EXECUTIVE SUMMARY

INTRODUCTION

The Department of Defense (DOD) is conducting a nationwide program to evaluate waste disposal practices on DOD property, to control the migration of hazardous contaminants, and to control hazards that may result from these waste disposal practices. Developed in 1980, the Installation Restoration Program (IRP) consists of four phases: Phase I, Initial Assessment/Record Search; Phase II, Problem Confirmation/Quantification; Phase III, Technology Base Development; and Phase IV, Remedial Actions.

The United States Air Force (USAF) initiated a Phase I IRP investigation of 13 sites at Hill Air Force Base (AFB) near Ogden, Utah in 1981.. Phase II Stage 1 was conducted by UBTL, Inc. and Radian Corporation from 1982 to 1984. The most recent investigation, Phase II Stage 2 Field Evaluation, has been performed by Radian Corporation and Science Applications International Corporation (SAIC), under contract to the U.S. Air Force Occupational and Environmental Health Laboratory (USAFOEHL). The work was performed under USAF Contract No. F33615-85-D-4509, Delivery Order 0004. Field activities were performed from April 1986 to February 1987.

PURPOSE AND SCOPE OF THE PHASE II STAGE 2 INVESTIGATION

The purpose of the IRP Phase II Stage 2 investigation at Hill AFB was to determine: (1) the presence or absence of contamination within the specified area of the field survey; (2) if contamination exists, the potential for migration in the various environmental media; (3) the extent and magnitude of contamination on Hill AFB property; (4) significant potential public health and environmental hazards of migrating contaminants based on state or federal standards for these contaminants; and (5) remedial action alternatives to mitigate observed contamination problems. For the sites in this program that were not previously studied under the Phase II Stage 1 investigation, the principal purpose was to define, by qualitative means, the presence or absence of contamination.

ENVIRONMENTAL SETTING

Hill AFB is located in northern Utah approximately 25 miles north of Salt Lake City and approximately 5 miles south of Ogden (Figure ES-1). Most of the base's approximately 6,700 acres are within Davis County with a small portion in Weber County. The base is situated just west of the Wasatch Mountain Range on the relic Weber Delta. The delta consists of broad plains and terraces extending from the shore of the Great Salt Lake eastward to the base of the Wasatch Range. The northern and eastern perimeters of the base are marked by the Davis-Weber Canal, a privately-owned irrigation canal. The western boundary of the base is formed by Interstate 15, while the southern boundary coincides with State Route 193. The geographic setting of Hill AFB is shown in Figure ES-2.

Topographically, Hill AFB is on a plateau formed by the Weber Delta approximately 300 feet above the valley floor. The Weber Delta, located immediately west of the Wasatch Range, slopes in a westerly direction toward the Great Salt Lake. Raised areas, such as the terrace on which Hill AFB is located, are generally level and exhibit slight to moderate relief where dissected by erosion. Surface elevations at Hill AFB vary from a low of approximately 4,600 feet above mean sea level (MSL) along the western installation boundary to 5,045 feet above MSL toward the installation's eastern boundary.

The surface drainage on Hill AFB is toward three off-base drainage systems: Kays Creek, Fife Ditch and the major base areas toward the Davis-Weber Canal. Installation land areas drain by overland flow to dry swales, terminating at the off-base water courses, or simply by infiltration into surface soils. The water is then used for irrigation purposes or flows westward into the Great Salt Lake.

