# Executive Summary

## Introduction

This report presents the results of the Operable Unit 1 (OU1) Landfills 3 and 4 Summary Investigation. Operable Unit 1 is located at Hill Air Force Base (HAFB), Utah. The purpose of the investigation is to assess the nature and extent of debris and contamination within Landfills 3 and 4. The investigation was divided into two phases: Phase I was conducted from February to May 1997; and Phase II was conducted from June to October 1997. 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:

1. Estimate the volume of waste in the landfills.
2. Determine the vertical and horizontal gradients below the landfills.
3. Evaluate the physical properties and continuity of the clay materials below the landfills.
4. Assess contaminants in soils, leachate, and groundwater below the landfill debris.
5. Evaluate the Landfill 3 magnetic anomaly areas.
6. Compare the OU1 leachate and groundwater with other military and municipal landfills across the country.
7. Reevaluate cost assumptions associated with the feasibility study alternative for landfill removal.

## Scope of Work

To accomplish these objectives, a field inspection, file and aerial photograph analysis, geophysical analysis, cone penetration testing, excavation of shallow soil borings, installation of monitoring wells, and excavation of exploratory trenches was performed. Sixty-two CPT exploration points were driven to depths ranging from 8 to 94 feet, 14 shallow soil borings were excavated to depths ranging from 24 to 45 feet, nine monitoring wells and 4 piezometers were installed to depths ranging from 29 to 84 feet, and 6 exploratory trenches were excavated.

## Landfills 3 and 4 History

**Landfill 3.** Landfill 3 is located in the northeast corner of HAFB and is considered part of HAFB OU1. The landfill was in operation from the early 1940s to the mid 1970s and

accepted residential and industrial wastes from HAFB. The landfill area was originally a gravel pit excavated to provide sand and gravel materials for runway and building construction projects on the Base. Wastes deposited in the landfill were burned until the mid-1960s. Additional materials placed in Landfill 3 after the mid-1960s were mainly construction debris. The bottom of Landfill 3 is unlined. A low-permeability cap was constructed over the surface of the landfill in 1985 to limit infiltration of surface water. Another OU1 source area, Fire Training Area 1, is located in the southwest portion of Landfill 3.

**Landfill 4.** Landfill 4 is also located in the northeast corner of HAFB, south of Landfill 3, and is considered part of HAFB OU1. 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, when disposal of HAFB solid waste was contracted with the Davis County Landfill. The landfill received solid waste, including scrap metal; construction debris; domestic refuse; industrial refuse; small amounts of industrial waste consisting of sludge from the IWTP drying beds, sulfuric acid, chromic acid, phenol, and methyl ethyl ketone. The landfill contained 12 parallel landfill trenches and one pit, oriented north-south, approximately 15 to 30 feet deep and 20 to 40 feet wide. A low-permeability cap was constructed over the surface of the landfill in 1985 to limit infiltration of surface water.

# Landfill Area

Landfill 3 was found to be considerably larger than was identified in the *Comprehensive RI*. This is mainly due to a redefinition of the landfill area, which is based on the method of landfilling. Landfill 3 was a "dump and burn" type landfill. In the *Comprehensive RI*, the eastern portion of Landfill 3 had been designated as Landfill 4, although the method of landfilling was similar to landfilling methods performed in the adjacent areas of Landfill 3. The areas of debris were continuous throughout the area; therefore, the area was designated as Landfill 3. Landfill 4 is considered the "trench and cover" landfill, southeast of Landfill 3. The aerial extent of the landfill was evaluated by a visual inspection, aerial photograph interpretation, Electromagnetic Induction Survey (EMI), Cone Penetration Test (CPT) and soil boring exploration, and exploratory trenching. The limits and depth of the landfill debris were evaluated using these exploration techniques.

