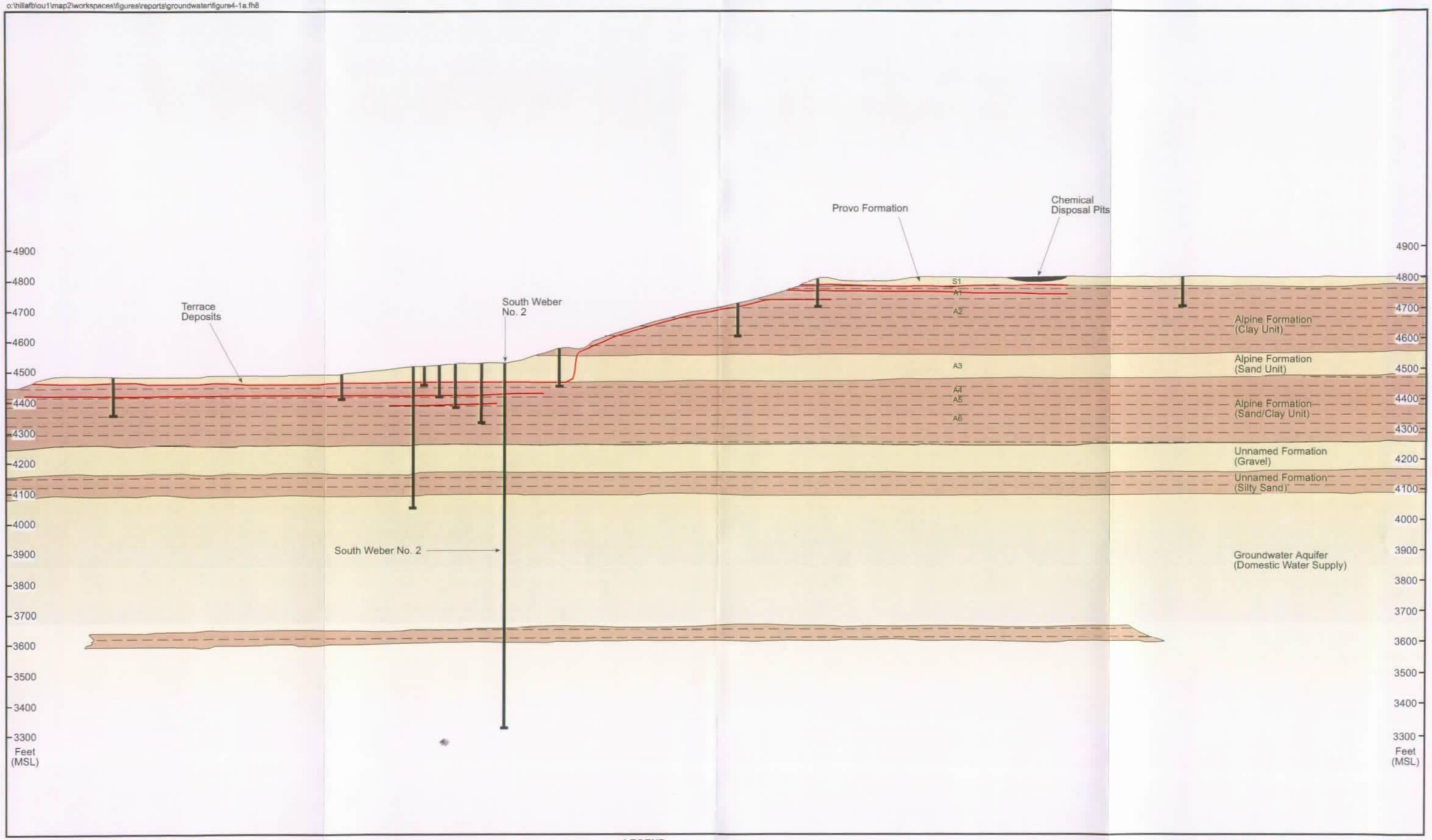

Notes:
1) Alpine Formation/Groundwater Aquifer contact can be extrapolated to domestic supply wells near the southeast corner of Hill Air Force Base.
2) Selected exploration points shown in the cross-section are the deepest exploration points in the area.
3) No vertical exaggeration.

LEGEND

- Fine-grained Materials
- Coarse-grained Materials
- Approximate Location of Groundwater Contamination
- Exploration Point

FIGURE ES-2
GENERALIZED GEOLOGIC CROSS-SECTION
OPERABLE UNIT 1
HILL AIR FORCE BASE, UTAH

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U1-309 Seep Collection and Piping to Remote Treatment Plant

U1-309

Off-Base Plume

U1-306 Seep Collection & Piping

U1-306

Existing Seep U1-307 Collection System

U1-307

U1-305 Seep Collection

New Extraction Trench

U1-305

Existing Extraction Trench

U1-318 Seep Collection & Piping

Existing Spring Collection Gallery

U1-304

U1-303

U1-204

Trench D

U1-203

U1-202

U1-318

U1-205

Trench A

Trench B

Trench C

Landfill 3

U1-301

Western Plume

U1-201

U1-318 Seep Collection & Piping

U1-206

U1-207

Hill Air Force Base Property Boundary

U1-209

U1-208

Landfill 4

N

0 300 600

1 inch = 600 feet

Explanation

- DCE Contamination, 0 - 70 ppb
- DCE Contamination, 70 - 1000 ppb
- DCE Contamination, greater than 1000 ppb
- Landfill Repair Area
- Spring/Seep
- Groundwater Extraction Sump/Well
- Proposed Groundwater Extraction Trench
- Existing Groundwater Extraction Trench

FIGURE ES-3
PROPOSED REMEDIATION SYSTEM LOCATION MAP
OPERABLE UNIT 1
HILL AIR FORCE BASE, UTAH