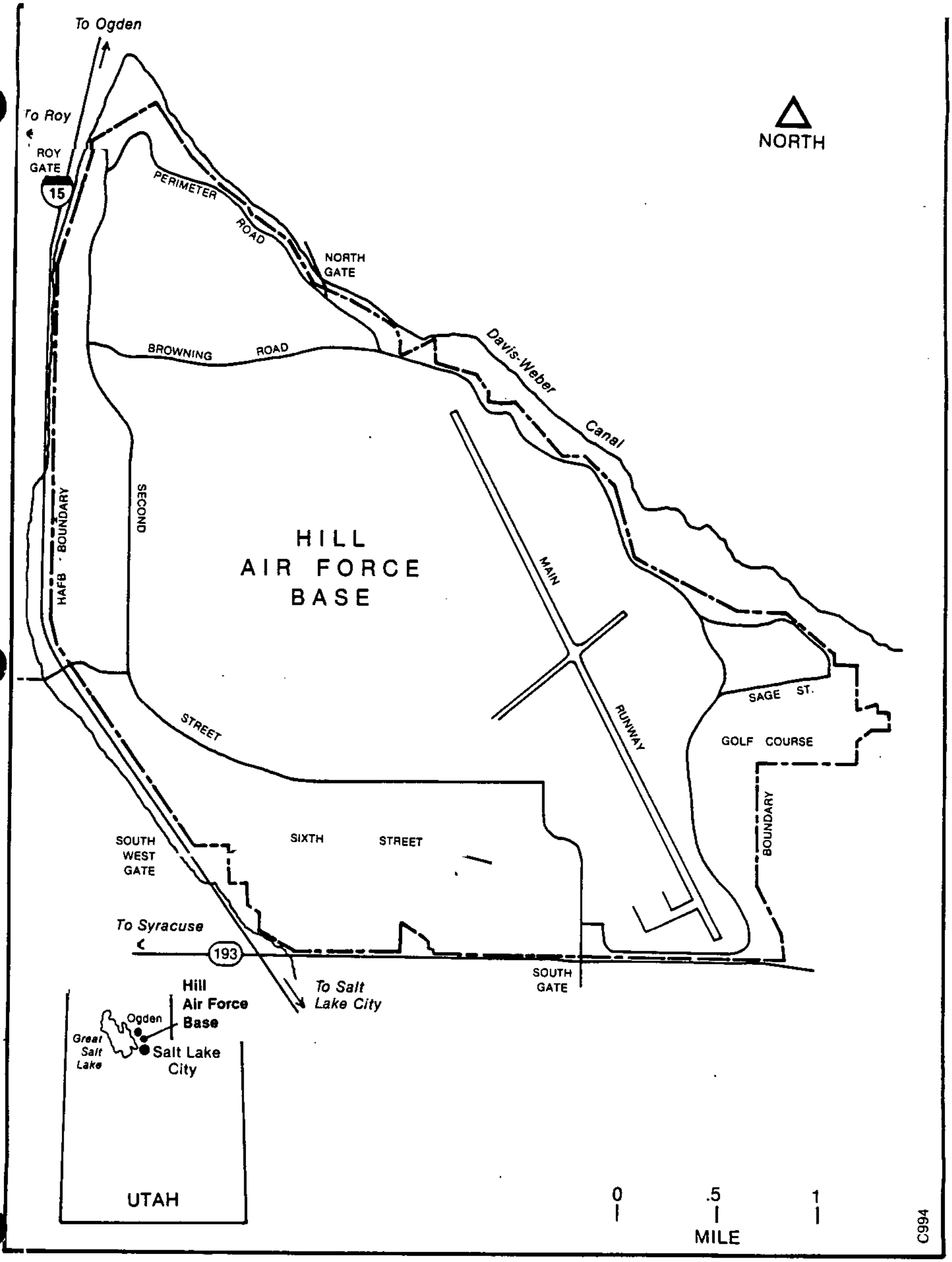

Figure ES-1. Location of Hill AFB, Utah

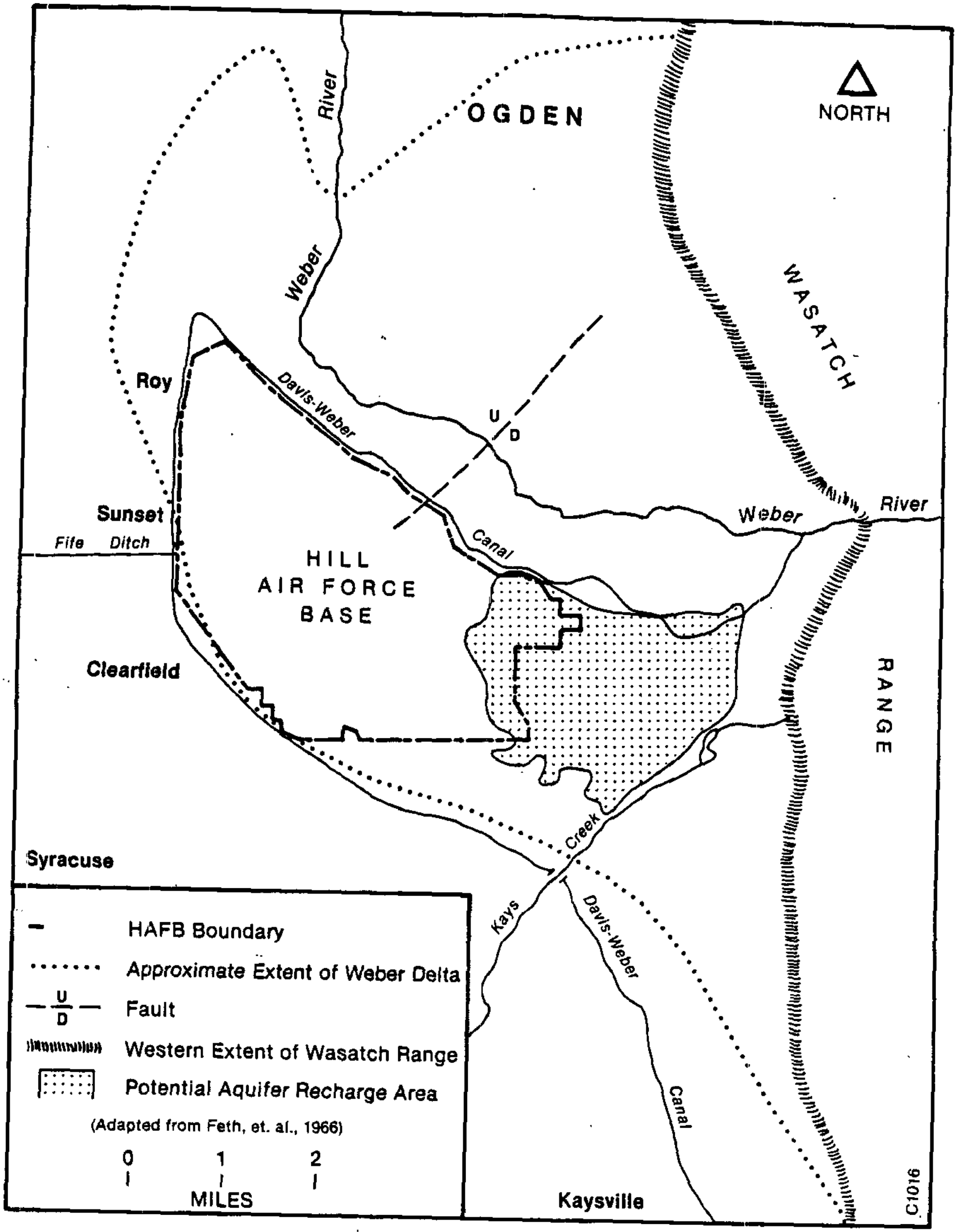

Figure ES-2. Hill AFB Geographical Setting

The geologic materials in the Hill AFB area consist of unconsolidated silts, clays, gravels and sands which are deposited in a complex basin system formed by the block faulting of older consolidated units. The development and eventual disappearance of glacial Lake Bonneville during Pleistocene time resulted in the deposition of the major Quaternary geologic units and the geomorphologic features in the area, such as the Weber Delta (Engineering-Science, 1982).

Hill AFB is located in the Weber Delta District (approximately 140 square miles) and is situated on the southwestern part of the ancient Weber Delta, the largest of the Pleistocene age deltas associated with Lake Bonneville (Feth, et al., 1966). The Weber Delta formed as the Weber River flowed into Lake Bonneville, a much larger ancestor to the present Great Salt Lake. The deltaic sediments alternate between fine and coarse materials which were eroded from the Wasatch Mountains. The gravels consist of pebbles of quartzite, chert, gneiss, limestone, and volcanic rock. Finer sediments consist of silt and clay (Morse, 1976).

Few significant structural discontinuities are known in the study area. The major discontinuities in geologic units are the Wasatch Fault, east of the base, an inferred fault extending from the main instrument runway at the base to the northeast, and a few folds in Pleistocene unconsolidated deposits (Feth, et al., 1966). The Wasatch Fault extends along the western margin of the Wasatch Range, forming the boundary between the Basin and Range Physiographic Province in which the installation is situated, and along the Rocky Mountains to the east. The Wasatch Fault is probably not a single break, but rather a wide zone of breakage and slippage more than one mile wide and over 150 miles long.

Hill AFB lies within the limits of the Weber Delta groundwater district (Feth, et al., 1966). Groundwater occurs in the unconsolidated alluvial materials that were deposited in the downfaulted basins of the region. Major sources of groundwater consist of westward subsurface flow from the Wasatch

Range, direct infiltration of precipitation, and seepage from streams and irrigated areas. Groundwater generally flows from the recharge areas of the Wasatch Range to the west (Engineering-Science, 1982). Recharge areas of concern to this study are shown in Figure ES-2.

The Delta Aquifer is the principal source of groundwater in the area. This highly permeable artesian aquifer is located about 500 to 700 feet below the surface throughout much of the area and varies from about 50 to over 150 feet in thickness. Minor aquifers include the Sunset Aquifer and shallow aquifers underlying the areas of Roy and Syracuse (Figure ES-2), northwest and southwest of Hill AFB, respectively. The artesian Sunset Aquifer generally lies 250 to 400 feet below the surface and varies from 50 to 200 feet thick. Water quality is similar to that of the Delta Aquifer, but permeability is considerably lower (Feth, et al., 1966). Groundwater in the shallow unnamed aquifers is more highly mineralized than in the Delta and Sunset Aquifers.

Perched water tables occur locally in the study area because of the presence of near-surface clay layers at shallow depths. These clay layers impede the downward migration of infiltrating precipitation, which then flows downdip along the clay surface, emerging as springs where the clay intersects the land surface. Most springs flow following periods of precipitation and cease to flow entirely during dry periods (Engineering-Science, 1982).

Hill AFB currently obtains most of its potable water from base wells and purchases the remainder from the Weber Basin Water Conservancy District. All Hill AFB wells produce water from the Delta Aquifer. Base wells now in service range in depth from 627 feet to 900 feet. Static water levels range from 418 to 515 feet below land surface. The quality of water derived from the base wells is generally good, with the exception of high iron content in wells 4 and 5 (Engineering-Science, 1982).

SITE DESCRIPTIONS

The 18 sites evaluated in IRP Phase II Stage 2 included spill areas, landfills, evaporation pits, and a variety of other sites. Fourteen of the sites are located on base as depicted on Figure ES-3. Three of the remaining sites are located at the Little Mountain Sludge Drying Beds and Utah Test and Training Range (UTTR) and are shown on Figure ES-4. Site 14 is the Base Golf Course. This is not a hazardous waste site, but is irrigated and was evaluated only to determine its influence on local groundwater conditions.

Sites from the Phase II Stage 1 study were included in the Phase II Stage 2 investigation to further quantify contamination confirmed in Stage 1. Site operation and history are summarized briefly below.

Site 1, Landfill 4

Hill AFB operated Landfill 4 as a sanitary landfill from 1967 to 1973. From about 1970 to 1973, the landfill received domestic refuse, industrial waste consisting of small amounts of sludge from the IWTP drying beds, and small quantities of chemicals including sulfuric acid, chromic acid, and methyl ethyl ketone (MEK).

Investigations during the Phase II Stage 2 investigation indicate that the clay beneath Landfill 4 area occurs in multiple distinct layers with varible thicknesses. This creates a complex hydraulic connection between the water table and the deeper groundwater beneath the clay.

During an interim remedial action program initiated by the base in late 1984, independent of the IRP, a contractor placed a slurry trench wall on the upgradient side of Landfill 4. The interim remedial action included installing seven dewatering wells inside the slurry trench wall. A dewatering trench, two pump stations, and an on-site water treatment plant were also constructed to lower static water levels below the refuse and are currently operating. A soil/bentonite cap was placed over Landfill 4 to reduce infiltration. An off-base collection gallery was installed to prevent contaminated water from leaving the base.

