**POSITION PAPER ON THE APPLICABILITY
OF SUPPLEMENTAL STANDARDS TO THE
UPPERMOST AQUIFER AT THE URANIUM MILL
TAILINGS REMEDIAL ACTION VITRO
PROCESSING SITE, SALT LAKE CITY, UTAH**

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STANDARDS TO THE UPPERMOST AQUIFER AT THE URANIUM
MILL TAILINGS VITRO PROCESSING SITE, SALT LAKE CITY, UTAH**

March 1996

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**Prepared for
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Grand Junction Projects Office**

**Prepared by
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LAKE CITY, UTAH

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LIST OF ACRONYMS

<u>Acronym</u>	<u>Definition</u>
AEC	Atomic Energy Commission
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
HP	health physics
MK-F	MK-Ferguson Company
NRC	U.S. Nuclear Regulatory Commission
OCS	Opposed Crystal System
OSCR	on-site construction review
QA	quality assurance
QAPP	quality assurance program plan
QC	quality control
RAC	Remedial Action Contractor
RAC-AL	Remedial Action Contractor - Albuquerque Office
RAIP	remedial action inspection plan
RAP	remedial action plan
STP	staff technical position paper
TAC	Technical Assistance Contractor
UMTRA	Uranium Mill Tailings Remedial Action
UMTRCA	Uranium Mill Tailings Radiation Control Act
VP	vicinity property

1.0 INTRODUCTION

This report documents the results of the evaluation of the potential applicability of supplemental standards to the uppermost aquifer underlying the Uranium Mill Tailings Remedial Action (UMTRA) Project, Vitro Processing Site, Salt Lake City, Utah. There are two goals for this evaluation: provide the landowner with information to make an early qualitative decision on the possible use of the Vitro property, and evaluate the proposed application of supplemental standards as the ground water compliance strategy at the site. Justification of supplemental standards is based on the contention that the uppermost aquifer is of limited use due to wide-spread ambient contamination not related to the previous site processing activities.

In support of the above, this report discusses the site conceptual model for the uppermost aquifer and related hydrogeological systems and establishes regional and local background water quality. This information is used to determine the extent of site-related and ambient contamination. A risk-based evaluation of the contaminants' effects on current and projected land uses is also provided.

Reports of regional and local studies and U.S. Department of Energy (DOE) site investigations provided the basis for the conceptual model and established background ground water quality. In addition, a limited field effort (4 through 28 March 1996) was conducted to supplement existing data, particularly addressing the extent of contamination in the northwestern portion of the Vitro site and site background ground water quality. Results of the field investigation were particularly useful in refining the conceptual site model. This was important in light of the varied ground water quality within the uppermost aquifer.

Finally, this report provides a critical evaluation, along with the related uncertainties, of the applicability of supplemental standards to the uppermost aquifer at the Salt Lake City Vitro processing site.

2.0 SITE CONCEPTUAL MODEL SUMMARY

2.1 SITE LOCATION

The Salt Lake City uranium ore processing site (the Vitro site) is between the Wasatch Mountains to the east and the Oquirrh Mountains to the west, 4 miles (mi) (6 kilometers [km]) south-southwest of the center of Salt Lake City, in the city of South Salt Lake. Figure 2.1 shows the site location.

2.2 SITE HISTORY

In 1941, a large smelting operation known as Calunite Smelter, Inc., was completed at the Vitro site. In 1946, the plant became known as the Vitro Chemical Company Calunite Plant. From 1941 through 1951, this smelter processed aluminum from aluminite. In May 1951, the Vitro plant began processing uranium ore under contract to the U.S. Atomic Energy Commission (AEC). From 1951 to 1964, the Vitro plant processed uranium ores by acid leaching. In 1965, the mill converted to the production of vanadium. Vanadium production ceased in 1968 and the plant was dismantled in 1970. A detailed description of uranium and vanadium extraction processes used at the Vitro site is given in the *Baseline Risk Assessment of Ground Water Contamination at the Uranium Mill Tailings site Near Salt Lake City, Utah* (DOE, 1995a).

Figure 2.2 shows the Vitro mill site after the plant was dismantled. The eastern portion of the site was used for the ore processing mill, ore storage, and transportation facilities (FB&D, 1981). The remainder of the site served as a tailings (pond) area for the mill.

Remedial action at the Vitro site occurred from January 1985 to March 1987. A total of 2,798,000 cubic yards (yd³) (2,139,000 cubic meters [m³]) of tailings was removed from the site and stabilized in a disposal cell at Clive, Utah (approximately 85 mi [140 km] west of Salt Lake City). The state of Utah was the remedial action contractor. The surface cleanup left the former Vitro site free of process-related soil contamination (except for the areas where supplemental standards for radium-226 and thorium-230 were applied to parts of the site) (DOE, 1994). Clean fill was placed in all excavated areas and the ground was recontoured and revegetated.

Figure 2.1
South Clive Disposal Site and
Salt Lake City Processing Site Locations

MAC: SITE/SLC/SUPP STAND/SITELOC

DOE/AL/62350-227
REV. 0, VER. 3

27-Mar-96
013D3WP.DOC (SLC)

Figure 2.2
Aerial Photograph of the Vitro Processing Site (2/81),
Salt Lake City, Utah

MAC: SITE/SLC/SUPP STAND/PASTEUP

3.0 PHYSIOGRAPHIC FEATURES

The Jordan River, the main drainage for the Salt Lake City valley, flows to the north about 1500 feet (ft) (500 meters [m]) west of the site. Mill Creek, which originates in the Wasatch Mountains, flows westerly across the northern boundary of the Vitro processing site and the Central Valley Water Reclamation Facility (CVWRF) (Figure 2.2). The area is characterized by very gentle topography in which anthropogenic changes are more apparent than the original topographic features. Sewer mains to the CVWRF were buried at a depth of approximately 20 ft (6 m) from east to west across the site and from south to north on the west side of 900 West Street. The foundations and buried maintenance tunnels of the CVWRF are at depths up to 23 ft (7 m).

3.1 HYDROGEOLOGY

After site surface remediation, the upper 4 to 13 ft (1.2 to 3.9 m) of soil were replaced with clean, sandy-gravel fill material. The lithology underlying this fill at the Vitro processing site consists of a thick sequence of Quaternary lacustrine and fluvial deposits with minor alluvial overburden. These unconsolidated deposits below the site are approximately 700 ft (210 m) thick (Arnow et al., 1970). Tertiary deposits underlie the Quaternary deposits to a depth of approximately 1200 ft (370 m) (Mattick, 1970). These Tertiary deposits consist of semiconsolidated clay, sand, and gravel interspersed with lava and cemented layers of sand and gravel (Arnow et al., 1970).

The ground water regime in the vicinity of the Vitro processing site is generally characterized by two aquifer systems: a shallow, unconfined system and a deeper, confined system. The two aquifers are separated by interbedded layers of low-permeability clays and silts. The shallow unconfined aquifer extends down to 50 ft (15 m), with static water levels at 5 to 10 ft (1.5 to 3 m) below ground level. Wells in the confined aquifer, at depths from 70 to 330 ft (20 to 100 m) below the ground surface, are under substantial artesian pressure, with ground water flowing from several wells under as much as 15 ft (4.6 m) of head above ground level. Therefore, the potential for vertical ground water flow is upwards from the confined into the unconfined aquifer. Near the site, lateral ground water flow in both aquifers is predominantly to the west-northwest, toward the Great Salt Lake. Water in the shallow unconfined aquifer near the site discharges to the Jordan River. According to the U.S. Geological Survey (USGS), the Jordan River is a head-dependent boundary (Lambert, 1995); if the water level in the aquifer adjacent to the river is higher than the water level in the river, then ground water will discharge to the river. If the water level in the aquifer is lower than the river, then river water will recharge the aquifer. In either case, ground water will not flow under the river because the river acts as a hydrologic barrier.

3.1.1 Shallow unconfined aquifer

In the vicinity of the former tailings pile, the upper, unconfined aquifer is approximately 50 ft (15 m) thick. Ground water levels in the unconfined aquifer

range from 5 to 15 ft (1.5 to 4.6 m) or more below the ground surface. The water level is highest in March or April and lowest in mid- to late summer. Topographic lows east of the site are perennially marshy. Regionally, the ground water flows primarily from southeast to northwest. Figure 3.1 gives the locations of monitoring wells, well points, and hydropunch sampling sites used to determine water levels. Locally, however, recent data (March 1996) indicate that ground water flows toward the site from all directions in response to dewatering activities at the CVWRF (Figure 3.2).

Near the site, the shallow unconfined aquifer consists of unconsolidated fluvial deposits of the Jordan River and Mill Creek. There appear to be three general lithologic types in the upper 40 ft of the aquifer, based on results of cone penetrometer data collected in March 1996 (Plate 1; Attachment 1). The first lithologic type is gravely sand and sand, which tends to fine upward (for example, 22 to 8 ft [6.7 to 2.4 m], HP-10, Plate 1). This lithology is interpreted as fluvial channel (point-bar) deposits. The second lithologic type is thinly interbedded fine sand and clay sequences, which tend to coarsen upward (for example, 40 to 28 ft [12 to 8.5 m], HP-14, Plate 1). These are interpreted as flood splay deposits. The third lithologic type is silty clay and clayey silt, interpreted as floodplain deposits (for example, 34 to 24 ft [10 to 7.3 m], HP-15, Plate 1). Additionally, man-made fill, to depths of 4 to 7 ft (1 to 2 m), occur in several areas on and around the site (HP-1, -2, -6, -12, and -13; Plate 1).

The channel deposits occur in the upper portion of the unconfined aquifer, from 8 to 35 ft (2.4 to 11 m) below land surface. The bases of these deposits vary in depth from 13 to 35 ft (4 to 11 m). These channel deposits are not present everywhere; in some areas, the upper 30 to 36 ft (9.1 to 11 m) of the unconfined aquifer consist of floodplain deposits (HP-1, -2, and -4; Plate 1).

Floodplain deposits also underlie the shallow channel deposits in most areas near the site. These are relatively impermeable. There is a zone of thinly interbedded sand and clay beneath the floodplain deposits, interpreted as flood splay deposits. This zone occurs from about 30 to 40 ft (9.1 to 12 m) below the surface and is separated from the shallow channel sands by floodplain clays and clayey silts. However, in 2 of the 10 locations sampled (HP-10 and -12, Plate 1), the base of the channel sand is in contact with these deeper splay deposits.

On-site, there appear to be two channel sands in the area of HP-12: a lower channel (from 18 to 36 ft [5.5 to 11 m]) and a shallow channel (from 8 to 14 ft [2.4 to 4.3 m] below land surface). These are separated by a clay unit at 14 to 18 ft (4.2 to 5.5 m). The upper channel is thought to have been deposited by Mill Creek, based on descriptions of a shallow sand, trending east-west, encountered during surface remediation of the site. The deeper channel is likely a Jordan River channel deposit (point-bar deposit). Deeper, thicker Jordan River channel deposits also occur at locations HP-6, -10, -12 and -13 (Plate 1). Shallower sands, likely older Mill Creek channels, occur at locations HP-15 and -16 (Plate 1).

Figure 3.1
Site Map Showing Logging and Sampling Locations
Salt Lake City, Utah, Vitro Processing Site

MAC: SITE/SLC/SUPP STAND/BASE

Mill Creek recharge to ground water

The channel sands are the best ground water producers. A shallow (<30 ft) dewatering well at the CVWRF, pumped since January 1995, yields approximately 300 gallons (gal) (1100 liters [L]) per minute. This well is screened in a channel sand. Other wells screened in thin splay sands and in the floodplain deposits are poor ground water producers and may yield less than 2 gal (4 L) per minute.

The hydraulic conductivities, determined from slug tests and an aquifer test conducted in 1992, ranged from 0.37 to 8.9 ft (0.11 to 2.7 m) per day (Calculation No. SLC-07-92-14-03-00; TAC, 1992). A range of average linear ground water velocities in the shallow unconfined aquifer was calculated using the range of hydraulic conductivities, a hydraulic gradient of 0.005, and an assumed effective porosity of 0.20. Using Darcy's Law, the average linear velocities for ground water flow in the shallow unconfined aquifer range from approximately 3 to 80 ft (1 to 20 m) per year under normal site conditions when the dewatering wells are inactive.