# Geology and Hydrogeology

## Geology

The sequence of materials in the landfills consists of the landfill cap, landfill cover, and landfill debris overlying the Provo Formation. The Alpine Formation underlies the Provo Formation and consists mainly of clay materials. The landfill debris in Landfill 3 varies significantly based on the time period of the landfilling. The older landfill debris found in the western and central portions of the landfill consists of sandy cover materials and ash mixed with metals debris. The debris has been thoroughly burned. The eastern portions of the landfill consist mainly of unburned, construction debris such as asphalt and concrete. The debris in Landfill 4 consists mainly of residential and industrial wastes mixed

with sandy cover materials. The underlying Provo Formation is composed of medium- to coarse-grained sands and gravels. The Alpine Formation underlies the Provo Formation and is composed mainly of silty clay with fine-grained sand interbeds. The top of the Alpine Formation is approximately 25 to 35 feet bgs. The landfill debris was deposited within the Provo Formation.

## Hydrogeology

Three different shallow water-bearing zones were identified immediately beneath Landfills 3 and 4. Deeper water-bearing zones do exist beneath the landfills, including drinking water aquifers. However, because of the depth of the water-bearing zones and the numerous low-permeability layers between the contaminated water-bearing zones and drinking water aquifer, it is unlikely that lower water-bearing zones and drinking water aquifers are affected by contamination from the landfills. The 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, and within the lower clay unit of the Alpine Formation, approximately 70 to 90 feet bgs. Monitoring wells and piezometers were installed in each water-bearing unit to evaluate groundwater elevations and contamination levels. The water-bearing zone in the Provo formation is unconfined, the water-bearing zone in the upper clay unit of the Alpine Formation is partially confined, and the water-bearing zone in the lower clay unit of the Alpine Formation is confined.

A considerable permeability difference exists between the two formations. 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 Provo Formation water-bearing zone. Based on horizontal gradients maps, the water-bearing zone in the upper clay unit of the Alpine Formation appears to be connected to the water-bearing zone of the Provo Formation. The lower clay unit of the Alpine Formation does not appear to be connected to the other water-bearing zones. Vertical groundwater gradients were also calculated for the water-bearing zones, and a minor downward gradient exists between the water-bearing zones.

## Continuity of Clay Materials Under the Landfills

The top of the Alpine Formation was mapped to evaluate the continuity of the clay materials. Fifty-eight exploration points out of a total of 96 exploration points were excavated to the Alpine Formation. The exploration points that were not excavated to the Alpine Formation meet refusal in the Provo Formation gravels or in landfill debris. Based on the number of exploration points that penetrated the clay surface, clay materials of the Alpine Formation appear to be continuous under Landfills 3 and 4. 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 $2.8 \times 10^{-7}$ cm/sec to $8.8 \times 10^{-8}$ cm/sec.

# Assessment of Landfill Contamination

The investigation evaluated contamination associated with the landfill by collecting soil and groundwater samples for analytical testing. The results of the testing provided an indication of the type of chemical contamination in landfill soils and groundwater underlying the landfills. The following section summarizes the leachate, groundwater, and soil contamination found underlying the landfills.

## Leachate Assessment

Leachate was not identified under Landfills 3 and 4. The soil materials under the landfill areas are comprised of medium- to coarse-grained sands and gravels. Because of the permeability of these materials, any leachate flowing out of the landfills would flow to the water-bearing zone along the Provo/Alpine Formation and dissolve into the groundwater and be considered groundwater contamination.

## Groundwater Contamination

Groundwater contamination underlying Landfill 3 was mapped on the basis of the three water-bearing zones identified below the landfills. The shallow, unconfined 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. A very limited amount of groundwater contamination was observed in the lower clay unit of the Alpine Formation underlying Landfill 3. The groundwater contamination consisted of 1,2-Dichloroethane and 2,4-DB, a herbicide, at very low concentrations in Monitoring Well U1-170. The detection of 1,2-Dichloroethane is slightly above detection limits and the detection of 2,4-DB is estimated. This groundwater should be sampled in the future to verify the contamination found in the monitoring well.

It is unknown how much the contents of Landfill 3 contribute to groundwater contamination in the area. Based on the results of soil sampling of landfill debris, visual inspection of landfill debris, the method of landfilling ("dump and burn"), field monitoring of soils using an OVM during exploration, and the type of groundwater contamination, Landfill 3 is not the main source of groundwater contamination in this area. The source of groundwater contamination is the Chemical Disposal Pits and Fire Training Area 1. Landfill 4 is upgradient of other OU1 source areas. Soils within the landfill appear to be the source of groundwater contamination underlying Landfill 4.