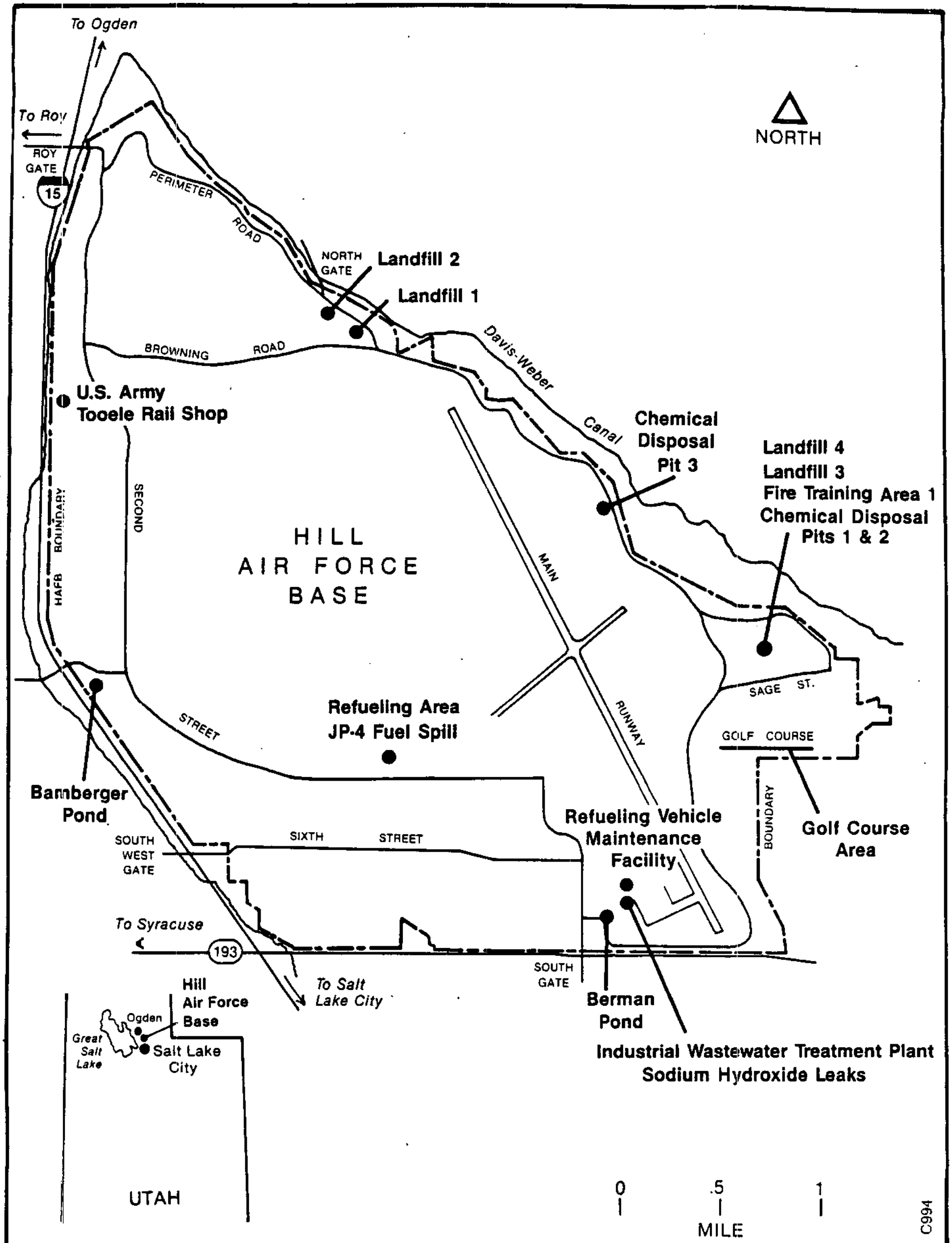

Figure ES-3. General Locations of On-Base IRP Phase II Stage 2 Sites, Hill AFB, Utah

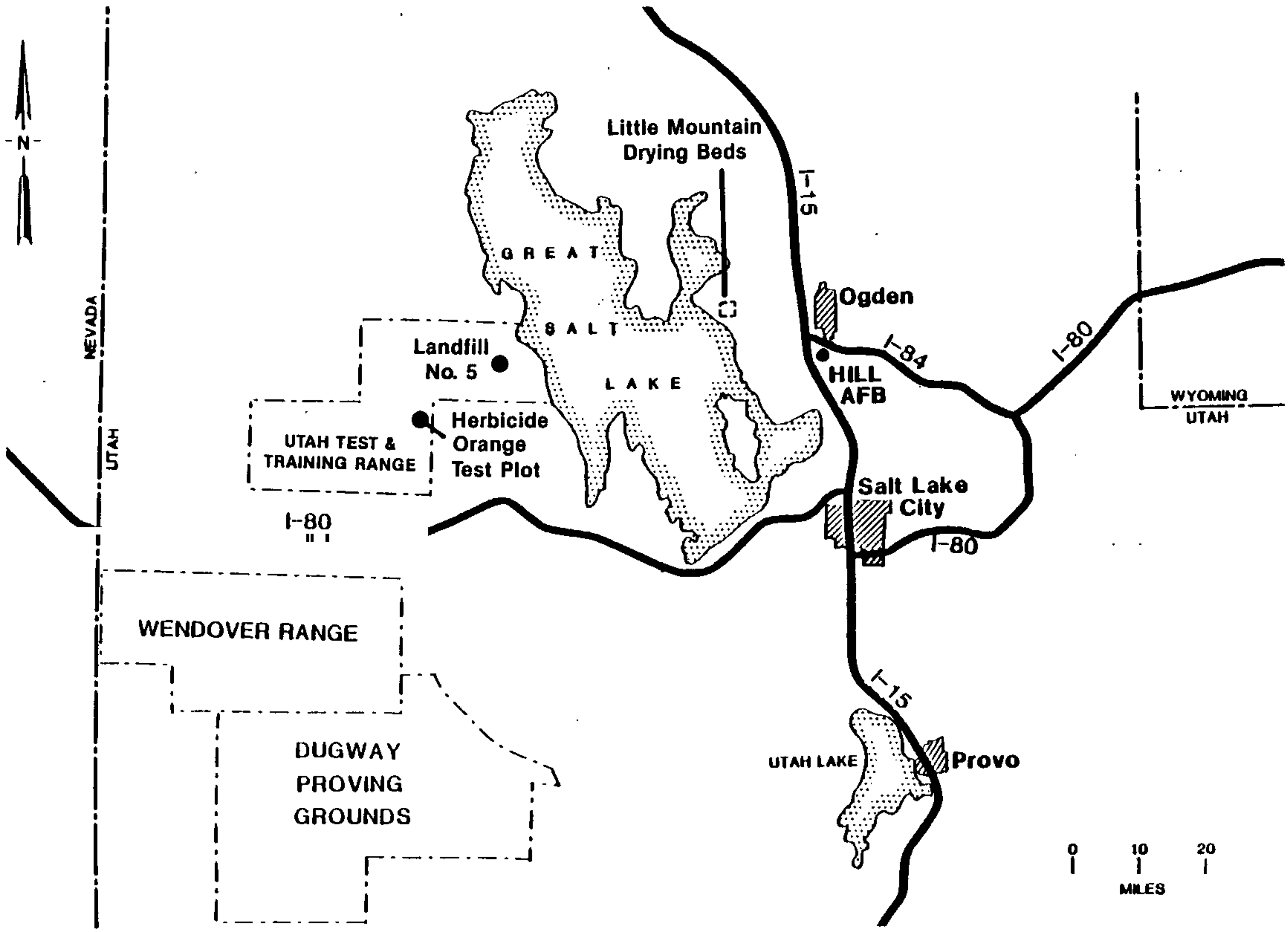

Figure ES-4. General Locations of Off-Base Sites For IRP Phase II Stage 2 Studies, Hill AFB, Utah

Site 2, Chemical Disposal Pits 1 and 2

Chemical Disposal Pits 1 and 2 were for disposal of liquid wastes (principally petroleum hydrocarbons and spent solvents) from 1954 to 1973. According to the Phase I Report, liquids were burned periodically, but an unknown quantity of liquids percolated into the underlying sediments. The slurry trench wall emplaced for Landfill 4 in 1984 also encompasses the Chemical Disposal Pits. A clay cap system was completed in 1986.

Site 3, Landfill 3

Landfill 3 operated from 1947 through 1967 for general refuse disposal. Large quantities of waste solvents, bottoms from solvent cleaning operations, and sludge from the IWTP were disposed of and burned in this landfill from 1970 to 1973. Concern over burial of large quantities of drums were discussed at the Phase II Stage 2 presurvey meeting. In late 1984, Landfill 3 was enclosed on the south side with a slurry trench wall as part of base interim remedial activities. A soil/bentonite cap was emplaced on Landfill 3 in 1986. As mentioned in the description of Site 1, Landfill 4, the clay beneath the Landfill 4 area--including Landfill 3--occurs in multiple distinct layers with variable thicknesses.

Site 4, Sodium Hydroxide Leaks

Two 12,000-gallon underground storage tanks are used to hold sodium hydroxide (NaOH) at the IWTP. A leak occurred over a 12-month period around 1980 in which an estimated 150,000 gallons of the caustic solution escaped. The leak occurred during the upgrading of the treatment plant. Since the plant continued transitional operation during the upgrade, the leak was not detected until completion of the upgrade. Slotted (PVC) casing was installed in boreholes in the leak area by the base civil engineers to collect the sodium hydroxide. A second leak occurred in 1984 from about April to June which released about 132,000 gallons of caustic solutions to the subsurface.

Site 5, Berman Pond

Berman Pond was used as an unlined evaporation pond for industrial wastewater, including electroplating wastes, from 1940 to 1956. The site was later filled with construction rubble and regraded. A clay cap and parking lot were constructed over the site during 1985.

Site 6, Industrial Wastewater Treatment Plant Sludge Drying Beds

The IWTP, built in 1956, pretreats all industrial wastewater on base prior to discharge to the North Davis Sewer District Treatment Plant. The plant receives wastewater from paint stripping, degreasing, and metal plating facilities. From 1961 to 1976, sludge from the IWTP was held in the unlined drying beds. In 1976, the previously unlined sludge drying beds were modified and converted to a concrete bed structure in which the sludge drying filtrate could be recirculated back to the treatment plant. In 1987, sludge drying facilities were completed to comply with the RCRA ban on landfilling liquid waste and waste reduction requirements.

Site 7, Chemical Disposal Pit 3

Chemical Disposal Pit 3 was used from 1967 to 1975 for disposal of large quantities of trichloroethylene (TCE), bottoms from the solvents recovery unit, and vapor degreasers. The Phase I report indicated that the area also received bottoms from plating operations during the 1940s. The IRP Phase II Stage 1 study resulted in detection of chlorinated solvents and metals in groundwater beneath the site. Samples from an upgradient test well also contained solvents, suggesting another contaminant source.

Site 8, Little Mountain Drying Beds

The Little Mountain site consists of two shallow unlined pits originally used for disposal of clarifier sludge from raw water treatment of river water. The sludge beds were no longer used when water treatment stopped. For several years during the mid-1970s, the site received phenolic paint strippers from Hill AFB.

Site 9, Fire Training Area 1

Hill AFB used this site from 1958 to 1973 as a practice area for extinguishing simulated aircraft fires. During these training exercises, large quantities of oil and combustible waste chemicals were poured into a dirt pit surrounded by an earthen dike and then were ignited. The Phase I report indicates that most of the chemicals burned during the exercises, although some chemicals probably infiltrated into the soil. Fire Training Area 1 was deactivated and a newer training facility was built with a concrete pit and apron. The base paved over the Fire Training Area 1 site in 1986, as part of interim remediation activities for this and adjacent waste sites.