The major sources of recharge to the unconfined aquifer are precipitation infiltration and upward leakage from the confined aquifer. Ground water in the unconfined aquifer generally discharges to surface water drainages such as Mill Creek and the Jordan River (Figure 2.2). Geochemistry and water level data suggest that Mill Creek is a sources of recharge near the Vitro site. However, a highway drain at the 3300 South Street underpass below the Denver & Rio Grande Western Railroad locally influences ground water flow in the unconfined aquifer. Ground water entering the drain is pumped out by a lift station into a culvert that discharges into the head of South Vitro Ditch. Ground water levels in the area indicate that a local ground water cone of depression in the southeast corner of the site draws ground water from that area toward the drain (Figure 3.2). A significant depression in the water table has been created in the vicinity of CVWRF (Figure 3.2) from dewatering wells that were installed or reactivated for expansion of the facility. These wells are estimated to extract a total of about 400 to 500 gal (1500 to 1900 L) per minute.

A 28-acre (ac) (11-hectare [ha]) golf driving range has been constructed on the southeast corner of the site. Irrigation of the golf course has a potential to recharge minor amounts of water to the shallow unconfined aquifer.

3.1.2 Confined aquifer

The confined aquifer begins approximately 70 ft (20 m) below the ground surface at the site. Ground water is under substantial artesian pressure in this aquifer. Hydraulic head levels range from approximately 8 ft (2.5 m) above the ground surface for the well screened at 70 ft (20 m), to 15 ft (4.5 m) above ground surface for the wells screened at a depth of approximately 130 ft (40 m). Near the Jordan River, this confined (artesian) aquifer system extends to depths of 500 to 800 ft (150 to 240 m) below the ground surface (Hely et al., 1971).

The major sources of recharge to the confined aquifer are precipitation infiltration and snowmelt along the flanks of the Wasatch and Oquirrh Mountains. Beneath the site, the ground water in this aquifer flows west-northwest. Natural discharge is

upward to the unconfined aquifer system. Artificial discharge includes pumpage of wells completed in the confined aquifer system.

The relatively good water quality of the confined aquifer is maintained by the upward vertical hydraulic gradient between the two aquifers, which prevents downward water migration from the unconfined aquifer. Modeling of the confined aquifer by the USGS (Waddell et al., 1987) indicates that, with an increase in ground water withdrawals of about 60% from 1982 rates, drawdown in the vicinity of the Vitro site in the year 2020 would be less than 20 ft below 1982 levels. This suggests that regional drawdown is likely to be small. Locally, the effects of pumping from a well in the confined aquifer could cause a cone of depression to develop and could lead to reversal of gradient and potential migration of contaminants from the shallow aquifer into the confined aquifer. However, due to the thickness of the confining layer and the depth at which water supply wells are screened in the vicinity of the Vitro site it is unlikely that any contaminants would ever be detected in discharge from such a well due to dispersion and dilution.

3.2 BACKGROUND GROUND WATER QUALITY SUMMARY

Background water quality for the Vitro site is defined as the water quality if uranium milling activities had not occurred. The deep confined aquifer is the principal aquifer in the Salt Lake Basin (Seiler and Waddell, 1984). The shallow, unconfined aquifer is seldom used as a source of water for domestic or industrial purposes because of its ease of contamination, thus generally yielding water of poor quality (Seiler and Waddell, 1984).

Water quality is different in various areas of the Salt Lake Valley area. For example, along the Wasatch Front, ground water quality reflects that of mountain stream recharge, while near the Great Salt Lake, ground water quality is saline, reflecting the influence of the lake and salt deposits. For the purposes of this report, the Central Valley area is defined as an area along the Jordan River extending about 5 miles (8 km) south of the site, 2 miles (3.2 km) north of the site, and about 2 miles (3.2 km) east and west of the Jordan River. This area is representative of ground water quality reasonably expected in the area of the former Vitro site, based on regional studies of water quality throughout the valley (Thiros, 1995; Waddell et al., 1987; Seiler and Waddell, 1984).

3.2.1 Confined aquifer water quality

None of the DOE monitor wells in the confined aquifer (principal aquifer in the area) are designated as background because of possible historical variations in the local ground water flow related to pumpage of water supply wells in the region. This would include pumpage from the deep wells that provided process water for the Vitro uranium mill during its operation. Total dissolved solids (TDS) concentrations in the confined aquifer range from 251 to 1400 mg/L (DOE, 1995). The more saline water is found in monitor well 005, on the west side of the site. This well has the highest sulfate and chloride levels of the four confined aquifer monitor

wells. Historical data from DOE well 015 also show higher sulfate, chloride, and TDS levels in the area west of the site within the confined aquifer.

Previous studies (Waddell et al., 1987) have suggested that the TDS, chloride, sulfate, and iron levels in the confined aquifer west of the site are site related. This conclusion was based upon comparison of water quality west of the site (well 015) to water quality in wells north, southeast, and east of the site (001, 002, and 003). Such a comparison (Table 3.1) indicates that the concentrations of major elements are greater in the western well. Nonetheless, levels of major elements and TDS observed in monitor wells west of the site are similar to levels reported for public water-supply wells completed in the confined aquifer west of the Jordan River (Table 3.1). Also, levels of uranium, a site-related contaminant, in ground water from monitor wells west of the site are low (0.003 mg/L or less). In general, uranium is a sensitive site indicator of ground water contamination, and levels observed in the confined aquifer to the west do not reflect site-related contamination.

The higher levels of major elements in the samples from DOE wells completed in the confined aquifer west of the site reflect natural ground water quality west of the Jordan River; pumpage of both the Vitro wells and City of South Salt Lake municipal wells east of the river may have drawn ground water west of the Jordan River toward the site.

Ground water from the DOE wells completed in the confined aquifer north, southeast, and east of the site is notable in that it contains little or no sulfate. This has been reported of ground water from the confined aquifer. The low concentrations may be the result of sulfate reduction in finer grained, confined layers (Thiros, 1995). This agrees with well logs and regional mapping of the thickness of the confining layer near the site, which indicate a thicker, more well developed confining zone east of the site when compared to the west. Thus, ground water in DOE wells north, southeast, and east of the site probably differ from those to the west not because of site-related contamination, but rather because of natural variations in lithology and geochemical conditions. Thus, there are no site-related impacts to the principal aquifer in the vicinity of the Vitro site.

3.2.2 Background water quality in the shallow unconfined aquifer

Regional background quality

Regional data for the shallow, unconfined aquifer indicate that water quality is variable, primarily because of the influence of activities at the land surface (Thiros, 1995). Natural processes of evapotranspiration are documented to affect its water quality (Thiros, 1995). Also, it is contaminated because of its proximity to the land surface. Sources of ambient contamination include historical landfills, lead smelters, cement kilns, chemical plants, and other active and inactive industrial sites spread throughout the valley.

Table 3.1 Comparison of ground water quality in the confined aquifer at the Vitro site to water quality in public supply wells west of the Jordan River

Well ID	DOE well SLC-01-002	DOE well SLC-01-015	DOE well SLC-01-005	(C-1-1) 23caa-1	(C-1-1) 33ddd-1
Location	East side of site	West of site	West side of site	Public supply well, west of Jordan River, northwest of site	Public supply well, west of Jordan River, southwest of site
Date sampled	8/31/90	8/23/83	8/31/90	8/19/83	8/6/92
Alkalinity	282	200	200	170	149
Chloride	8	270	207	250	280
Calcium	40	180	122	150	76
Fluoride	0.3	NA	0.2	0.2	0.4
Magnesium	20	79	60	83	51
pH	7.6	7.4	7.4	7.6	7.6
Potassium	11	18	17	13	6
Sodium	35	43	36	56	160
Silica	30	NA	36	15	49
Sulfate	<0.1	390	230	340	250
Uranium	0.0003	<0.003	<0.0003	NA	NA
TDS	308	1120	855	1010	969

Notes:

1. Data for public supply wells from Thiros, 1995.
 2. Data are for filtered samples. Units are mg/L except for pH (standard units).
- NA - Not analyzed.

Ground water in the unconfined aquifer is recharged by streams draining from the Wasatch Front, water diverted for irrigation from the Jordan River, upward leakage from the confined part of the principal aquifer, and infiltration from precipitation (Thiros, 1995, Seiler and Waddell, 1984). In the central portion of the valley, shallow ground water (less than 60 ft [18 m] deep) tends to be a calcium-magnesium/sulfate-chloride type (Thiros, 1995). TDS concentrations are in the range of about 600 to 1900 mg/L. Water from somewhat deeper depths (60 to 100 ft [18 to 30 m]) and probably within the confining layer or upper portion of the confined layer (Thiros, 1995) tend to have lower TDS concentrations (400 to 700 mg/L), reflecting the influence of vertical leakage from the confined portion of the principal aquifer (Table 3.2).

Seiler and Waddell (1984) found that the greatest concentrations of trace elements in the unconfined aquifer were in water from wells near landfills or tailings areas. The greatest measured concentration of cadmium was 0.2 mg/L, of mercury was 0.0001 mg/L, of iron was 37 mg/L, and of arsenic was 360 mg/L. All of these concentrations exceed criteria of the U.S. Environmental Protection Agency (EPA) for a domestic water supply (Seiler and Waddell, 1984). Also, several hazardous organic constituents were found in wells near landfills and tailings, including benzene, phenol, 1,1-dichloroethane, trichloroethylene, and chloroethylene.

Table 3.2 Comparison of ground water quality in the unconfined aquifer at the Vitro site to general water in the unconfined aquifer in the central Salt Lake Valley

Well ID	Range in water quality of the unconfined aquifer 22 - 52 ft (7 - 16 m)	Range in water quality of the unconfined aquifer 66-100 ft (20 - 30 m)	Average water quality in DOE background well 006, 26 - 28 ft (7.9 - 8.5 m)	Average water quality in DOE background well 007 26 - 28 ft (7.9 - 8.5 m)
Location	Central Valley region	Central Valley region	Southeast of site	East of site
Alkalinity	103-451	280-343	692	432
Arsenic	<0.001- 0.11	NA	0.094	0.04
Chloride	100-850	21-92	314	63
Calcium	40-190	22-110	62	12
Fluoride	0.2 - 3.1	NA	0.4	0.7
Iron	<0.003 - 37	NA	0.15	90.11
Magnesium	34-110	27-41	69	34
Manganese	<0.003 - 0.4	NA	0.38	0.033
pH	6.3 - 7.9	NA	7.5	8.01
Potassium	9-38	4-32	52	30
Silica	14 - 44	NA	NA	26
Sodium	79-450	47-71	241	136
Sulfate	92-910	8-190	100	<2
Uranium	NA	NA	0.003	<0.001
TDS	615-1890	441-690	1220	547

Notes:

1. Data for Central Valley region from Thiros (1995) and Seiler and Waddell (1984).
 2. DOE well data collected from 1990 through 1995.
 3. Values are for filtered samples. Units are mg/L except for pH (standard units).
- NA - Not analyzed.

Of the hazardous trace metals studied by Seiler and Waddell, (1984), arsenic tended to be most widely dispersed in the shallow aquifer, occurring in over 90 percent of the wells sampled and analyzed. The average concentration for arsenic in wells sampled was 0.048 mg/L, with a range of <0.001 to 360 mg/L. Overall, the range of data suggests that elevated levels of arsenic, as a well as other trace metals, occur in localized areas throughout the valley. This likely reflects, in many cases, the influence of past industrial activities on the water quality within the shallow unconfined aquifer, though natural sources of arsenic may also affect water quality (Seiler and Waddell, 1984).

Landfills appear to have been one source of arsenic to the shallow aquifer. Others appear to be tailings and slag heaps associated with abandoned smelters in the valley. Thirty-seven former smelter sites have been identified in the Salt Lake Valley (D.W. Moore and Associates, 1992). Most were in operation near the turn of the century, but in many cases, the slag heaps and tailings are still present at the former sites. Most smelters processed lead ores, though copper, silver, and gold were also produced.