## Soil Contamination

**Landfill 3.** The majority of the soil contamination observed underlying Landfill 3 was found in soils below the groundwater table. Contaminated groundwater from the upgradient Chemical Disposal Pits 1 and 2 and Fire Training Area 1 is probably the source of this contamination. The general lack of contamination is in conformance with the burning of

landfill debris. Metals, PCBs, and pesticides were also found in the soils. With the exception of some metals, the concentrations of these compounds are very low.

**Landfill 4.** Based on the results of this investigation, soil contamination exists within soils underlying Landfill 4. Significant detections of VOCs, SVOCs, PCBs, and metals were observed in soils underlying the landfill. These contaminants are not found in the groundwater. Most of the soil contaminants are bound to the soil and relatively immobile. The migration of these contaminants to the groundwater may be limited by the landfill cap, which minimizes surface water infiltration and mobilization of the contamination.

## Evaluation of Magnetic Anomalies

Two EMI surveys have been conducted on the landfill areas of OU1 to identify the presence of buried metal debris. The primary reason for these surveys was to attempt to locate a suspected, buried drum storage area within Landfill 3. Both surveys revealed significant magnetic anomalies within the Landfill 3 area. Exploratory trenches were excavated to evaluate the nature of the anomalies and determine whether buried drums were causing the anomalies. Based on landfill debris observed during the exploratory trenching, the EMI survey was able to identify high concentrations of metal debris. The most common cause of the anomalies appearing in the survey was miscellaneous industrial and demolition waste, such as pipes, scrap metal, car parts, cans, landing mats, and metal strapping. Some of the anomalies suspected of being metallic were actually large quantities of reinforced concrete. Drum disposal areas were not encountered.

## Leachate and Groundwater Contamination Comparison

An evaluation of leachate and groundwater contamination from other military and municipal landfills was performed so a comparison of the leachate and groundwater contamination associated with Landfills 3 and 4 could be made. A leachate comparison could not be made because leachate was not observed at Landfill 3 and 4. The landfills used for the comparison consisted of local municipal landfills (Weber County Landfill and Logan City Sanitary Landfill in Utah), other military landfills (Camp Allen Landfill, the CD Landfill at Norfolk Naval Base, and the Landfill associated with OUD at McClellan Air Force Base), and industrial landfills (OII Municipal Landfill Superfund Site, Los Angeles, California). A proprietary database of approximately 115 public, private, and unpublished sources was also used for the comparison. The data in the proprietary database was averaged and provided a good estimate of typical contamination conditions.

With the exception of arsenic and barium, the residual chemical constituents found in the OU1 groundwater were within the range of contaminants found in the groundwater from other military and municipal landfills. The results of the comparison indicate that there are no apparent anomalies in the OU1 data, either qualitative or quantitative, with respect to the other facilities and databases included in this analysis. The mean concentrations of two metals, arsenic and barium, detected in groundwater at OU1 were slightly higher in concentration than the other landfills. This is the result of chemically reducing conditions (low-dissolved oxygen, low-redox potential) in OU1 groundwater under the landfills. The reducing conditions tend to dissolve naturally occurring metals compounds.

# Landfill Removal Cost Reevaluation

The cost of the Feasibility Study (FS) Source Area Alternative 7 was reevaluated using data generated as part of this investigation. Source Area Alternative 7 includes excavation, treatment, and offsite disposal of the landfill contents. The alternative also includes many of the remediation systems included as part of other alternatives. Cost estimate revisions are based on the revised estimate of the volume and contamination levels in the landfill debris.

The approach to the reevaluation of the cost estimate for FS Source Area Alternative 7 was to identify the line items in the cost estimate that could be recalculated using the data from this investigation. The line items in the cost estimate that were modified were concerned with the excavation, treatment, and disposal of landfill debris. The cost for other line items, such as groundwater extraction systems and operation and maintenance, were not changed. In order to make a meaningful comparison, the unit costs included in the cost estimate were not changed.

The results of the reevaluation indicate the cost estimate is 6 percent less than estimated in the FS. The cost difference is mainly due to the more accurate estimate of the aerial extent and depth of the landfill debris based on exploration performed as part of this investigation. The amount of contaminated materials was found to be less than estimated in the FS because the landfill materials were found to be less contaminated.