Site 10, Landfill 5

Hill AFB operated Landfill 5 as a hazardous waste landfill and a drum storage area. This area is located at the Utah Test and Training Range (UTTR) and is regulated under the Utah Hazardous Waste Management Regulation (UHWMR). The facility was permitted to receive and manage reactive wastes (D003), EP toxic wastes (D006), solvents (F001-F005), and electroplating wastes (F006, F008). Wastes which have been sent to the landfill include: beryllium-contaminated wastes, waste sludges, drums of spent solvents (TCE, methanol, MEK, trichloroethane), paint containers, pesticides, and asbestos. The landfill operations stopped 17 January 1983 in response to changing RCRA regulations. Landfill 5 is currently in an interim closure status.

Site 11, Landfill 2

Landfill 2 operated from 1963 to 1965 as a solid waste management facility. This site is located on the side of a hill, and the solid waste was dumped down the hill and periodically burned. The waste was general refuse; there are no records of industrial or hazardous waste disposal at this site. The inactive site was covered over with local soil and native grasses.

Site 12, Landfill 1

Landfill 1 operated as a hillside dump with a daily burning operation. The base used the landfill from 1955 until 1967 when waste burning on the base ended. The Phase I records search indicated that the base disposed of little, if any, chemical waste within this landfill during its period of operation. However, individuals interviewed during the records search reported that this general area was also the site of solid waste disposal from the old Ogden Arsenal. This waste may have included waste oils and solvents from their vehicle maintenance facility. Former Ogden Arsenal employees reportedly remembered a daily burn operation.

Site 13, Herbicide Orange Test Plot

In 1973, the U.S. Air Force conducted tests at the UTTR to evaluate the biodegradation of herbicide orange. Also in 1973, the Air Force performed a separate test at the UTTR to evaluate the corrosion rate of coated steel herbicide containers.

To evaluate biodegradation technicians applied herbicide orange at six test plots, each 10 feet by 15 feet. The herbicide was placed into several 6-inch wide furrows at each plot for testing. Application rates varied between 1,000 and 4,000 pounds per acre (equivalent to about 35 pounds over the entire area).

The corrosion testing involved digging six trenches--each 50 feet long, 10 feet wide and 5 feet deep. Lids from the drums were weighed and buried in the trenches along with 60 empty drums. Two trenches were backfilled with fly ash, two with soil, and two with dried sewage sludge to evaluate corrosion potential. The metal lids were then periodically removed and weighed to evaluate the amount of corrosion that occurred.

Site 14, Golf Course

The base golf course is located about 50 to 90 feet higher topographically than the base disposal areas (Landfill 3, 4, and Chemical Disposal Pits 1 and 2). The golf course is not a waste disposal area; however, since it is irrigated, this site was investigated to determine if hydraulic connection exists between the golf course and the topographically lower disposal areas. If a hydraulic connection does exist, the irrigation water could impact flow conditions near the waste sites resulting in increased leachate generation, and secondarily could recharge the aquifers beneath the base.

Site 15. Refueling Area JP-4 Fuel Spill (Building 914)

This site, located near Building 914, contains four 25,000-gallon underground JP-4 tanks. The tanks are paired for two fuel distribution systems (Nos. 39 and 40) which were installed in 1973. About 27,000 gallons of JP-4 overflowed from a tank at the No. 39 distribution system on 10 January 1985. Other undocumented spills may have occurred in the past.

Site 16, Bamberger Pond

Bamberger Pond is a storm runoff holding pond which is presently divided into two long holding basins. The unlined basins are excavated into sandy soil and are hydraulically connected with a culvert drain. A discharge gate is available to release storm water off base. Base vehicle maintenance facilities and wash racks were formerly located nearby, and runoff from these activities also drained into Bamberger Pond.

Site 17, U.S. Army Tooele Rail Shop

This site, located at Building 1701, is used to service and repair railroad engines for the military. The facility has been in existence for more than 20 years. An open area outside of the building is used for cleaning large train parts.

Prior to about 1979, runoff from steam cleaning engine parts went into a ground grate to drainage lines. The cleaning water then collected in a nearby underground oil/water separator. The water was then discharged into the North Davis County storm sewer while the waste was hauled to the IWTP. The wash rinse contained a sodium cyanide solution used for alkaline stripping of the rail engine parts. The cleaning facility was modernized with a new concrete pad, rinse tanks, sump and drainage system in about 1979. The old separator was filled with soil and is no longer in use. The runoff from cleaning operations now collects in a new oil/water separator and the water flows into an off-base sanitary wastewater treatment plant.

Site 18, Refueling Vehicle Maintenance Facility (Building 514)

The Air Force used this site for maintenance on refuel vehicles from the late 1950s until mid-1985. Excess fluids were drained from the vehicle tanks into a floor grate and drain system connected to an oil/water separator. The separated fluids were periodically collected for recycling and/or disposal while the water portion drained to the industrial wastewater treatment line.

FIELD PROGRAM

Radian and SAIC conducted eight major field activities at Hill AFB as part of the IRP Phase II Stage 2 investigation. These activities consisted of the following: 1) geophysical surveys at Landfill 3, Berman Pond, Chemical Disposal Pit 3, Refueling Area JP-4 Spill (Building 914), Bamberger Pond, and along the slurry trench wall; 2) soil gas surveys at Chemical Disposal Pit 3, Refueling Vehicle Maintenance Facility (Building 514), and Refueling Area JP-4 Spill (Building 914); 3) installation of 66 test wells; 4) drilling of 23 coreholes; 5) hand augering of 12 coreholes; 6) slug testing of test wells at Landfill 4, Chemical Pits 1 and 2 and the Golf Course; 7) collection and analysis of soil formations, surface water, and groundwater samples; and 8) direct groundwater flow measurements. These field activities began in April 1986 and ended in February 1987. Table ES-1 summarizes Phase II Stage 2 activities by site.

SUMMARY OF RESULTS AND RECOMMENDATIONS

Each site investigated in the Hill AFB IRP Phase II Stage 2 program has been assigned to one of the following categories:

- Category I - Sites where no further action is required;
- Category II - Sites requiring additional monitoring or work to assess the extent of current or future contamination; and

TABLE ES-1. SUMMARY OF IRP PHASE II, STAGE 2 INVESTIGATION ACTIVITIES, HILL AFB, UTAH

Site	Investigation Activities	Purpose	Site Map Location
Landfill 4	Review construction and hydrogeolgic data for 42 existing pre-IRP test wells.	Determine suitability of these wells for use in monitoring program.	Figure 3.2.1-1
	Conduct ground penetrating radar, electromagnetic terrain conductivity and seismic surveys.	Identify any discontinuities in the slurry trench wall.	
	Install six shallow zone and six deep zone test wells in pairs on either side of the slurry wall.	Evaluate shallow and deep groundwater systems on either side of the wall to determine slurry wall effectiveness.	
	Install one shallow zone test well on the northeast side of the landfill.	Detect contaminants that may have migrated downgradient; help delineate groundwater flow direction.	
	Groundwater sampling.	Evaluate possible effects of landfill on groundwater and slurry wall effectiveness.	
	Slug testing of deep zone.	Determine permeability characteristics of the deep zone.	
	Direct groundwater flow measurements.	Determine groundwater flow along the slurry trench wall.	
	Screen microcomputer-based groundwater models for potential application to landfill evaluation.	Determine model applicability and benefit to the evaluation of the site.	

(Continued)

TABLE ES-1. (Continued)

Site	Investigation Activities	Purpose	Site Map Location
Chemical Disposal Pits 1 and 2	Identify slump features of the South Weber Landslide Complex.	Define structural controls on groundwater flow.	Figure 3.2.2-1
	Identify and inventory springs and seeps on the downslope area.	Determine if contaminated groundwater is surfacing downslope from the disposal pits.	
	Inventory wells and springs within one mile of the base boundary.	Determine groundwater users that may be impacted by off-base migration of leachate.	
	Conduct ground penetrating radar, electromagnetic terrain conductivity, and seismic surveys.	Identify any discontinuities in the slurry trench wall.	
	Install six shallow test wells.	Define a previously detected "oil slick."	
	Install three shallow test wells north-northeast of the disposal pits.	Define the hydrogeologic conditions in an area where no data existed previously.	
	Install two shallow and two deep test wells outside of the slurry trench wall.	Determine effectiveness of the slurry trench wall; define the hydrogeologic conditions to the west and northwest.	

(Continued)

TABLE ES-1. (Continued)

Site	Investigation Activities	Purpose	Site Map Location
Chemical Disposal Pits 1 and 2 (Cont.)	Install five shallow test wells downslope on the South Weber Landslide complex.	Assess contaminant migration; determine impact of landslide on groundwater flow.	
	Drill six coreholes and conduct formation sampling in the area of the chemical disposal pits.	Characterize the area; provide data on lateral hydrocarbon migration.	
	Slug testing of the deep zone.	Determine permeability characteristics of deep zone.	
	Direct groundwater flow measurements.	Determine effect of slurry trench wall, cap and dewatering system on the shallow groundwater.	
	Formation sampling.	Characterize waste that might be encountered during drilling within the disposal pits; define the extent of formation contamination.	
	Groundwater sampling.	Evaluate possible effects of the disposal pits on groundwater.	
	Surface water sampling.	Determine if contaminated groundwater is surfacing downslope from the disposal pits.	