Several of the old smelter sites were located near the Vitro site, including three smelters along Big Cottonwood Creek located south-southeast of the site. These three smelters (Morgan-Haunauer Smelter, Wasatch Silver Lead Works Smelter, and Horns Silver Smelter) were about 1.5 miles (2.4 km) upgradient of the Vitro Site. Another smelter, the Badger State Smelter Works, was located on the south side of Mill Creek, just one mile (1.6 km) east and upstream of the Vitro Site. As discussed in the following sections, arsenic and high concentrations of particulate lead occur in background ground waters at the Vitro processing site. Old smelters in the area may account for these constituents in ground water.

Ground water in the areas of the four smelters closest to, and upgradient of, the Vitro site has not been characterized. However, ground water in the shallow aquifer at several other smelter sites, generally located further upgradient from the Vitro site, has been characterized in reports prepared for the EPA. Table 3.3 summarizes the concentrations of constituents that have been reported at two of these sites. These concentrations of constituents are likely typical of those to be expected in association with the old smelters.

Trace metals found in ground water affected by the smelters include arsenic, cadmium, copper, lead, and selenium. Of these, arsenic has the highest concentrations (up to 28.9 mg/L) and a widespread occurrence, as indicated by the frequency of detection in ground water near the old smelter sites. The arsenic exists as a dissolved anion in the ground water at the smelter sites. By contrast, lead more commonly occurs as a solid adsorbed onto suspended solids (fine-grained particles) in ground water, as indicated by the difference in frequency of detection of dissolved lead (analyzed in filtered samples) and total lead (analyzed in unfiltered samples; Table 3.3).

Airborne dusts from the old smelter slag heaps and dust from operating mines and smelters in the valley may be a source of contaminants to the shallow, unconfined aquifer. Results of state of Utah air quality monitoring in the Salt Lake Valley are presented in Table 3.4.

Airbornes in the valley have normal concentrations (within a factor of three compared to normal soils) of vanadium, iron, manganese, chromium, and nickel. Concentrations of arsenic, zinc, lead, copper, molybdenum, and selenium are 17 to 186 times normal concentrations for soils. This likely reflects the influence of mining and smelters on dust composition in the valley. Airbornes affect sediment chemistry and surface water quality. Those effects on the surface water and sediment may also affect ground water quality in the shallow, unconfined aquifer.

Other documented impacts to the shallow unconfined aquifer occur crossgradient (north) and downgradient (northwest) of the Vitro site. These include inorganic contaminants in ground water (arsenic to 10.2 mg/L, chromium to 0.132 mg/L, molybdenum to 137 mg/L, and lead to 0.071 mg/L) at the Portland Cement Kiln Dust Superfund Site located about 3 miles (5 km) northwest of the Vitro processing site (URS Consultants, 1993). Inorganic contaminants detected in ground water at

Table 3.3 Ground water quality in the shallow, unconfined aquifer associated with former smelters in the Salt Lake City Valley

Smelter site	Murray Smelter			Sharon Steel/Midvale tailings site		
	Minimum mg/L	Maximum mg/L	Frequency of detection	Minimum mg/L	Maximum mg/L	Frequency of detection
Depth (ft)	19	45	NA			
Arsenic	<0.005	28.9	16/20	<0.01	0.219	4/7
Cadmium	<0.0005	0.134	5/20	<0.003	0.040	1/7
Copper	<0.005	0.064	4/20	<0.002	0.035	6/7
Lead	<0.002	0.132	5/20	<0.005	0.008	1/7
Lead (total)	<0.002	0.15	18/20	NA	NA	NA
Manganese	0.023	1.86	20/20	0.014	1.54	7/7
Nickel	<0.04	0.041	1/20	<0.014	<0.014	0/7
Selenium	<0.005	0.192	11/20	NA	NA	NA
Silver	<0.0003	0.004	1/20	<0.004	<0.004	0/7
Thallium	<0.01	<0.01	0/20	NA	NA	NA
Zinc	<0.02	1.39	10/20	0.013	8.52	7/7
TDS	539	3174	20/20	610	2330	7/7
Calcium	71	320	20/20	81	389	7/7
Magnesium	34	160	20/20	28	94	7/7
Sodium	60	205	20/20	77	229	7/7
Potassium	10	58	20/20	5	25	7/7
Sulfate	52	1325	20/20	160	1300	7/7
Chloride	47	381	20/20	100	280	7/7
pH	6.98	7.55	20/20	6.6	7.2	7/7
Iron	0.0	4.6	10/20	NA	NA	NA
Sulfide	0	1.5	4/20	NA	NA	NA

Notes:

1. Data from EPA, 1989, and Hydrometrics, Inc., 1995.
 2. Values given are for filtered samples unless noted as total (unfiltered). Units in mg/L except for pH (standard units).
- NA = Not analyzed.
TDS = Total dissolved solids.

Table 3.4 Comparison of the composition of Salt Lake Valley airbornes to average Western U.S. soils

Element	Average Western U.S. soil in mg/kg	Salt Lake Valley airbornes in mg/kg	Ratio airborne element to element in average soil
Vanadium	70	22	0.3
Iron	21,000	16,135	0.8
Manganese	380	327	0.9
Chromium	41	53	1.3
Nickel	15	28	1.8
Arsenic	5.5	92	16.8
Zinc	55	1146	20.8
Lead	17	609	35.8
Copper	21	952	45.3
Molybdenum	0.85	69	81.7
Selenium	0.23	43	186.4
Silver	NA	70	NA
Cadmium	NA	79	NA
Antimony	NA	113	NA

Notes:

1. Data for Western U.S. soils from Shacklette and Boerngen, 1984.
2. Data for Salt Lake Valley aerosols from Utah Division of Air Quality, 1995.

NA = Not analyzed.

the Wasatch Chemical Superfund Site, about 1.3 miles (2 km) north of the Vitro processing site (crossgradient), include arsenic (up to 0.194 mg/L) and antimony (up to 0.086 mg/L). In addition, several organic compounds were detected in ground water, including herbicides (Harding Lawson Associates, 1990).

Background water quality at the Vitro processing site

Based on results of Hydropunch ground water screening (see Attachment 1), background water quality in the confined aquifer varies with depth and the lithologic type. Splay deposits at depths of about 28 to 37 ft (8.5 to 11 m [HP-1, HP-14, HP-15, and HP-16]) have low chloride concentrations and little or no detectable sulfate. This likely reflects recharge by vertical leakage from the confined aquifer, sulfate reduction related to organic matter in the floodplain deposits, and isolation from overlying sources of ground water recharge. By contrast, ground waters in the shallower channel sands have greater concentrations of chloride and sulfate, reflecting the influence of surface water on ground water in the shallow channel sands.

Background water quality for the shallow unconfined aquifer at the Vitro site has been established in two DOE monitor wells, 007 and 006 (Figure 3.1). Monitor well 007 is about 1000 ft (300 m) from the site and crossgradient (east) of the site. It is screened at 30 to 40 ft (9 to 12 m) and is completed in a splay deposit (based on water quality). Monitor well 006 is located about 1000 ft (300 m) upgradient

(southeast) of the site and is also screened at 30 to 40 ft (9 to 12 m) below the surface. However, well 006 has greater TDS and sulfate concentrations when compared to well 007, and therefore, is thought to be completed in a channel deposit.

Water quality in samples collected from monitor well 006 is similar to that reported regionally from the shallow portion of the unconfined aquifer in the Central Valley area (Table 3.2). Concentrations of calcium, magnesium, sodium, chloride, and sulfate fall within reported ranges for these major elements in ground water of the shallow aquifer. Alkalinity is somewhat higher than is normal. This may be due to the influence of suspended solids on the alkalinity, determined in unfiltered samples. Uranium concentrations in the samples range from <0.001 to 0.004 mg/L.

The Hydropunch screening of ground water determined that the water quality in well 006 is actually lower in sulfate than background ground water sampled at several other locations (HP-13, -14, -15, and -16). For example, sulfate in well 006 is about 160 mg/L compared to 280 to 4000 mg/L in background samples collected during screening. However, chloride concentrations in well 006 are similar to those at the other background locations, which range from 90 to 1320 mg/L. Thus, ground water in well 006 is typical of background in the shallow aquifer channel deposits except for somewhat lower sulfate concentrations, likely reflecting the influence of sulfate reduction.

Screening samples of ground water in shallow channel deposits at background locations HP-13, -14, -15, and -16 (Figure 3.1) determined that arsenic was present at all these locations at levels ranging from 0.009 to 0.029 mg/L. Arsenic concentrations in well 006 range from 0.063 to 0.132 mg/L and exceed the UMTRA maximum concentration limits (MCL) (40 CFR Part 192) and the EPA primary drinking water standard. These values likely reflect the influence of smelting operations in the Salt Lake Valley. This is supported by concentrations of two other constituents (copper and lead) associated with smelting in ground water samples from well 006. The lead and copper are concentrated on filterable particulates sampled from well 006. Dissolved concentrations are below the method detection limits. In the unfiltered samples, total lead ranges from 0.009 up to 1.08 mg/L and total copper ranges from <0.02 up to 0.88 mg/L. The high variability reflects the variation in the amount of suspended particulates in the samples collected from well 006. Arsenic occurs primarily as a dissolved component, and its concentrations are less sensitive to levels of suspended solids.

Ground water quality in well 007 differs from that of well 006. Concentrations of major elements and TDS are less (Table 3.2). Water quality in well 007 is similar to that reported regionally for the deeper portions of the unconfined aquifer, the portions that appear to be influenced more by vertical leakage from the confined aquifer coupled with sulfate reduction (Thiros, 1995). The influence of sulfate reduction is reflected in the low sulfate concentrations in ground water sampled from well 007 (generally less than 2 mg/L). Uranium concentrations in this background well are generally less than 0.001 mg/L.

Screening sampling of background ground water in splay deposits at locations HP-13, -14, -15, and -16 determined that arsenic was again present at these locations at levels ranging from 0.023 to 0.173 mg/L. The Hydropunch screening of ground water quality also determined that the water quality in well 007 is typical of background in the unconfined aquifer splay deposits at 28 to 37 ft (8.5 to 11 m) (see data for HP-13, -14, -15, and -16 in Attachment 1).

Arsenic also occurs in DOE monitoring well 007, at levels ranging from 0.021 up to 0.060 mg/L. Copper has not been detected in either filtered or unfiltered samples collected from this well, and lead has only been detected at low levels (0.003 mg/L) in unfiltered samples. This reflects lower concentrations of suspended solids in samples collected from well 007 when compared to those collected in well 006.

Table 3.5 provides a statistical summary of water quality data for monitor wells 006 and 007 (background).

3.3 MAGNITUDE AND EXTENT OF CONTAMINATION

The original tailings solution within tailings piles and evaporation ponds was an acid solution (pH less than 4) composed predominantly of aluminum and magnesium sulfate (Markos and Bush, 1983). Previous geochemical studies demonstrated that, as the solutions migrated into the unconfined aquifer, they were immediately neutralized at the tailings-soil interface by the reaction of calcite and dolomite with the acid solution. This produced a thin zone of precipitates at the interface. This 4-inch (10-centimeter) zone, including gypsum, iron oxides, basic iron, and aluminum sulfates (Markos and Bush, 1983), was removed along with other residual radioactive materials during surface remediation of the site.

As a result of neutralization, precipitation, and pH-dependent sorption, contaminated ground water within the unconfined aquifer contains relatively low concentrations of heavy metals and metalloids. Contamination is primarily recognized by high concentrations of TDS and major ions including sulfate, chloride, calcium, magnesium, and sodium and by elevated concentrations of uranium.

Site-related constituents in ground water at the site have been identified as ammonium, barium, calcium, chloride, fluoride, iron, magnesium, manganese, molybdenum, potassium, silver, sodium, strontium, sulfate, uranium, and radium-226 (DOE, 1995). Of these, constituents having the greatest contrast in the contaminated area compared to background (greater than 50 times background) are molybdenum, sulfate, and uranium. These are the most sensitive indicators of ground water contamination. Calcium, chloride, iron, magnesium, potassium, sodium, and strontium levels are closer to background (between 4 and 14 times background concentrations). Ammonium, fluoride, manganese, silver, and radium-226 are only slightly elevated above background and are poor indicators of site-related contamination of ground water.