(Continued)

TABLE ES-1. (Continued)

Site	Investigation Activities	Purpose	Site Map Location
Chemical Disposal Pits 1 and 2 (Cont.)	Screen microcomputer-based groundwater models for potential application to evaluation of the site.	Determine model applicability and benefit to the evaluation of the site.	
Landfill 3	Identify and inventory all springs and seeps on the downslope area.	Determine if contaminated groundwater is surfacing downslope from the landfill.	Figure 3.2.3-1
	Inventory wells and springs within one mile of the base boundary.	Determine groundwater users that may be impacted by off-base migration of leachate.	
	Conduct ground penetrating radar, electromagnetic terrain conductivity, and seismic surveys.	Determine if large numbers of drums and/or tanks have been buried within the landfill; identify any discontinuities in the slurry trench wall.	
	Install three shallow test wells downslope and north of the landfill.	Define downslope groundwater gradients and contaminant flow directions.	
	Install one shallow and one deep test well north of Landfill 3.	Define the stratigraphy and groundwater quality north of the landfill.	
	Install two shallow test wells on the south side of the landfill on opposite sides of the slurry trench wall.	Determine the effectiveness of the slurry trench wall.	

(Continue

TABLE ES-1. (Continued)

Site	Investigation Activities	Purpose	Site Map Location
Landfill 3 (Cont.)	Formation sampling.	Characterize waste that might be encountered during drilling around the landfill; define extent of formation contamination.	
	Groundwater sampling.	Evaluate possible effects of the landfill on groundwater and slurry wall effectiveness.	
	Surface water sampling.	Determine if contaminated groundwater is surfacing downslope from the landfill.	
Sodium Hydroxide Leaks	Perform a data review.	Obtain information on tank construction, utility lines, previous test holes, subsurface geology, and sodium hydroxide leaks.	
	Drill four deep borings around the sodium hydroxide tanks.	Evaluate the extent of contamination.	
	Complete one of the borings as a test well.	Evaluate groundwater in the vicinity of the leaks.	
	Formation sampling.	Define extent of formation contamination.	
	Groundwater sampling.	Evaluate possible effects of the leaks on groundwater.	

(Continued)

TABLE ES-1. (Continued)

Site	Investigation Activities	Purpose	Site Map Location
Berman Pond	Perform data review of the clay cap system.	Determine the clay cap systems impact on the IRP investigation.	Figure 3.2.5-1
	Inventory of wells and springs within one mile of the base boundary.	Identify any shallow groundwater users that may be impacted by off-base migration of leachate.	
	Conduct ground penetrating radar, electromagnetic terrain conductivity, seismic refraction, and resistivity vertical soundings.	Determine the presence of subsurface clays along the southern boundary of the base.	
	Slant drill one corehole under the pond.	Detect the presence of any contaminants underneath the pond.	
	Install three shallow and two deep lysimeters in three additional slant coreholes.	Collect samples of vadose zone water for analysis.	
	Formation sampling.	Detect the presence of any contaminants underneath the pond.	
	Vadose zone sampling.	Detect the presence of any contaminants in the vadose zone underneath the pond.	
	Groundwater sampling.	Evaluate possible effects of the pond on groundwater.	

(Continued)

TABLE ES-1. (Continued)

Site	Investigation Activities	Purpose	Site Map Location
Berman Pond (Cont.)	Conduct a series of water level measurements taken at two previously existing wells.	Determine the hydraulic relationship of the Berman Pond area with that of the Golf Course.	
Industrial Wastewater Treatment Plant Sludge Drying Beds	Perform data review and interview base personnel.	Obtain information on sludge bed construction, operations, waste characteristics and site geology.	Figure 3.2.6-1
	Slant drill one corehole under the sludge drying beds.	Evaluate vertical migration of contaminants under the sludge drying beds.	
	Install two deep test wells.	Identify the presence of contaminants; evaluate groundwater flow direction.	
	Formation sampling.	Detect the presence of contaminants.	
	Groundwater sampling.	Evaluate possible effects of the sludge drying beds on groundwater.	
Chemical Disposal Pit 3	Review of base activities upslope from the disposal pit.	Identify possible contaminant sources upgradient from the disposal pits.	Figure 3.2.7-1

(Continued)

TABLE ES-1. (Continued)

Site	Investigation Activities	Purpose	Site Map Location
Chemical Disposal Pit 3 (Cont.)	Identification and inventory of all springs and seeps on the downslope area.	Determine if contaminated groundwater is surfacing downslope from the disposal pits.	
	Inventory of wells and springs within one mile of the base boundary.	Determine groundwater users that may be impacted by off-base migration of leachate.	
	Conduct seismic refraction, electromagnetic terrain conductivity, and resistivity surveys.	Determine the depth and extent of a sand layer beneath the clay in the vicinity of the disposal pits suitable for installing a test well.	
	Conduct soil gas investigations.	Determine the areal extent and migration direction of contamination emanating from the disposal pits and to aid in test well placement.	
	Install five shallow on-base test wells.	Provide hydrogeologic data for identifying the source of contaminants.	
	Install five shallow off-base test wells.	Detect off-base migration of any contaminants.	
	Install a 6-inch test well at the disposal pits and conduct a short-term pump test.	Determine aquifer productivity for use in designing remedial actions.	

(Continued)

TABLE ES-1. (Continued)

Site	Investigation Activities	Purpose	Site Map Location
Chemical Disposal Pit 3 (Cont.)	Surface water sampling.	Determine if contaminated groundwater is surfacing downslope from the disposal pits.	
	Groundwater sampling.	Evaluate possible effects of the disposal pits on groundwater.	
	Conduct monthly insitu field measurements.	Monitor groundwater levels, temperatures, and conductivities during wet and dry seasons.	
Little Mountain Drying Beds	Perform a data review.	Obtain information on the construction of the sludge beds, operations, and waste characteristics.	Figure 3.2.8-1
	Drill one borehole into each of the sludge drying beds.	Characterize contaminants contained within the sludge drying beds.	
	Drill three boreholes in the vicinity of the sludge drying beds.	Provide data on lateral contaminant migration.	
	Formation sampling.	Characterize waste within the sludge drying beds; define extent of formation contamination.	

(Continued)

TABLE ES-1. (Continued)

Site	Investigation Activities	Purpose	Site Map Location
Fire Training Area 1	Perform data review.	Determine location of the old fire training area.	Figure 3.2.9-1
	Install two shallow coreholes.	Characterize area; confirm the site and provide data on lateral contaminant migration.	
	Install one shallow test well north of the site.	Assess contaminant migration toward downslope area.	
	Groundwater sampling.	Evaluate possible effects of the fire training area on groundwater.	
Landfill 5	Collect background information and data.	Assess acceptability of monitoring program and recommendations, as appropriate, for additional activities.	Figure 3.2.10-1
Landfills 1 and 2	Perform data review.	Determine location of the landfills operations and define geologic conditions.	Figure 3.2.11-1
	Install two test wells around Landfill 1.	Assess contaminant migration.	
	Install one test well near Landfill 2.	Assess contaminant migration.	
	Groundwater sampling.	Evaluate possible effects of the landfills on groundwater.	

(Continued)

TABLE ES-1. (Continued)

Site	Investigation Activities	Purpose	Site Map Location
Herbicide Orange Test Plot	Perform data review.	Obtain information on test location, procedures, and condition of test barrels when buried.	Figure 3.2.13-1
	Drill six coreholes.	Characterize contaminants at test areas.	
	Install two test wells. Formation sampling.	Assess herbicide migration. Define extent of formation contamination.	
	Groundwater sampling.	Evaluate possible effects of test plots on groundwater.	
Golf Course	Perform data review.	Obtain information on irrigation practices, herbicide use, septic systems, and maintenance areas.	Figure 3.2.14-1
	Perform water balance analysis.	Determine possible recharge contributions to the landfill areas north of golf course.	
	Install three test wells.	Confirm presence of groundwater and define hydrogeology.	
	Groundwater sampling.	Observe impact of irrigation on shallow aquifers and provide upgradient background conditions.	

(Continued)

TABLE ES-1. (Continued)

Site	Investigation Activities	Purpose	Site Map Location
Golf Course (Cont.)	Conduct series of water level measurements.	Determine nature of groundwater recharge, verify water balance, and identify flow directions.	
Refueling Area JP-4 Fuel Spill (Building 914)	Perform data review.	Obtain information on fuel spills.	Figure 3.2.15-1
	Conduct seismic, electromagnetic, and resistivity surveys.	Identify a clay substrate.	
	Conduct a soil gas investigation.	Identify suitable locations for test well and soil borings.	
	Install one test well.	Assess hydrocarbon migration.	
	Drill two soil borings.	Provide data on lateral and vertical contaminant migration.	
	Formation sampling.	Define extent of formation contamination.	
	Groundwater sampling.	Evaluate possible effects of fuel spills on groundwater.	
Bamberger Pond	Perform data review.	Verify extent of the pond, characterize wastes, identify substrate beneath pond.	Figure 3.2.16-1
	Conduct electromagnetic conductivity and resistivity surveys.	Detect moisture migration and identify shallow clay layers.	

(Continued)

TABLE ES-1. (Continued)

Site	Investigation Activities	Purpose	Site Map Location
Bamberger Pond (Cont.)	Drill one corehole.	Provide data on lateral and vertical contaminant migration.	
	Install one test well. Formation sampling.	Assess contaminant migration. Define extent of formation contamination.	
	Surface water sampling.	Characterize pond effluent.	
	Groundwater sampling.	Evaluate possible effects of pond on groundwater.	
U.S. Army Tooele Rail Shop	Perform data review.	Obtain information on facility construction and maintenance activities.	Figure 3.2.17-1
	Auger twelve shallow borings about the site.	Assess contamination in vicinity of concrete cleaning pad and open air facilities.	
	Drill one corehole.	Provide data on lateral and vertical contaminant migration.	
	Formation sampling.	Define extent of formation contamination.	

(Continued)

TABLE ES-1. (Continued)

Site	Investigation Activities	Purpose	Site Map Location
Refueling Vehicle Maintenance Facility (Building 514)	Perform a data review.	Obtain information regarding construction details, operations, and oil/water separator system.	Figure 3.2.18-1
	Conduct soil gas investigations.	Detect any fuel or volatile organic compound migration in the subsurface, and aid in locating coreholes and test wells.	
	Drill four coreholes.	Provide data on lateral and vertical contaminant migration.	
	Install three test wells.	Assess contaminant migration.	
	Formation sampling.	Define extent of formation contamination.	
	Groundwater sampling.	Evaluate possible effects of maintenance facility on groundwater.	

- Category III - Sites that require and are ready for remedial action.

Table ES-2 summarizes the categorization of sites. Brief descriptions of the findings at each site and recommended monitoring activities for Category II sites follow.

Site 1. Landfill 4 - Figure ES-3 (Radian)

Surface geophysical surveys revealed two possible anomalous zones along the slurry trench wall. On the east side of Landfill 4 the results indicated that the slurry trench wall may not be keyed into the clay at depth. Similarly the geophysical surveys detected another anomaly indicating a possible deepening of the key clay layer or physical change in the wall on the west side of Landfill 4.

A data review was conducted of the construction and hydrogeologic data for existing test wells in the Landfills 3 and 4, Chemical Disposal Pits 1 and 2, and Fire Training Area 2.

This data review focused on earlier studies which identified an upper water table aquifer underlain by a clay layer. These studies interpreted the clay layer to be laterally continuous throughout the area, acting as a barrier to downward groundwater flow. The IRP Phase II Stage 1 investigation detected groundwater beneath the clay and identified silt or sand layers within the clay zone. The presence of groundwater beneath the clay and silt or sand layers within the clay indicates the possibility of hydraulic connection between the groundwater above and below the clay layer. Therefore, recommendations for the Phase II Stage 2 program were to drill deeper test wells to determine the nature and extent of the clay and identify deeper groundwater. The results of the present Stage 2 investigation indicate that the clay occurs in multiple distinct layers with variable thicknesses

TABLE ES-2. SUMMARY OF RECOMMENDED SITE CATEGORIES

Category I Sites - No Further IRP Activities	
Site 8, Little Mountain Sludge Drying Beds	
Site 9, Fire Training Area 1	
Site 13, Herbicide Orange Test Plot	
Category II Sites - Additional Monitoring Required	
Site 1, Landfill 4	
Site 2, Chemical Disposal Pits 1 and 2	
Site 3, Landfill 3	
Site 4, Sodium Hydroxide Leaks	
Site 5, Berman Pond	
Site 6, IWTP Sludge Drying Beds	
Site 7, Chemical Disposal Pit 3	
Site 10, Landfill 5	
Site 11, Landfill 2	
Site 12, Landfill 1	
Site 14, Golf Course	
Site 15, Refueling Area JP-4 Spill (Building 914)	
Site 16, Bamberger Pond	
Site 17, U.S. Army Tooele Rail Shop	
Site 18, Refueling Vehicle Maintenance Facility (Building 514)	
Category III - Ready for Remedial Action	
None	

throughout the Landfill 4 area creating a complex hydraulic connection between the water table and deeper groundwater below the clay. The pre-IRP test wells may have been drilled and completed within both the shallow and deeper groundwater zones, which could permit hydraulic communication through the clay.

An examination of the Stage 2 lithologic logs along the slurry trench wall from test well M-19 (east) to test well M-22 (west) indicates that clay occurs in variable thicknesses at different depths (Table 4.3.1-2). The clay varies in thickness from sequences of less than 1 foot at test well M-20 to more than 15 feet at test well M-14. The depths of first clay range from 20 feet at test well M-42 to 47 feet at test well M-19. Because of the vertical variability and lateral discontinuities of the clay layers, it is difficult to make lateral correlations over short distances in the landfill area. Evidence, including static water levels and geology reviewed to date, suggest that in the area of the landfills and chemical disposal pits there is a hydraulic connection exists between the upper shallow groundwater and the lower groundwater below the clay layers.

The occurrence of groundwater in these shallow sediments is controlled by the zones of permeability associated with fine- to medium-grained sands which interfinger with the finer grained silts and clays. The analytical results of the groundwater sampling indicate that all of the Landfill 4 test wells contained inorganic parameters in excess of the federal standards and criteria for drinking water. Organic compounds were, in almost all test wells, detected at concentrations below federal criteria. However, high concentrations of organic compounds were detected in many of the dewatering wells associated with Landfill 4. Surface water samples collected downgradient and downslope from Landfill 4 were also contaminated.

The results of the slug testing and direct groundwater flow measurements were impacted by the incompatibility between the well materials and the requirements of the techniques of analysis.

On the basis of available data, Radian recommends the following Phase II activities:

- Install six additional test wells along the slurry trench wall; conduct dye tracer and pump tests to determine if leakage is occurring across or beneath the slurry trench wall.

- Conduct additional groundwater sampling at existing test wells and proposed new test wells. Analyze samples for volatile halocarbon compounds (VOX), volatile aromatic compounds (VOA), and primary and secondary drinking water standards.

- Conduct additional groundwater flow testing in the proposed new wells to determine flow velocities and directions around the slurry trench wall.

- Install four deeper test holes to increase the database on hydrogeology beneath Landfill 4 and further define the occurrence of groundwater.

Site 2, Chemical Disposal Pits 1 and 2 - Figure ES-3 (Radian)

Shallow soil and groundwater contamination are well documented. Surface water samples collected from seeps and springs below the Chemical Disposal Pits 1 and 2 have shown elevated levels of inorganic parameters which exceed the federal MCLs. The off-base water well inventory indicated that potential pathways of human exposure to contaminated groundwater exist where seeps and springs occur. The continuity of the slurry trench wall and the effectiveness of the wall and the clay cap may be impacted by the variable depths of a clay layer below the site. Results of the investigation suggest that the slurry trench wall may not extend deep enough into the underlying clay layer to control groundwater flow across the site. Additional data on the continuity of the slurry trench wall are needed to determine the effectiveness of the current remediation strategies.

On the basis of the available data, Radian recommends the following additional Phase II activities:

- Continue sampling water from the springs and seeps down slope of Chemical Disposal Pits 1 and 2 to assess the effectiveness of the slurry trench wall and clay cap system in reducing the quantity of contaminated groundwater exiting the site. Analyze water samples for VOX, VOA, and primary and secondary drinking water standards.

- Install 4 additional pairs of test wells on both sides of the slurry trench wall in both the shallow and deep water zones to determine the groundwater flow conditions near the wall.

- Conduct additional direct groundwater measurements in the recommended new wells to define the direction and rate of groundwater at Chemical Disposal Pits 1 and 2 near the slurry trench wall.

- Conduct dye tracer and pump tests on recommended new wells to determine if leakage is occurring across or beneath the slurry trench wall.

- Conduct two rounds of groundwater sampling in the Phase II Stage 2 test wells and the 8 new wells to be installed. Analyze the water samples for volatile organics (EPA Methods 601 and 602) and metals.

Site 3, Landfilll 3 - Figure ES-4 (Radian)

The testing and evaluation along the slurry trench wall indicated that discontinuities may occur at the base of the wall. The variable depths at which clay was encountered during various drilling efforts, both during this investigation and previous ones, indicates that the effectiveness of the cutoff wall cannot be completely determined. Results of the groundwater sampling indicate contamination including volatile organics and metals in test wells M-45 and M-47, downgradient of Landfill 3.

In order to identify the potential pathways for human and environmental exposure to contaminated groundwater originating from Landfill 3, Radian recommends the following additional Phase II activities:

- Inventory and sample springs and seeps below Landfill 3 and downslope of the Davis-Weber Canal and east of those sampled by SGB. Analyze the samples for volatile organics (EPA Method 601 and 602) and metals.

- Conduct additional soil gas surveys for volatile organic compounds to provide data to identify additional test well locations off base and below the Davis-Weber Canal.

- Install 4 additional test wells into the shallow groundwater beneath the area downslope of Landfill 3. Install the test wells at locations identified based on results of soil gas surveys for volatile organic compounds.

- Conduct dye tracer and pump tests on recommended new wells to determine if leakage is occurring across or beneath the slurry trench wall.

- Collect 2 rounds of groundwater samples from the recommended new test wells and the existing Landfill 3 test wells. Analyze all samples for volatile organics (EPA Method 601 and 602) and metals.