Hydraulic gradients prevent migration of contaminants east and south of the site. On-site and to the west of the site, concentrations of site-related constituents vary

Table 3.5 Summary of ground water quality data in the shallow unconfined aquifer at Salt Lake City, Utah, 1990 -1995

Parameter ^b	Detection frequency ^c	Concentration ^a		
		Minimum	Median	Maximum
Alkalinity as mg/L CaCO ₃ ^d				
Background (006)	5/5	537	670	890
Background (007)	11/11	298	445	495
Site-affected wells	65/65	263	478	1178
Well 135	3/3	1070	1088	1178
Aluminum				
Background (006)	0/1	-	<0.05	-
Background (007)	1/6	<0.05	<0.05	<0.05
Site-affected wells	10/40	<0.05	<0.05	0.14
Well 135	2/3	<0.05	0.05	0.14
Ammonium				
Background (006)	4/4	27	31	56
Background (007)	9/9	6	9	12
Site-affected wells	59/59	0.45	8.6	20.9
Well 008	9/9	6.6	11	20.9
Antimony				
Background (006)	NA	-	-	-
Background (007)	1/6	<0.003	<0.003	0.025
Site-affected wells	14/33	<0.003	<0.003	0.027
Well 135	1/3	<0.01	<0.015	0.027
Arsenic				
Background (006)	4/4	0.063	0.090	0.132
Background (007)	10/10	0.021	0.035	0.06
Site-affected wells	49/58	<0.005	0.028	0.145
Well 131	6/6	0.047	0.079	0.145
Arsenic (total)				
Background (006)	3/3	0.110	0.150	0.289
Background (007)	3/3	0.021	0.030	0.031
Site-affected wells	25/28	<0.005	0.050	0.140
Well 131	3/3	0.070	0.116	0.140
Barium ^d				
Background (006)	1/2	<0.1	<0.15	0.15
Background (007)	8/8	0.10	0.12	0.12
Site-affected wells	34/51	<0.01	0.18	0.61
Well 134	5/5	0.30	0.47	0.61

**Table 3.5 Summary of ground water quality data in the shallow unconfined aquifer at
Salt Lake City, Utah, 1990 -1995 (Continued)**

Parameter ^b	Detection frequency ^c	Concentration ^a		
		Minimum	Median	Maximum
Beryllium				
Background (006)	NA	-	-	-
Background (007)	0/5	<0.0012	<0.005	<0.005
Site-affected wells	0/26	<0.0012	<0.005	<0.01
Not detected	-	-	-	-
Cadmium				
Background (006)	0/1	-	<0.001	-
Background (007)	0/7	<0.0005	<0.001	<0.001
Site-affected wells	1/39	<0.0005	<0.001	0.001
Well 131	1/3	<0.001	<0.001	0.001
Calcium ^d				
Background (006)	4/4	47	62	76
Background (007)	10/10	11	12	13
Site-affected wells	66/66	22	81	426
Well 008	9/9	29	266	426
Chloride ^d				
Background (006)	4/4	296	310	342
Background (007)	10/10	56	62	74
Site-affected wells	66/66	10	423	2830
Well 135	3/3	2580	2780	2830
Chromium				
Background (006)	0/1	-	<0.01	-
Background (007)	0/6	<0.003	<0.01	<0.01
Site-affected wells	0/33	<0.003	<0.01	<0.02
Not detected	-	-	-	-
Chromium (total)				
Background (006)	1/1	-	0.03	-
Background (007)	0/1	-	<0.01	-
Site-affected wells	1/7	<0.01	<0.01	0.01
Well 008	1/1	-	0.01	-
Cobalt				
Background (006)	NA	-	-	-
Background (007)	0/5	<0.03	<0.03	<0.05
Site-affected wells	0/26	<0.004	<0.05	<0.10
Not detected onsite	-	-	-	-

Table 3.5 Summary of ground water quality data in the shallow unconfined aquifer at Salt Lake City, Utah, 1990 -1995 (Continued)

Parameter ^b	Detection frequency ^c	Concentration ^a		
		Minimum	Median	Maximum
Copper				
Background (006)	0/2	<0.02	<0.02	<0.02
Background (007)	1/7	0.003	<0.02	<0.02
Site-affected wells	4/43	<0.01	<0.02	0.37
Well 136	1/3	<0.02	<0.02	0.37
Copper (total)				
Background (006)	2/3	<0.02	0.22	0.88
Background (007)	0/3	<0.02	<0.02	<0.02
Site-affected wells	2/27	<0.02	<0.02	0.60
Well 136	1/3	<0.02	<0.02	0.60
Cyanide				
Background (006)	NA	-	-	-
Background (007)	0/4	<0.01	<0.01	<0.01
Site-affected wells	0/17	<0.01	<0.01	<0.01
Not detected onsite	-	-	-	-
Fluoride ^d				
Background (006)	3/3	0.4	0.4	0.4
Background (007)	8/8	0.6	0.7	0.9
Site-affected wells	50/50	0.4	0.9	2.8
Well 136	3/3	1.7	1.7	2.8
Iron ^d				
Background (006)	4/4	0.07	0.15	0.21
Background (007)	10/10	0.04	0.08	0.25
Site-affected wells	65/66	<0.03	1.40	6.78
Well 008	9/9	0.13	2.22	6.78
Iron (total)				
Background (006)	3/3	2.04	48	212
Background (007)	4/4	0.33	0.57	0.90
Site-affected wells	33/34	<0.03	2.26	13.9
Well 008	4/4	7.6	8.9	13.9
Lead				
Background (006)	0/4	<0.003	<0.003	<0.003
Background (007)	0/7	<0.002	<0.003	<0.005
Site-affected wells	3/59	<0.003	<0.003	0.009
Well 008	1/8	<0.003	<0.005	0.009

**Table 3.5 Summary of ground water quality data in the shallow unconfined aquifer at
Salt Lake City, Utah, 1990 -1995 (Continued)**

Parameter ^b	Detection frequency ^c	Concentration ^a		
		Minimum	Median	Maximum
Lead (total)				
Background (006)	3/3	0.009	0.55	1.08
Background (007)	1/3	<0.003	<0.003	0.003
Site-affected wells	6/27	<0.003	<0.003	0.022
Well 130	1/3	<0.003	<0.003	0.022
Magnesium^d				
Background (006)	4/4	61	70	75
Background (007)	10/10	32	33	36
Site-affected wells	66/66	34	128	900
Well 135	3/3	757	846	900
Manganese^d				
Background (006)	4/4	0.27	0.36	0.53
Background (007)	10/10	0.03	0.03	0.04
Site-affected wells	66/66	0.03	0.19	0.63
Well 109	5/5	0.11	0.45	0.63
Mercury				
Background (006)	NA	-	-	-
Background (007)	0/4	<0.0001	<0.0002	<0.0002
Site-affected wells	1/26	<0.0001	<0.0002	0.0002
Well 011	1/5	<0.0002	<0.0002	0.0002
Molybdenum^d				
Background (006)	0/4	<0.01	<0.01	<0.01
Background (007)	1/10	<0.01	<0.01	0.01
Site-affected wells	43/66	<0.01	0.045	1.39
Well 131	4/4	0.88	0.91	1.39
Molybdenum (total)^d				
Background (006)	1/2	<0.01	<0.02	0.02
Background (007)	1/5	0.007	<0.04	<0.04
Site-affected wells	14/20	<0.01	0.01	1.02
Well 131	2/2	0.31	0.67	1.02
Nickel				
Background (006)	NA	-	-	-
Background (007)	1/5	0.007	<0.04	<0.04
Site-affected wells	0/26	<0.006	<0.04	<0.08
Not detected onsite				

Table 3.5 Summary of ground water quality data in the shallow unconfined aquifer at Salt Lake City, Utah, 1990 -1995 (Continued)

Parameter ^b	Detection frequency ^c	Concentration ^a		
		Minimum	Median	Maximum
Nitrate				
Background (006)	1/1	-	3	-
Background (007)	5/6	<1.0	1.9	5.5
Site-affected wells	12/32	<1.0	<1.0	4.6
Well 008	3/5	<1.0	0.90	4.6
pH				
Background (006)	4/4	7.1	7.8	7.8
Background (007)	10/10	7.9	8.1	8.2
Site-affected wells	67/67	5.71	7.36	8.01
Well 133	7/7	5.71	7.61	7.84
Potassium ^d				
Background (006)	4/4	47	51	59
Background (007)	10/10	26	31	35
Site-affected wells	65/65	17	42	274
Well 136	5/5	176	200	274
Selenium				
Background (006)	0/1	-	<0.005	-
Background (007)	0/7	<0.001	<0.005	<0.005
Site-affected wells	3/39	<0.002	<0.005	0.03
Well 109	1/5	<0.002	<0.005	0.03
Silver ^d				
Background (006)	0/2	<0.0002	<0.0006	<0.0006
Background (007)	0/7	<0.0002	<0.01	<0.01
Site-affected wells	11/41	<0.0002	<0.01	0.042
Well 135	1/2	<0.02	-	0.042
Silver (total)				
Background (006)	0/1	-	<0.0006	-
Background (007)	0/1	-	<0.0006	-
Site-affected wells	0/11	<0.0006	<0.0006	<0.0006
Not detected onsite				
Sodium ^d				
Background (006)	4/4	230	244	248
Background (007)	10/10	129	136	150
Site-affected wells	66/66	23	332	3160
Well 135	4/4	2710	3100	3160

**Table 3.5 Summary of ground water quality data in the shallow unconfined aquifer at
Salt Lake City, Utah, 1990 -1995 (Continued)**

Parameter ^b	Detection frequency ^c	Concentration ^a		
		Minimum	Median	Maximum
Strontium ^d				
Background (006)	3/3	0.52	0.57	0.80
Background (007)	9/9	0.20	0.21	0.55
Site-affected wells	60/60	0.21	1.39	5.58
Well 008	9/9	0.8	3.64	5.58
Sulfate ^d				
Background (006)	4/4	56	106	137
Background (007)	5/9	<0.1	1.0	4.7
Site-affected wells	72/72	<1.0	510	5560
Well 135	5/5	5100	5480	5560
Sulfide				
Background (006)	NA	-	-	-
Background (007)	3/5	<1	1.2	2.3
Site-affected wells	4/26	<0.10	<1.0	2.1
Well 109	1/5	<0.10	<1.0	2.1
Thallium				
Background (006)	NA	-	-	-
Background (007)	0/5	<0.005	<0.01	<0.07
Site-affected wells	0/24	<0.005	<0.005	<0.07
Not detected	-	-	-	-
Tin				
Background (006)	NA	-	-	-
Background (007)	1/5	<0.005	<0.005	<0.03
Site-affected wells	0/26	<0.005	<0.005	<0.10
Not detected	-	-	-	-
Total Dissolved Solids ^d				
Background (006)	3/3	1220	1220	1290
Background (007)	9/9	530	543	565
Site-affected wells	66/66	310	1825	14,500
Well 135	3/3	12,400	13,500	14,500
Uranium ^d				
Background (006)	3/4	<0.001	0.003	0.004
Background (007)	1/10	<0.0001	<0.001	0.001
Site-affected wells	50/66	<0.0001	0.017	0.266
Well 109	5/5	0.160	0.233	0.266

Table 3.5 Summary of ground water quality data in the shallow unconfined aquifer at Salt Lake City, Utah, 1990 -1995 (Continued)

Parameter ^b	Detection frequency ^c	Concentration ^a		
		Minimum	Median	Maximum
Uranium (total) ^d				
Background (006)	2/2	0.001	0.008	0.016
Background (007)	0/3	<0.001	<0.001	<0.001
Site-affected wells	23/28	<0.001	0.016	0.173
Well 139	2/2	0.088	0.016	0.173
Vanadium ^d				
Background (006)	0/4	<0.01	<0.01	<0.01
Background (007)	0/9	<0.005	<0.01	<0.01
Site-affected wells	13/60	<0.005	<0.01	0.17
Well 139	2/2	0.12	-	0.17
Vanadium (total) ^d				
Background (006)	1/2	<0.01	<0.36	0.36
Background (007)	0/3	<0.01	<0.01	<0.01
Site-affected wells	4/27	<0.01	<0.01	0.18
Well 139	2/2	0.12	-	0.18
Zinc				
Background (006)	NA	-	-	-
Background (007)	2/6	<0.005	<0.007	0.018
Site-affected wells	17/33	<0.005	0.015	0.187
Well 135	2/4	<0.005	<0.12	0.187
Radionuclide				
Radium-226 ^d				
Background (006)	2/2	0.3	0.35	0.4
Background (007)	4/7	0.0	0.3	0.5
Site-affected wells	42/43	0.0	0.40	1.30
Well 008	7/7	0.20	0.50	1.30
Radium-226 (total)				
Background (006)	NA	-	-	-
Background (007)	1/1	-	0.2	-
Site-affected wells	8/8	0.3	0.5	1.1
Well 134	1/1	-	1.1	-
Radium-228				
Background (006)	NA	-	-	-
Background (007)	4/5	0.0	0.9	8.9
Site-affected wells	21/26	0.0	1.3	5.2
Well 008	4/5	0.0	1.1	5.2

**Table 3.5 Summary of ground water quality data in the shallow unconfined aquifer at
Salt Lake City, Utah, 1990 -1995 (Concluded)**

Parameter ^b	Detection frequency ^c	Concentration ^a		
		Minimum	Median	Maximum
Polonium-210 (total)				
Background (006)	NA	-	-	-
Background (007)	0/1	-	0.0	-
Site-affected wells	2/7	0.0	0.0	0.10
Well 135	1/2	0.0	-	0.10
Thorium-230				
Background (006)	NA	-	-	-
Background (007)	3/5	0.0	0.2	0.94
Site-affected wells	16/26	0.0	0.25	1.40
Well 132	1/2	0.0	-	1.4
Thorium-230 (total)				
Background (006)	NA	-	-	-
Background (007)	0/1	-	0.0	-
Site-affected wells	7/7	0.3	0.3	0.6
Well 008	1/1	-	0.6	-
Lead-210 (total)				
Background (006)	NA	-	-	-
Background (007)	1/1	-	0.5	-
Site-affected wells	5/7	0.0	0.4	1.4
Well 133	1/1	-	1.4	-

^aInorganic constituent concentrations are reported in milligrams per liter. pH is reported in standard units. Radionuclide concentrations are reported in picocuries per liter.

^bBackground wells are 006 and 007. Site-affected wells are 008, 011, 109, 130, 131, 132, 133, 134, 135, 136, 139, 140, and 141. Last well listed for each parameter is that well having the highest observed concentration of the site-affected wells.

^cNumber of samples with detected concentrations/total number of samples.

^dConstituents are elevated in site-affected wells compared to background at the 0.05 level of significance.

over time and area. Many of these variations likely reflect short-term changes in the local hydrology related to the history of surface activities that have occurred on or around the site, including surface remediation, development of properties around the perimeter, construction activities at the CVWRF, construction of a golf driving range, and maintenance and construction of storm sewers along the south and west boundaries of the site. These activities contribute to the complex distribution of site-related constituents.

Pumping of dewatering wells (and likely dewatering of subgrade foundations and leakage of ground water into sewer mains) at the CVWRF has created a ground water sink on site (Figure 3.2). As a result, contaminated ground water surrounding the site is being flushed toward the site.

Trends in water quality data from monitor wells west, northwest, and north of the site are likely the result of this flushing. In monitor wells immediately west of the site (011 and 109), concentrations of sulfate and chloride have steadily decreased since 1983. For example, in well 011 sulfate decreased from 7500 mg/L in 1983 to 1160 mg/L in 1992 (when the wells were abandoned), and uranium concentrations decreased from 0.14 mg/L to 0.044 mg/L.

In well 134, located at the northwest corner of the site, concentrations of site-related constituents abruptly decreased between July and December of 1995. Prior to December of 1995, sulfate concentrations were up to 505 mg/L while in December the sulfate was 91 mg/L. Uranium concentrations also decreased from 0.06 to 0.019 mg/L.

To the north of the site, in monitoring well 008, sulfate concentrations increased from 384 mg/L in 1990 to 2920 mg/L in 1995. However, uranium concentrations in this well have remained low (less than 0.005 mg/L). Thus, the increased sulfate may reflect migration of ambient ground water toward the site rather than site-related contamination.

Chemical data from monitor wells on the south and east boundaries of the site (wells 130, 132, and 133) indicate that, prior to December 1994, contamination had not affected these crossgradient wells. These wells appear to have been completed in the deeper, hydrologically isolated, splay deposits. However, site-related contaminants, including uranium and molybdenum, were detected in these wells beginning in December of 1994. These changes may be the result of near-surface leakage of shallow ground water into the sand filter packs that extend up to within a few feet of the surface in these wells. These changes have been short term, and concentrations are returning to normal (background) at these locations. Arsenic concentrations have been elevated (up to 0.126 mg/L) in all samples collected from these wells, including those collected prior to December of 1994. Thus, the arsenic is likely ambient.

In the southeast corner of the site, monitor well 131 has shown evidence of site-related contamination. This well is near the old mill site, adjacent to the underpass of State Route 171 (3300 South Street) beneath the Southern Pacific Railway

(Figure 3.1). There is a drain field at this underpass, and contaminated ground water in this area is discharged to the drainfield and then to a storm sewer and sump. The ground water is then pumped into a sewer that empties into the on-site South Vitro ditch. The underpass drainage system has created a local gradient reversal in the southeast corner of the site.

Two construction dewatering wells on the CVWRF site (wells 139 and 141) have sulfate and chloride concentrations similar to those in background ground water in the shallow channel deposits south of the site (HP-15 and -16). These wells appear to be pumping ambient (background) ground water from channel deposits. However, concentrations of molybdenum, uranium, and vanadium are relatively high (up to 0.43, 0.17, and 0.18 mg/L, respectively), reflecting the influence of desorption of contaminants during the flushing of the aquifer. Based on two sampling rounds, levels of these metals are decreasing as pumping continues.

A Hydropunch sample collected from the deepest channel sand encountered on site (HP-12, sample 412) had 5000 mg/L of sulfate and a sulfate to chloride ratio of about 7. Molybdenum concentrations were relatively high (0.09 mg/L). The high sulfate concentration relative to chloride suggests that this ground water has a significant proportion of uranium processing solutions (which had median sulfate to chloride ratios of about 19 [Markos and Bush, 1983]). However, uranium concentrations were relatively low (0.008 mg/L). By contrast, ground water at the same location but in a shallower channel deposit, had the same uranium level (0.008 mg/L) but lower sulfate (1200 mg/L) and molybdenum (0.03 mg/L) and a ratio of sulfate to chloride similar to that in background (between 1 and 3). This suggests that the shallower ground water is being diluted by ambient ground water at this location.

Screening of shallow ground water off-site during March 1996, indicates that site-related contamination is limited to areas close to the site. Sand deposits at four downgradient locations were sampled at shallow (about 12 ft [3.7 m]) and deeper (27 to 38 ft [8.2 to 12 m]) depths using a Hydropunch. Two of the locations were adjacent to the Jordan River (Hydropunch locations HP-2 and HP-4). At both locations, the lithology indicated floodplain and splay deposits. The low permeability of these deposits inhibits ground water flow. Sulfate, chloride, and uranium concentrations (ranges of 500 to 580, 390 to 505, and 0.003 to 0.012 mg/L, respectively) are similar to those in the Jordan River upstream of the site. There is no clear evidence of site-related contamination in these deposits.

Channel sands were encountered at locations HP-6 and HP-10. HP-6 is west-northwest of the site, between the site and Mill Creek. Shallow ground water at this location had relatively low concentrations of sulfate and chloride. Ground water levels at HP-6 indicate that there is a potential for this ground water to discharge to Mill Creek. Concentrations of molybdenum are low (0.02 mg/L) and similar to those in Mill Creek (about 0.01 mg/L) and do not clearly indicate site-related influences on water quality. At greater depth at the same location (21 ft [6.4 m]) and within the same channel deposit, concentrations of TDS, sulfate, and chloride are greater. But, the ratio of sulfate to chloride is again similar to that of

background, molybdenum concentrations are lower than the detection limit (0.01 mg/L), and uranium concentrations are low (0.004 mg/L). Thus, it is likely that ground water at depth at location HP-6 is also ambient rather than site-related.

A channel sand encountered north of Mill Creek (HP-10) and northwest of the site is on the floodplain of the Jordan River. Water levels at this location are higher than those to the south along Mill Creek and higher than those at the northeast corner of the site. The potential for ground water flow at HP-10 is west-southwest, toward the confluence of the Jordan River and Mill Creek. Therefore, ground water flow from the site and from Mill Creek does not influence this location. Ground water levels at this location are within about 1 ft (0.3 m) of the surface of the floodplain, and evapotranspiration appears to have had an effect on ground water quality. At both sampled depths (11 and 27 ft [3.3 and 8.2 m]), sulfate and chloride concentrations are elevated (about 2 to 3 times higher) relative to Mill Creek and the Jordan River. Molybdenum concentrations are below detection and uranium concentrations (0.018 mg/L) are similar to those in the Jordan River upstream of the site (0.015 mg/L), indicating no site-related influence on water quality. The relatively high sulfate and chloride concentrations at this location (1700 mg/L and 612 mg/L, respectively) are likely due to evapotranspiration of ground water at the shallow water table at HP-10 or recharge of evaporatively concentrated surface water in low areas.

The conceptual model for the magnitude and extent of contamination is that contaminated ground water is currently being pumped from the site by CVWRF, and channel deposits in the shallow aquifer are being flushed by natural ground waters in response to this pumping. This pumping, in conjunction with natural ground water gradients (controlled by water levels in Mill Creek and the Jordan River) and the distribution of channel deposits, has limited the extent of contamination to the site and areas just west of the site, in the vicinity of former monitoring wells 011 and 109.

Trace metals (uranium, molybdenum, and vanadium) adsorbed onto the aquifer matrix are desorbing during flushing of the channel deposits. Flushing appears to be most rapid in the shallower portions of the channel sands. Deeper portions, for example at 28 ft [8.5 m] in HP-12 on the site are less affected. However, in other areas, naturally high TDS water found near the base of some channel deposits is apparently flushing toward the site (monitor well 008). The depth of site-related contamination and ambient ground water having high TDS concentrations is limited by the depth of the channel sands (maximum depth of 35 ft [11 m] deposited by the Jordan River.

In the absence of dewatering at CVWRF, the Jordan River, located about 2000 ft (600 m) west of the site, is the natural line of discharge for ground water in the shallow unconfined aquifer downgradient of the site (Lambert, 1995). Thus, the downgradient extent of contamination is limited to the west by the Jordan River. Based on regional modeling of ground water flow in the Salt Lake Valley (Lambert, 1995), ground water moving downgradient from the site should tend to flow in the

direction of Mill Creek (west) toward its confluence with the Jordan River and discharge to the creek or river.

3.4 SURFACE WATER RESULTS

Except for a possible increase in uranium and molybdenum in Mill Creek attributable to site-related constituents in the treated sewage outfall, there appear to be no site-related impacts due to contaminated ground water discharge to Mill Creek or the Jordan River. The levels of uranium and molybdenum in Mill Creek, due to the treated sewage discharge, are less than ambient levels of these constituents in the Jordan River.

3.4.1 Mill Creek

Mill Creek surface water has been sampled three times during 1994 and 1995. Sampling locations are upstream of the site (location 180), north (downgradient) of the site but upstream of CVWRF effluent discharge (locations 181 and 192), and downstream (and downgradient) of both the site and CVWRF discharge (location 182) (Figure 3.1). In addition, CVWRF effluent, which is a significant source of water to Mill Creek (about 53 gal [200 L] per day), has been sampled (location 193). Results are shown in Table 3.6.