Site 4, Sodium Hydroxide Leaks - Figure ES-3 (Radian)

Results of the Phase II Stage 2 field investigation confirmed earlier data on shallow soil contamination. The field pH and conductivity measurements detected elevated pH levels in the soil sampled from seven borings surrounding the sodium hydroxide tanks. Results of test drilling indicate that downward migration of contaminants may be restricted by the presence of a very fine-grained silty sand which has a reduced permeability. The analytical results for groundwater samples collected from test well SHT-1 at Site 4 do not indicate contamination by the past sodium hydroxide leaks. However, field data from test well BPM-1, located at Berman Pond to the southwest and hydraulically downgradient from the sodium hydroxide leaks, indicate elevated pH levels in the groundwater. Water level measurements made during the Phase II Stage 2 investigation indicate a groundwater mound beneath the sodium hydroxide leaks site as well as the IWTP site. The results of the water level measurements can be interpreted to indicate that groundwater is flowing from Site 4 towards BPM-1.

In order to confirm the groundwater quality and flow direction, Radian recommends the following additional Phase II activities:

- Install 2 additional test wells to define groundwater quality and flow directions.

- Collect 12 monthly water level measurements from test wells SHT-1, BPM-1, DBT-1, DBT-2 and the new proposed test wells. This data will be used to assess seasonal variability in the shallow groundwater.

- Collect 2 rounds of groundwater samples from test wells SHT-1, BPM-1 and the proposed new test wells. Analyze the samples for inorganic and organic parameters.

- Perform direct groundwater flow measurements on the recommended wells to determine flow direction and rate.

- Perform a video camera inspection of underground utility lines to detect line leaks. The video camera inspection of utility lines will indicate if leaks or breaks in the subsurface are contributing to the mounding effect observed during water level measurements.

Site 5, Berman Pond - Figure ES-3 (Radian)

The subsurface geology of the Berman Pond site is well documented. Results from the geophysical surveys indicate that a continuous, thick clay is not present along the southern boundary of the base at Berman Pond. Groundwater is known to occur in two different zones over an aerial distance of several hundred feet. Test well BPM-2 has artesian characteristics while BPM-1 appears to be a water table well. Results of soil sample analyses for EP toxicity revealed that all metals concentrations were less than the maximum allowable levels. Analytical results for groundwater from BPM-1 indicated elevated concentrations of metals and total dissolved solids. Both analytical results and field measurements for pH of water from BPM-1 show pH values which exceed the federal MCLs. Only one sample of groundwater collected from lysimeter BPL61B-shallow exceeded federal MCLs for organic compounds.

On the basis of the available data and identified data needs, Radian recommends the following additional Phase II activities:

- Install 4 additional test wells. Collect soil samples during drilling and analyze for EP toxicity parameters.

- Conduct two rounds of groundwater sampling from existing Berman Pond wells BPM-1, BPM-2, and the proposed new test wells. Analyze all groundwater samples for volatile organics (EPA Method 601 and 602), metals and hydroxide. Collect field data on pH and conductivity during sampling.

- Conduct 12 monthly rounds of water level measurements in existing test wells SHT-1, BPM-1, BPM-2, DBT-2 and all proposed new test wells. The water levels will be used to assess the seasonal variability of the groundwater system.

Site 6, Industrial Wastewater Treatment Plant Sludge Drying Beds - Figure ES-3 (Radian)

The Phase II Stage 2 investigation confirmed the presence of metals at levels exceeding federal MCLs for drinking water. Groundwater samples contained levels of volatile organic chemicals which exceeded the federal criteria for drinking water. The results of test well installation and water level measurements indicated that the groundwater is mounding in the area surrounding the IWTP and the sodium hydroxide leaks. The synoptic water level data show that groundwater may be flowing in more than one direction locally because of the mounding effect. Contaminants which become entrained in the groundwater will move downgradient in these flow directions.

In order to determine the source of the groundwater mounding and define the flow directions, Radian recommends the following additional Phase II activities:

- Install 3 additional shallow test wells or piezometers.

- Collect 12 monthly water level measurements from the proposed new wells at Site 6, the existing and proposed wells at Berman Pond and the sodium hydroxide leaks. The water levels will be used to assess the seasonal variability of the groundwater system.

- Perform direct groundwater measurements to determine flow directions and rates.

- Perform video camera inspection of underground utility lines to detect line leaks.

- Inspect the clarifier tanks.

Site 7, Chemical Disposal Pit 3 - Figure ES-3 (Radian)

Soil gas surveys and water samples at Chemical Disposal Pit 3 indicated that trichloroethylene is migrating off base from the site. Spring and seep water samples contained levels of TCE exceeding federal criteria for drinking water. Water samples from one spring, CP3-SP-12, contained concentrations of chromium which exceeded the federal criteria for drinking water. Groundwater samples contained levels of inorganic and organic compounds which exceeded the federal MCLs. The results from the surface and groundwater sampling confirmed the contamination at Chemical Disposal Pit 3. The inventory of springs and seeps off base indicated that contaminants have migrated off base. Groundwater samples collected during the short-term pump test indicated that the groundwater at test well CP3T-1 contained very high concentrations of TCE. The complex geology of the landslide blocks and the steep slopes below Chemical Disposal Pit 3 makes it difficult to completely characterize the hydrogeology of the site. In order to completely define the extent of the contamination and the continued potential for off-base migration, additional IRP Phase II activities should be conducted.

On the basis of available data, Radian recommends the following Phase II activities:

- Conduct additional soil gas studies on base north of CP-3 to define the lateral limits of the contaminant plumes.

- Drill and sample deep (approximately 100 feet) five soil borings to determine the vertical extent of the contaminant plumes. The locations of the test holes will be both off base and on base. Locations for the borings will be chosen based on the results of the soil gas studies and the Phase II Stage 2 report. Analyze soil samples for volatile organics (EPA Method 8010 and 8020).

- Convert five of the deep boreholes to test wells and install casing and screen. Sample the groundwater and analyze for volatile organics (EPA Method 601 and 602) and metals.

- Conduct a long term (approximately 14 days) aquifer test on existing well CP3T-1 to evaluate the potential for groundwater recovery and treatment.

- Collect periodic samples of the pump test discharge for chemical analyses (EPA 601 and 602) for determining contaminant concentration changes with time.

- Install three large diameter (6") recovery wells and conduct pilot recovery testing.

- Collect two rounds of groundwater samples from existing wells CP3T-1 through CP3T-11. Analyze water for volatile organics (EPA Method 601 and 602) and metals.

- Conduct 12 months of groundwater elevation measurements. Inventory and measure seeps and springs throughout the year to document the hydrologic cycle throughout the year and survey locations of springs and seeps.

- Collect 12 monthly water samples from the seeps and springs downslope of Chemical Disposal Pit 3. Analyze the water samples for volatile organics (EPA Method 601 and 602) and metals. We understand SGB is already doing some of this.

Site 8. Little Mountain Sludge Drying Beds - Figure ES-4 (SAIC)

Phenols were detected in the sludge drying beds and near the outflow of the discharge drainage ditch. This ditch carries discharge from the sludge drying beds to the south of the site. The presence of phenols is attributed to the past dumping of phenolic strippers on the sludge drying beds. The depth to groundwater and the low rate of precipitation create a remote possibility of contaminant migration into the environment. No further IRP activities are recommended.

Site 9, Fire Training Area 1 - Figure ES-4 (Radian)

The Phase II Stage 2 investigation found no evidence of shallow soil contamination at the FTA-1 Site. The site is surrounded by an interim remediation systems including a clay cap, asphalt paving and a shallow groundwater collection gallery. Any remaining contamination not detected in the investigation will be controlled by the existing systems. No further IRP activities are recommended.

Site 10, Landfill 5 -Figure ES-4 (SAIC)

Evaluation of data generated during the current monitoring effort shows two areas of concern. Of the eight existing test wells, two are north of the landfill and six are arrayed to the south and southwest. These wells are reported to monitor the surfical aquifer. With a local westerly groundwater flow direction, there is a strong likelihood that the majority of contamination migrating from the landfill would miss all test wells. Despite this well alignment, there have been three occasions when at least one well has yielded one or more metals in concentrations exceeding the Safe Drinking Water Act's MCLs. The possible reasons for these values include considerable variability in and uncertainty concerning groundwater flow direction, significant dispersion of contaminants due to a gentle hydraulic gradient, or contaminant sources other than the landfill. Contamination may have also resulted from field sampling or laboratory errors.

The following measures should be taken:

- Install a new set of one upgradient and three downgradient wells located on the basis of a westerly groundwater flow.

- In order to identify the extent to which contaminants that may be detected in the test wells are derived from Landfill 5, install two lysimeters in boreholes angled under the landfill.

- Collect three surface soil samples from points along the ephemeral stream channel west of Landfill 5, arranged from west to southwest of the landfill. One background soil sample should be collected from northeast of the landfill.

- Analyze groundwater and lysimeter water samples semiannually for all parameters required by the State of Utah and for beryllium, metals and polychlorinated biphenyls (PCBs).

- Analyze sediment samples from the angle boreholes for beryllium, metals, PCBs and VOCs (EPA 624).

- At least one new test well would be pump tested in order to begin to identify aquifer characteristics.