Surface water sampling of Mill Creek has detected no impacts of site-related constituents to Mill Creek water quality due to ground water discharge from the site. Decreases in calcium and sulfate and increases in sodium and chloride downstream of the site are attributable to CVWRF effluent discharge. The slight increase in uranium levels (from about 0.002 mg/L upstream to about 0.005 mg/L downstream) and molybdenum levels (from <0.01 to about 0.01 mg/L) downstream of the site are also attributable to the CVWRF discharge.

It is possible that site-related ground water is affecting levels of uranium and molybdenum in the CVWRF discharge. Beginning in January 1995, contaminated ground water was pumped from the shallow unconfined aquifer by CVWRF. Three wells were pumped to locally dewater the aquifer during construction of CVWRF facilities. These wells pumped continuously at about 100 to 300 gal (380 to 1100 L) per minute, for a total pumpage of about 1 million gal (3.8 million L) per day, or less. The water has been added to the sewage treatment circuit. Measured uranium levels from two of the dewatering wells (wells 139 and 141) varied from 0.036 to 0.166 mg/L. Molybdenum varied from 0.03 to 0.43 mg/L. Assuming 1) the highest of these uranium and molybdenum concentrations, 2) an average discharge of 53 million gal (200 million L) of treated sewage, and 3) the addition of 1 million gal (3.8 million L) of contaminated ground water to the treated sewage, then increases in uranium and molybdenum concentrations in the treated sewage can be calculated. The calculated increases are approximately 0.003 mg/L for uranium, and 0.008 mg/L for molybdenum. This calculation demonstrates that the dewatering is a possible explanation of the observed levels of uranium and molybdenum in the treated effluent.

Table 3.6 Surface water quality data for Mill Creek, Salt Lake City, Utah, site

Constituent	Upstream of site	West of railroad tracks		Treated sewage outfall	Downstream of treated sewage outfall
	180	181	192	193	182
Alkalinity	241	NA	196	196	198
Ammonium	0.13	NA	NA	NA	7.9
Arsenic	<0.005	NA	<0.005	<0.005	<0.005
Barium	<0.1	NA	NA	NA	<0.1
Calcium	102	NA	93	73	83
Chloride	59	67	54	196	155
Copper	<0.02	NA	<0.02	<0.02	<0.02
Copper (total)	<0.02	NA	<0.02	<0.02	<0.02
Iron	<0.03	NA	<0.03	0.04	0.04
Iron (total)	0.26	NA	0.33	0.10	0.17
Lead	<0.003	NA	<0.003	<0.003	<0.003
Lead (total)	<0.003	NA	<0.003	<0.003	<0.003
Magnesium	28	39	33	32	33
Manganese	0.02	NA	NA	NA	0.03
Molybdenum	<0.01	NA	<0.01	<0.01	<0.01
Molybdenum (total)	<0.01	<0.01	<0.01	0.01	0.01
pH	8.03	NA	7.91	7.12	7.11
Potassium	4.0	NA	NA	NA	21
Radium-226	0.1	NA	NA	NA	0.0
Selenium (total)	<0.005	<0.005	NA	NA	<0.005
Silver	<0.0006	<0.01	<0.0006	<0.0006	<0.0006
Silver (total)	<0.0006	NA	<0.0006	<0.0006	0.0005
Sodium	35	39	33	158	118
Strontium	1.1	1.1	NA	NA	0.94
Sulfate	165	173	137	148	141
TDS	729	NA	NA	NA	960
Uranium	0.001	0.002	0.0015	0.005	0.005
Uranium (total)	0.002	NA	0.0015	0.005	0.005
Vanadium	<0.01	NA	<0.01	<0.01	<0.01
Vanadium (total)	<0.01	NA	<0.01	<0.01	<0.01

Notes:

1. All data in mg/L except pH (standard units) and radium-226 (pCi/L).
 2. Data are for filtered samples, except for those constituents noted as total.
- NA - Not analyzed.

The observed levels of uranium and molybdenum in the effluent and Mill Creek are, however, well below criteria for the protection of aquatic life (DOE, 1995). Further, the observed levels of these constituents in the effluent and Mill Creek are less than or equal to ambient levels in the Jordan River.

3.4.2 Jordan River

Water samples were collected from the Jordan River during December 1994. Locations are upstream and upgradient of the site (location 185), downgradient of the site and upstream of the confluence of the river with Mill Creek (locations 188 and 184), and downstream of the confluence (location 183) (Figure 3.1). Data from these locations are in Table 3.7.

Table 3.7 Surface water quality data of Mill Creek and Jordan River, Salt Lake City, Utah, site

Contaminant	Jordan River			
	Upstream	Downstream		
	185	188	184	183
Calcium	135	139	141	86
Chloride	278	296	288	200
Magnesium	60	63	64	35
Molybdenum	0.01	0.01	0.01	<0.01
Selenium	<0.005	<0.005	<0.005	<0.005
Silver	<0.01	<0.01	<0.01	<0.01
Sodium	181	186	191	150
Strontium	1.25	1.29	1.28	0.79
Sulfate	339	349	340	147
Uranium	0.015	0.015	0.015	0.005

Notes:

1. Unfiltered water samples collected 6 December 1993.
2. All parameters reported in milligrams per liter.
3. Sampling locations 184, 185, and 188 are upstream of the site. Sampling location 183 is downstream.

Comparing surface water quality in the Jordan River upstream of the site to that downgradient of the site indicates that, during these two sampling events, there were no noticeable site-related impacts on Jordan River water quality. Concentrations of all constituents are nearly the same upstream and downstream of the site, except for an improvement in water quality downstream of the confluence with Mill Creek.

Below the confluence of the Jordan River and Mill Creek, the water quality of the Jordan River is nearly identical to that of Mill Creek during the 1993 sampling event. This probably means that the sample was Mill Creek water that had not yet mixed with the Jordan River water within the Jordan River channel. However, water quality in Mill Creek upstream and downstream of the site is better than that in the Jordan River, and water quality in the Jordan River can be expected to show some improvement downstream of the site.

4.0 LAND-USE EVALUATION

4.1 CURRENT AND PROJECTED USES OF THE UPPERMOST AQUIFER

As discussed later in this document, application for supplemental standards as a ground water compliance strategy at the Vitro site should ensure that current and reasonably projected uses of the affected ground water from the uppermost unconfined aquifer are preserved. In addition, this ground water strategy must protect public health and the environment from radiological and nonradiological hazards associated with historical uranium milling activities. Therefore, this section identifies existing and projected future uses of land and the shallow unconfined aquifer near the site. The identified current and reasonably projected future uses of ground water from the uppermost unconfined aquifer are then evaluated for the ground water's potential to adversely affect human health and the environment. Off-site upgradient/crossgradient (background), downgradient, and on-site land uses and associated shallow ground water uses are evaluated to assess whether the incremental contribution of site-related contamination degrades water quality to a point where it prevents use of the water for a current or projected purpose and whether any action would be necessary to protect this use.

The 128-ac (52-ha) processing site is in an urban area in the city of South Salt Lake. As the metropolitan area expanded, the area around the Vitro site changed from agricultural and limited residential use to commercial and industrial use. Projected uses are commercial and industrial.

4.1.1 Off-site land and shallow ground water uses

The CVWRF sewage treatment plant (on property adjacent to the central portion of the site) and the channel of Mill Creek are north of the site. Warehouses and Denver & Rio Grande Western Railroad property are farther to the north. The railroad also occupies the land on the east side of the site. This property extends as far as Interstate 15. A cement batch plant is at the southeastern corner of the site.

On the south, the site is bounded by 3300 South Street. The land across 3300 South Street is occupied mainly by car dealerships and junk car yards. A mixed residential and farming area, consisting of about 20 to 25 residences, is about 300 ft (90 m) away from the site's southwestern corner, across 3300 South Street. These are the nearest residences to the Vitro site. Livestock is kept by some of these residents. There is a planned correction facility to be located south of the western portion of the site.

On the west, the site is bounded by 900 West Street. The Jordan River affects land-use patterns further west. This area includes light industry, warehouses, commercial developments, and vacant land, with about 10 residences on 1100 West Street. An apartment complex, a correction facility, and a recreation area associated with the Jordan River are the other developments in the region.

A survey of ground water use in the area surrounding the former Vitro site was conducted using information from the Utah Division of Water Rights database (Point of Diversion Location Program) in March and April 1994 and December 1995. The area investigated is about 3 miles (5 km) downgradient and about 2 miles (3 km) upgradient or crossgradient of the site. Figure 4.1 shows the researched area .

Table 4.1 presents information on private ground water wells recorded by the Point of Diversion Location Program for the survey area. Because many ground water wells were drilled in the late 1800s and early 1900s and no field investigations have been conducted to confirm their present use, the data shown in Table 4.1 may overestimate the real number of active wells. Data shown in Table 4.1 indicate, however, that there is very little, if any, use of the unconfined (uppermost) aquifer within a 2- to 3-mile (3- to 5-km) radius of the site. The shallow unconfined aquifer is seldom used in the area for domestic (potable) purposes because the water is of poor quality (Seiler and Waddell, 1984; Hely et al., 1971).

About 1800 wells are reported in the database (Table 4.1) for the surveyed area, and 99 percent of them are completed at depths greater than 50 ft (16 m). These wells are screened in the confined aquifer (Hely et al., 1971; Lambert, 1995). As discussed in Section 2.4, the upward vertical hydraulic gradient between the confined and unconfined aquifers prevents downward water migration from the unconfined aquifer. The remaining 1 percent consist of 16 shallow wells, up to 50 ft (16 m) deep, which are believed to have been completed in the uppermost unconfined aquifer.

Only two shallow wells are west of the site (Table 4.1). These wells are in Section 22, Township 1 South, Range 1 West, and Section 27, Township 1 South, Range 1 West (Figure 4.1). Water rights were issued for their use as irrigation wells (Table 4.2). However, the two shallow wells, completed in 1929 and 1936, are west of the Jordan River. Because shallow ground water discharges into the Jordan River (Hely et al., 1971), their location prevents any site-affected ground water migration to these wells. A detailed examination of the state engineer's database and an intensive field investigation downgradient from the site to the Jordan River did not reveal any users of the shallow-unconfined aquifer ground water (DOE, 1995).

Fourteen shallow wells are located within about 2 miles (3 km) upgradient and crossgradient of the site and are used for domestic and agricultural purposes. These wells were drilled in early 1900s (except for one crossgradient well drilled in 1979).

No new shallow well development is anticipated downgradient of the site in the future due to predominantly commercial and industrial use of the land and the availability of city and county water supply systems.

4.1.2 On-site land and shallow ground water uses

The entire Vitro site is owned by the CVWRF, except for a 25-ft by 25-ft (8-m by 8-m) strip of land surrounding the municipal water well and an easement, which is

Figure 4.1
Area of Water Use Survey Upgradient, Crossgradient, and Downgradient
Salt Lake City, Utah, Site

MAC: SITE/SLC/SUPP STAND/SURVAREA

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Table 4.1 Private ground water wells in the Vitro site area

	Number of wells		
	50 ft and less	51 ft and deeper	Total number of wells
Upgradient	8	815	823
Crossgradient	6	427	433
Downgradient	2	530	532
Total number	16	1772	1788
Percent	1	99	100

Table 4.2 Possible uses of shallow private wells upgradient, crossgradient, and downgradient of the site

Ground water uses	Upgradient wells	Crossgradient wells	Downgradient wells	Total wells
Domestic	0	0	0	0
Domestic and agricultural	8	4	0	12
Agricultural	0	2	2 ^a	4
Total	8	6	2 ^a	16

^aBoth wells are west of the Jordan River from the site.

owned by the city of South Salt Lake. A 28-ac (11-ha) portion of the land in the southeast corner of the site has been leased and developed into a golf driving range. The city of South Salt Lake supplies irrigation water for about 25 ac (10 ha) of grass at the driving range. However, the treated water obtained from CVWRF may be used to irrigate the golf driving range in the future. Approximately 1 acre-foot of water is used for irrigation during the summer. About 0.2 to 0.9 inches (0.5 to 2.3 cm) of water are applied to the driving range each month from May through September (DOE, 1995).

In 1985, the CVWRF sold the water rights to four on-site water supply wells to the city of South Salt Lake. These wells had been owned by the Vitro Uranium Company. Three wells have been abandoned. The remaining well, a 10-inch cased well, is in the southeast portion of the site. The city had planned to develop this well as a source for the municipal water supply system (DOE, 1995a). Current

plans are to transfer the water rights to a off-site well and to abandon the on-site well (TAC, 1995).

The remaining on-site land is currently vacant but will probably be used for future expansion of the CVWRF. In the interim, the land may be leased for industrial, commercial, or recreational use.

4.2 RISK-BASED EVALUATION OF CURRENT AND PROJECTED LAND USES

This section evaluates whether current and projected future land uses and associated shallow ground water uses, downgradient off-site and on-site, are currently and will be protective of human health and environment. Off-site and on-site land uses and associated shallow ground water uses are evaluated separately.

4.2.1 Risk-based evaluation of off-site land uses

As discussed in previous sections, the site is in an urban area where commercial and industrial land use predominate. Based on the evaluation of the available information, it is anticipated that the land use near the site will not change substantially in the future. Therefore, this evaluation assumes current and projected future mixed commercial and industrial off-site land uses. This section evaluates both background and site-affected ground water to assess whether incremental contamination from the site would reduce already limited uses of the unconfined aquifer ground water any further.

Human health concerns

Currently, no one uses the uppermost unconfined aquifer ground water for any purpose downgradient of the site. Thus, no human health risks are associated with use of potentially site-affected shallow ground water downgradient of the site (see also DOE, 1995).

Because a few old shallow private wells are recorded for the areas upgradient and crossgradient of the site, this evaluation conservatively examines the possibility of using the uppermost unconfined aquifer for a drinking water source (Table 4.2). Due to their location, these shallow private wells have no potential to receive any site-affected shallow ground water. These wells might be completed in the areas where ambient non-site-related arsenic occurs in the unconfined aquifer (see Section 3.0). Therefore, this screening-level evaluation addresses the suitability of the off-site migrating site-affected shallow ground water as well as background (upgradient and crossgradient) ground water for drinking, using risk-based criteria or concentrations.

Table 4.3 compares concentrations of site-related constituents (DOE, 1995) and arsenic concentrations in background and off-site downgradient ground water of the unconfined aquifer to the no-observed-adverse-effect level (NOAEL) concentrations (benchmarks) developed for tap water (see Section 3.0 for definitions of background and off-site downgradient ground water). The results of this

Table 4.3 Comparison of off-site shallow ground water constituent concentrations to risk-based benchmark concentrations

Constituent	Background local range	Mean	Regional range	West MW 011(mean)	Off-site MW 109(mean)	North MW 008(mean)	Northwest MW 134	Risk-based benchmark concentrations nutritional ranges	NOAEL	LOAEL
Ammonium	6-56	20	NA	2.4	2.0	11	11		1.0	
Barium	<0.1-0.15	0.1	NA	0.02	0.01	0.20	0.47	200-600	2.6	
Calcium	11-76	37	40-190	57	88	266	119	200-600		
Chloride	56-342	186	100-850	968	1170	925	215	≤3000		
Fluoride	0.4-0.9	0.55	0.6-3.1	1.7	2.4	0.5	0.7		2.2	
Iron	0.04-0.25	0.12	<0.003-37	1.53	5.24	1.47	1.83	3-15	11.0	
Magnesium	32-75	51.5	34-110	180	271	260	96	20-200		
Manganese	0.03-0.53	0.2	<0.003-0.48	0.12	0.48	0.3	0.16		1.6	
Molybdenum	<0.01-0.01	<0.01	NA	0.15	0.07	0.01	0.02		0.18	
Potassium	26-59	41	9-38	50	93	42	33	250-1000		
Silver	<0.0002-<0.0	<0.01	NA	<0.01	<0.01	<0.01	<0.01		0.18	
Sodium	129-28	190	79-450	1260	1770	697	210	1200		
Strontium	0.2-0.8	0.39	NA	1.5	2.1	2.6	1.6		22	
Sulfate	<0.1-137	54	92-910	1420	2630	2405	450			600
Uranium (mg/L)	<0.0001-0.004	0.002	NA	0.061	0.23	0.004	0.057		0.11 (n)	
Uranium (pCi/L)	<0.07-3	1	NA	42	158	3	39		170 pCi/L (c)(1)	
Radium -226 (pCi/L)	0.0-0.5	0.3	NA	0.2	0.2	0.5	0.8		20 pCi/L (c)(2)	
Arsenic	0.02-0.13	0.063	<0.001-0.11	<0.01	<0.01	0.008	0.048		0.012 (n)	
									0.001 (c)(3)	

Note: All data in mg/L except as noted for uranium and radium-226 (pCi/L).

n - Based on noncarcinogenic effect.

c - Based on carcinogenic effect.

(1) This level could be associated with excess lifetime cancer risk of about 1 in 10,000.

(2) This level associated with excess lifetime cancer risk of 1E-06.

(3) This arsenic level could be associated with excess lifetime cancer risk of about 5 in 100,000.

NA - data not available.

NOAEL - no-observed-adverse-effect level.

LOAEL - lowest-observed-adverse-effect level.

comparison are expected to be conservative because 1) it is assumed that a person could drink 2 L of water a day; 2) NOAEL concentrations are based on the EPA oral reference dose, which usually incorporates a high safety factor (DOE, 1995); and 3) most NOAEL comparison benchmarks are based on oral reference doses (RfDs) established for long-term exposures.

This level of conservatism is needed to provide an upper bound on potential risks from unpredicted uses of the unconfined aquifer ground water in the future. Such uses may include future excavations that could result in transient surface exposure of the shallow ground water and that could lead to human contact with the water. Because the drinking water exposure pathway is associated with the highest potential exposure to inorganic ground water constituents, including metals and radionuclides, the potential risks from any other uses of ground water would be lower.

Ammonium and arsenic occur in both background and off-site downgradient ground water at concentrations exceeding NOAEL comparison values (Table 4.3). Ammonium levels are substantially higher than NOAEL comparison benchmarks only in local background ground water and off-site ground water north and northwest of the site. However, these levels of ammonium would not be associated with adverse effects, and they are well below the taste threshold (except for the upper end of local background concentrations range) of 35 mg/L (ATSDR, 1990). Although arsenic is not a site-related constituent of the shallow aquifer ground water, it is evaluated here because it is commonly present in background ground water in the site area. The arsenic levels exceed the NOAEL comparison criteria in background water and in water from one off-site well (134, northwest of the site). Again, although these levels of arsenic could be associated with adverse health effects following long-term use of ground water for drinking, no health problems are expected from incidental water ingestion.

Uranium is the site-related constituent that exceeded the comparison value only in one off-site well (109, west of the site). As with arsenic, the uranium level observed in water from this well would not result in adverse health effects following incidental consumption of the water.

Sulfate is the only constituent present at levels that could result in short-term effects, manifested as diarrhea, following ingestion of ground water from off-site locations downgradient of the site (west and north of the site but not to the northwest) and from some background locations (see the upper end of regional background water quality). However, sulfate-induced diarrhea would terminate after the cessation of exposure.

Other constituents listed in Table 4.3 are present in ground water at levels below their respective NOAEL comparison values or are essential nutrients and their levels observed in ground water fall within nutritional ranges.

In summary, the results of this analysis indicate that both background ground water and off-site downgradient ground water are not suitable for drinking water due to

their chemical characteristics and, therefore, are of limited use as defined in Section 5.0. In addition, data presented in Table 4.3 clearly indicate that site-related contamination does not substantially degrade water quality beyond natural conditions.

Environmental concerns

There are no known surface expressions of the site-affected ground water downgradient of the site. However, site-affected ground water discharges to Mill Creek, both naturally and temporarily through on-site dewatering wells (see Section 3.0). As discussed in Section 3.0, the incremental contamination from these discharges appears to have a negligible impact on surface water quality in Mill Creek. Therefore, no environmental harm is expected to be associated with this ground water now or in the future. However, there is a possibility that some terrestrial plants roots (e.g., trees) may extend into the shallow site-affected ground water. To assess the possibility of adverse effects to terrestrial plants from the above-mentioned scenario, the ground water constituent concentrations are compared to available screening benchmark concentrations (Table 4.4).

As can be seen in Table 4.4, based on available information, the ground water constituent concentrations would not adversely affect terrestrial plants. However, the salinity (concentrations of chloride, sodium, sulfate, and TDS) of the water could affect the growth of sensitive terrestrial plants (Wescot and Ayers, 1980). The salinity- associated effects, however, could potentially occur if plant root systems extend into the shallow site-affected ground water as well as the background ground water in certain areas.

4.2.2 Risk-based evaluation of on-site land uses

This section examines whether or not current and projected future on-site land uses could be associated with human and environmental exposures to the site-affected shallow ground water, and whether or not the potential exposures could result in adverse health effects.

As discussed in Section 4.1.2, a 28-ac (11-ha) portion of the site land (the southeast corner) has been developed into a golf driving range. The remaining portion of the site is currently vacant. Possible plans for the site land development could be associated with excavations and, consequently, a transient surface exposure of the shallow unconfined aquifer ground water. Another scenario considers permanent surface exposure of the shallow site-affected ground water in the form of a golf course pond.

Under these land use scenarios, ground water constituent concentrations could be lower than currently observed due to effects of precipitation. For the purpose of this evaluation, the constituent concentrations in the surface exposed ground water are conservatively assumed to be at the levels observed at present.

Table 4.4 Comparison of the off-site shallow ground water constituent concentrations to screening benchmark concentrations for terrestrial plants

Constituent	Off-site ground water concentration (mg/L)				Screening Benchmark Concentration for Plants
	West MW 011	Off-site MW 109	North MW 008	Northwest MW 134	
Ammonium	2.4	2.0	11	11	NA
Barium	0.02	0.01	0.20	0.47	NA
Calcium	57	88	266	119	NA
Chloride	968	1170	925	215	NA
Fluoride	1.7	2.4	0.5	0.7	5
Iron	1.53	5.24	1.47	1.83	10
Magnesium	180	271	260	96	NA
Manganese	0.12	0.48	0.3	0.16	4
Molybdenum	0.15	0.07	0.01	0.02	0.5
Potassium	50	93	42	33	NA
Silver	<0.01	<0.01	<0.01	<0.01	NA
Sodium	1260	1770	697	210	NA
Strontium	1.5	2.1	2.6	1.6	NA
Sulfate	1420	2630	2405	450	NA
Uranium	0.061	0.23	0.004	0.057	40
Radium -226	0.2	0.2	0.5	0.8	NA

MW = Monitor well.

NA = Not available.

Human health considerations

The above-mentioned future activities at the site could potentially result in human incidental dermal contact with site-affected shallow ground water. To determine if the dermal exposure of workers involved in excavations could result in potential adverse health effects, a screening level calculation was performed to estimate dermal absorption doses for the constituents of potential concern for human health (DOE, 1995) and compared to the NOAEL benchmarks (Table 4.5). Dermal exposure to radionuclides such as radium-226 and uranium-234 and -238 is not considered here because no alpha particles are expected to cross the skin barrier. Because chemical-specific absorption factors are not available for metals and other inorganic constituents listed in Table 4.5, it is assumed that they are absorbed across the skin at the same rate as water. This assumption is likely to overestimate any potential exposure contribution from dermal absorption. The results of the screening are shown in Table 4.5.

As can be seen in Table 4.5, exposure doses for the constituents of potential human health concern are well below their respective NOAEL benchmark values. No adverse health effects would be expected to result from dermal absorption associated with incidental occupational skin contact with site-related constituents present in the shallow ground water at currently observed levels.

Therefore, the results of this evaluation suggest that projected on-site excavations would be safe to potentially exposed workers under assumed exposure conditions.

Environmental concerns

A pond filled with site-affected ground water from the unconfined aquifer may create a hypothetical pathway into the aquatic and terrestrial ecosystem. Therefore, the concentrations of site-related constituents in the most contaminated ground water were compared to aquatic life and terrestrial plants screening benchmarks (Table 4.6).