Sites 11 and 12, Landfills 2 and 1 - Figure ES-3 (SAIC)

TCE (in excess of federal criteria) and benzene were found during test well sampling for these sites. Due to the closeness of the downgradient wells to the base boundary, further monitoring is needed to characterize the extent of contamination.

The following activities are recommended:

- Complete inventory of all seeps and springs along that portion of the escarpment within T5N, R1W, S19, deemed to be either directly or marginally downgradient of either landfill, based on an apparent groundwater flow direction of approximately N20E.

- Sampling of all inventoried seeps and springs either for laboratory analysis of IRP basic parameters or for field gas chromatographic analysis for benzene and trichloroethylene.

- Comprehensive soil gas survey of all accessible downgradient areas between the escarpment and the Davis-Weber Canal to determine the extent of detectable contaminant moving off base.

- Collection of at least three surface water samples from the Davis-Weber Canal, as follows: one upstream of the potentially impacted area; one downstream of the potentially impacted area; and one within this area, to be either analyzed for IRP basic parameters in the laboratory or benzene and trichloroethylene in field by GC.

- Ground Penetrating Radar (GPR) or seismic refraction surveys to locate and define slump planes and evaluate these planes as groundwater migration pathways.

- Electromagnetic (EM) or Ground Penetrating Radar (GPR) surveys to establish the boundaries of Landfill 1.

- One additional upgradient well to provide discrete water quality data for evaluating the impact of Landfill 1.

- Two additional test wells downgradient of Landfill 1 to characterize groundwater and contaminant transport in the vicinity of the escarpment.

- Four additional test wells located in the Weber River Valley on the basis of soil gas survey results to quantify the likelihood of groundwater contamination in the valley resulting from landfill activities.

- Expanded groundwater sampling analytical parameters to include metals and semi-volatiles to more fully characterize groundwater quality.

- Comprehensive aquifer testing to characterize groundwater behavior in the vicinity of the escarpment in order to more accurately predict contaminant migration.

Site 13, Herbicide Orange Test Plot -Figure ES-4 (SAIC)

Having found no detectable contamination in soils or water in the vicinity of the site, it must be presumed that all of the herbicide has decomposed and/or been transported off site by aeolian means. In the event that it has been transported, it has, in all probability, been dispersed to the point of being below detection limits all along the transport path. No further IRP activities are recommended.

Site 14, Golf Course - Figure ES-3 (Radian)

The golf course is not a waste disposal site. The Phase II Stage 2 investigation detected no contamination in either the shallow soil or the shallow groundwater beneath the golf course. The results of the water balance study and the data review of irrigation practices suggest that there is a net recharge potential at the golf course to the downgradient areas to the north which include Landfills 3 and 4. Also data from the Phase II Stage 1 and Stage 2 investigations indicate a hydraulic connection between the wells at the golf course and Berman Pond test well BPM-2.

Additional IRP Phase II investigations are necessary to determine the impact of irrigation water on the shallow groundwater beneath the golf course. No other drilling activities are recommended. The following actions are recommended for the golf course:

- Collect 12 monthly water level measurements at existing test wells GC-1 through GC-4.

- Collect 12 monthly water level measurements at Landfill 4 test wells M-6, M-7, M-11 through M-14, M-17, M-18, and Berman Pond test well BPM-2 to assess the impact of irrigation water to recharge to the shallow groundwater.

Site 15, Refueling Area JP-4 Spill (Building 914) - Figure ES-3 (SAIC)

High levels of fuel hydrocarbons were identified in the soil at the site, but no quantifiable levels were identified in the groundwater. Also, the geophysical investigation indicated the potential for high concentrations of hydrocarbons to be present below land surface.

Soil sampling has indicated that the contamination is migrating toward the water table. The rate at which the fuel hydrocarbons are moving and the quantities getting to the water table will be dependent on the amount of infiltrating water, absorptive capacity of the material and partitioning coefficients. The concentrations which were quantified in the soil are large enough to eventually adversely affect the quality of the groundwater. Because of this potential adverse impact, additional monitoring and investigation are considered necessary for this site.

An expanded soil gas survey should be conducted to delineate the area of soil contamination outside the fenced area. Archived soil samples should be analyzed for fuel hydrocarbons to obtain a better idea of vertical contaminant distribution. Also, additional soil samples should be collected to obtain a better areal distribution of the contaminants. Exact locations of these borings should be based on the results of the extended soil gas survey and existing data. Up to five additional borings are recommended. Selected intervals in borings should be sampled for physical testing such as grain size and vertical and horizontal permeabilities.

Additional groundwater test wells should be installed to obtain site specific hydrologic data and to obtain upgradient groundwater quality. Wells should be sampled and analyzed for fuel hydrocarbons. After the installation of the wells selected, wells should be hydraulically tested to obtain the transmissivity of the aquifer at the site.

Site 16, Bamberger Pond - Figure ES-3 (SAIC)

The detection of total organic carbon (TOC) in the surface water and the groundwater at levels of at least one order of magnitude above the detection limit and the identification of a high conductivity plume by the geophysical survey indicates the presence of contaminants at Site 16. The extent of contamination, however, is not discernible from the available data.

Additional monitoring should include installing new test wells, resampling BAT-1 and the surface water, and collecting samples from the sediments at the base of Bamberger Pond.

Three additional test wells should be installed--one in the center of the projected high conductivity plume identified by the geophysical survey and two spaced around the pond to form a triangle with BAT-1 about the well installed in the center of the projected high conductivity plume. Groundwater samples should be collected from two locations--the surface of the groundwater and at a depth greater than 25 feet below ground surface, which is the projected point of the highest concentration of the high conductivity plume. These samples should be analyzed for VOC (EPA 624), base neutral and acid extractables, and petroleum hydrocarbons.

Test well BAT-1 and Bamberger Pond should be resampled to verify past results and to determine whether or not the high value measured in BAT-1 on June 17, 1986, was an outlier. Surface water samples should be collected at the point of outflow from the storm drain as before. All samples should be analyzed for petroleum hydrocarbons and VOCs (EPA Method 624).

Four sediment samples should be collected along the trench area identified in the geophysical report and analyzed for petroleum hydrocarbons and VOCs.

Site 17, U.S. Army Tooele Rail Shop - Figure ES-3 (SAIC)

No groundwater test wells were installed at Site 17 and no existing wells were noted; therefore, information on the local geology is limited to a single 20-foot borehole. Information on local hydrogeology does not exist. Information from other wells drilled along the western fringe of Hill AFB suggests a depth to groundwater between 30 and 40 feet. Local topography in the vicinity of the site suggests a westward groundwater flow direction. Since the base boundary is less than 100 feet from the site, the possibility exists that any contaminants that have reached groundwater have migrated off base.

Soil samples collected from shallow hand auger borings northwest, west, and south of the concrete cleaning pad at this site were contaminated with some halogenated volatile organic compounds. When compared with depth discrete samples collected from borehole TRA-1 along the base boundary, the shallow soil samples also contained levels of oil and grease and total alkalinity in excess of local background levels. All contaminants noted, with the possible exception of toluene and m-xylene, are attributable to equipment-cleaning activities on the pad. The toluene and m-xylene may be related to the cleaning activities, but may reflect a spill from a drum or other container just south of the cleaning pad.

As an initial step, a soil gas survey is recommended to define the areal extent of soil contamination by VOCs and petroleum hydrocarbons, and to define where possible the specific VOCs. To the extent possible, the survey should also be depth-discrete, with soil gas samples analyzed at several depths as the probe penetrates the soils. It should be noted that site conditions--the fact that the entire area of investigations is either fill material or railroad sub-base of undetermined depth with extensive cobbles--will complicate soil gas survey implementation.

A detailed evaluation of soil gas survey findings should be the basis upon which monitoring wells are placed at Site 17. A minimum of two wells downgradient of the pad, within the area of contaminated soils as indicated by the soil gas, are recommended. A third well should be positioned in the suspected upgradient direction, either between Buildings 1701 and 1706 or east of Building 1701.

Site 18, Refueling Vehicle Maintenance Facility
(Building 514) - Figure ES-3 (Radian)

Results of the Phase II Stage 2 investigation did not indicate evidence of fuel hydrocarbon contamination. However, volatile halocarbon contamination was detected in soil samples from a location between Building 514 and Building 512. A records search revealed that solvents had been previously stored in an unlined area next to Building 512. A soil gas survey of the area between Building 512 and Building 514 detected a contaminant plume of trichloroethane and trichloroethylene apparently migrating to the south-southwest toward the base boundary. Groundwater samples collected from test wells VMT-2 and VMT-3 contained concentrations of trichloroethylene in excess of the federal criteria for drinking water.

On the basis of the available data, it appears appropriate to discontinue IRP activities at Building 514 but the associated IRP study should continue at Building 512. Radian recommends the following additional Phase II activities for the Building 514 and 512 area:

- Install three test wells to define the shallow groundwater flow gradients;
- Collect soil and water samples from the proposed new test wells and analyze samples for volatile organics (EPA Methods 601/8010 and 602/8020) to define the lateral limits of the contaminant plume;
- Collect two rounds of groundwater samples from existing test wells VMT-1 through VMT-3. Analyze the water samples for volatile organics (EPA Method 601 and 602); and
- Collect 12 monthly water levels at existing wells VMT-1 through VMT-3 and the proposed new test wells to determine groundwater flow directions and gradients.