The results of this analysis indicate estimated concentrations of barium, chloride, and uranium exceed the aquatic life acute and chronic benchmarks; while fluoride, iron, and strontium exceed chronic benchmarks only. These results indicate that an on-site pond, filled with the worst site-affected ground water, would not be acceptable for aquatic organisms.

Plants may be sending roots into the shallow unconfined aquifer because the water is available at a depth of 5 ft (2 m) or less in some on-site locations. Molybdenum is the only constituent exceeding screening benchmarks for terrestrial plants (Table 4.6). This constituent is just above the benchmark value and uncertainty is associated with its undesirable effects on plants at the observed concentrations (Will and Suter, 1994). However, the salinity-associated effects could prevent salinity-sensitive plants from growing on-site, if plant root systems extent into the shallow ground water.

Table 4.5 Incidental dermal contact with surface-exposed on-site ground water

Constituent	Exposure concentrations (mg/L)	Exposure dose (mg/kg-day)	NOAEL dose (mg/kg-day)
Chloride	2423	1.9E-3	NA
Fluoride	2.3	1.8E-6	6E-1
Magnesium	802.3	6.3E-4	3E-0
Manganese	0.36	2.8E-7	4.7E-2
Molybdenum	0.92	7.2E-7	5E-03
Sodium	2525	2.0E-3	NA
Sulfate	4678	3.7E-3	NA
Uranium	0.26	2.0E-7	3E-03

Equations and assumptions:

$$\text{Absorbed dose (mg/kg-day)} = \frac{C_w \times SA \times PC \times ET \times EF \times ED \times CF}{BS \times AT}$$

Where:

C_w = Constituent concentration in water (mg/liter); a constituent-specific value.

S_A = Skin surface area available for contact (cm²) (surface area at forearms and hands [1140 cm² + 840 cm² = about 2,000 cm²] for an adult man) assumed to come in contact with shallow ground water.

P_C = Dermal permeability constant for water (0.001 cm/hr)

E_T = Exposure time (1 hour per day)

E_F = Exposure frequency (10 days per year)

E_D = Exposure duration (2 years)

C_F = Volumetric conversion factor for water (1 liter/1000 cm³)

B_W = Body weight (70 kg adult men)

A_T = Averaging time (period over which exposure is averaged = 365 day × 2 years = 730 days)

Table 4.6 Comparison of on-site shallow ground water concentrations to screening benchmark concentrations for terrestrial plants and aquatic life

Constituent	On-site ground water concentration (mean)	Screening Benchmark Concentration		
		Terrestrial plants	Freshwater aquatic life	
			acute	chronic
Ammonium	11 ^a	NA	NA	NA
Barium	0.18	NA	0.068	0.0038
Calcium	81	NA	NA	NA
Chloride	2423	NA	860	230
Fluoride	2.3	5	19.2	1.18
Iron	1.4	10	NA	1.0
Magnesium	802	NA	NA	NA
Manganese	0.36	4	1.47	0.8
Molybdenum	0.92	0.5	NA	NA
Potassium	200 ^a	NA	NA	NA
Silver	<0.01	NA	NA	NA
Sodium	2525	NA	NA	NA
Strontium	1.39	NA	6.1	0.62
Sulfate	4678	NA	NA	NA
Uranium	0.26	40		

Note: All data are in mg/L.

^aMedian value for the on-site well with the highest concentration for that constituent. All other values are mean concentrations for the well having the highest levels for that constituent.

NA = Not analyzed.

Summary

Based on this analysis, the on-site land excavations involving incidental dermal exposure to the unconfined aquifer ground water would not be associated with increased health risks. However, building a pond filled exclusively with the most contaminated ground water would not be acceptable for aquatic organisms to live in. Any other uses of the site land, which were not considered here, should be evaluated upon determination.

5.0 APPLICABILITY OF SUPPLEMENTAL STANDARDS

5.1 DEFINITION OF SUPPLEMENTAL STANDARDS

The UMTRA Project is regulated by both EPA and U.S. Nuclear Regulatory Commission (NRC) regulations 40 CFR Part 192 and 10 CFR Part 40, respectively. The DOE must comply with EPA and NRC regulations for remediation of uranium mill tailings and associated ground water contamination and for long-term care. This section provides a review of the regulations pertaining to ground water compliance standards.

On 11 January 1995, the EPA published the final rule for the ground water standards, with which the DOE must comply as it conducts the UMTRA Ground Water Project. The EPA standards have two subparts that apply to the UMTRA Ground Water Project: Subpart B and Subpart C (EPA, 1995).

5.1.1 Subpart B - Background levels, maximum concentration limits, alternate concentration limits, monitoring, and natural flushing

Subpart B, "Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites," requires conducting remedial action at processing sites to ensure that the amounts of residual radioactive materials and associated hazardous constituents in ground water meet any one of the following three criteria:

- Background levels—Concentrations of constituents in nearby ground water that was not contaminated by processing activities.
- MCLs—EPA's maximum concentration of certain hazardous constituents for ground water protection. Hazardous constituents with MCLs that may be present in contaminated ground water at UMTRA Project sites include arsenic, barium, cadmium, chromium, lead, mercury, molybdenum, nitrate, radium, selenium, silver, and uranium.
- Alternate concentration limits (ACL)—Concentrations of contaminants that may exceed the MCLs; or, limits for those constituents without MCLs. If DOE demonstrates, and NRC concurs, that human health and the environment would not be adversely affected, the DOE may meet an ACL.

Subpart B also defines limited-use ground water. Ground water may be classified as limited-use if the TDS exceed 10,000 mg/L, there is widespread surrounding contamination that cannot be cleaned up using treatment methods reasonably employed in public water supply systems, or the quantity of ground water available to a well is less than 150 gal (570 L) per day.

5.1.2 Subpart C - Application of Supplemental standards

Subpart C, "Implementation," provides guidance for implementing methods and procedures that will reasonably assure the public that the provisions of Subpart B are satisfied.

Subpart C specifies eight conditions for which the DOE may apply supplemental standards to contaminated ground water (40 CFR §192.2). These conditions are supplemental to background levels, MCLs, or ACLs. The conditions that most likely would apply to the ground water near the Vitro site are the following:

- The remediation of ground water quality at any designated processing site is technically impracticable from an engineering perspective.
- The ground water is not a current or potential source of drinking water, in the absence of contamination from residual radioactive materials, due to the following:
 - Widespread, ambient contamination, not due to activities involving residual radioactive materials from a designated processing site, exists that cannot be cleaned up using treatment methods reasonably employed in public water systems. Ambient conditions caused by natural or human-induced conditions exclude contributions from residual radioactive materials.

The EPA final rule states that if supplemental standards are applied, the DOE must select and perform remedial action that comes as close to meeting the otherwise applicable standard as reasonably achievable. Supplemental standards must also ensure that current and projected uses of the affected ground water are preserved.

5.1.3 Demonstration of supplemental standard applicability

Background ground water quality in the shallow unconfined aquifer in the vicinity of the Vitro site supports the limited-use ground water classification. The ambient contamination in background ground water includes dissolved arsenic as well as particulate lead concentrations likely associated with smelters in the Salt Lake Valley.

Evaluation of water rights in the Central Valley area indicates that, in general, there are no current users of shallow ground water in the vicinity of the site or in areas downgradient of the site (that is, between the site and the Jordan River). The general lack of use of the shallow, unconfined ground water throughout the Salt Lake Valley reflects any combination of the following: 1) it yields water slowly, 2) it is readily contaminated by surface activities, and 3) there are readily available sources of good quality water from either public water supply systems or wells completed in the principal aquifer.

Potential future use of the shallow, unconfined aquifer downgradient of the site is unlikely. Present and future land use in the region of the site is primarily commercial and industrial and water is supplied by public water systems. A small number of residences are also currently served by public water supply systems.

Although arsenic-contaminated background ground water could be treated for arsenic with existing treatment techniques, it would not be reasonable to employ such a treatment of the unconfined aquifer because it has not been a viable water resource in the Central Valley area.

5.2 SUMMARY AND CONCLUSIONS

5.2.1 Site conceptual model

Hydrogeology

At the Salt Lake Vitro site, site-related ground water contamination occurs in fluvial channel deposits. These channel sand deposits occur in the upper 35 ft (11 m) of the shallow, unconfined aquifer. Dewatering at the CVWRF adjacent to the site has created a ground water sink in the area. Contaminated ground water on-site is being flushed from the channel sands as ambient (background) ground water migrates toward the site.

Trace metals (uranium, molybdenum, and vanadium) adsorbed onto the aquifer matrix are desorbing during flushing of the channel deposits. Limited data suggest that levels of contaminants are decreasing. Flushing appears to be most rapid in the shallower portions of the channel sands. Deeper portions, for example at 28 ft. [8.5 m] in HP-12 on the site, are less affected. However, in other areas, naturally high TDS water found near the base of some channel deposits is apparently flushing toward the site (monitor well 008).

Regional and local background water quality

Regional background water quality data for the confined aquifer indicate widespread occurrence of arsenic due, at least in part, to former smelters and landfills in Salt Lake Valley. Also, water quality in the shallow unconfined aquifer is affected by evapotranspiration and it is readily contaminated because of its proximity to the land surface.

Local background water quality varies with depth and lithology. Ground water in thin splay sands at a depth of about 30 to 40 ft (9 to 12 m) has low TDS, reflecting vertical leakage from the deeper confined aquifer and sulfate reduction associated with organic matter in the floodplain deposits. These sands are poor producers of ground water. By contrast, ground water in shallower channel sands has higher concentrations of TDS, reflecting surface recharge and evapotranspiration. Channel sands are better producers of ground water but have poorer quality water, with TDS concentrations of at least 1200 mg/L. Ambient arsenic occurs in the shallow unconfined aquifer near the site at all six background sampling locations. Arsenic

also occurs at these locations in both the deeper splay sands and the shallow channel sands.

Extent of site-related contamination

Dewatering at the CVWRF, in conjunction with natural ground water gradients (controlled by water levels in Mill Creek and the Jordan River) and the distribution of channel deposits, has limited the extent of contamination to the site and areas just west of the site (in the area of former monitoring wells 109 and 011). Recent field screening of ground water in other areas downgradient of the site did not encounter ground water having clear evidence of site-related contamination. In all cases, ground water samples had uranium concentrations within range of both background ground water and sources of surface recharge (the Jordan River and Mill Creek). The depth of site-related contamination and ambient ground water having high TDS concentrations is limited by the depth of the channel sands (maximum depth of 35 ft [11 m]).

5.2.2 Risk-based evaluation of contaminant effects on current and projected land uses

Effects on off-site land uses

A risk-based evaluation of contaminant effects on current and projected land use and associated ground water use off-site determined that site-related contamination does not substantially degrade water quality beyond ambient (background) condition. There are currently no uses of shallow ground water downgradient of the site, and no future use is anticipated due to the predominantly commercial and industrial use of the land and the availability of city and county water supply systems. Incidental consumption of either contaminated ground water or background ground water would not result in adverse health effects, other than short-term effects (manifested as diarrhea) from sulfate.

No environmental harm is expected to be associated with contaminated ground water off-site. Salinity of ground water could potentially affect the growth of sensitive terrestrial plants if the plant root systems extend into the shallow site-affected ground water, but the same is true of the background ground water in certain areas. Discharge of site-affected ground water naturally and through on-site dewatering has a negligible impact on water quality in Mill Creek and Jordan River.

Effects on on-site land uses

Risk-based evaluation of the effects of the human exposure to contaminated ground water on-site by dermal contact indicates exposure would not result in adverse health effects. Therefore, on-site excavations would be safe to potentially exposed workers under assumed exposure conditions.

An evaluation of environmental effects of on-site contaminated ground water determined that a pond filled with site-affected ground water would not be acceptable for aquatic organisms. Native plants, sending roots into the shallow

unconfined aquifer, are not likely to be adversely affected by site-affected ground water.

5.2.3 Possible use of the Vitro property

Construction activities at CVWRF, including on-site excavations and pumpage of ground water from the shallow aquifer, are not associated with increased human health risks or environmental harm due to the presence of site-affected ground water. A golf course would not be associated with increased human health and environmental concerns. However, building ponds filled exclusively with the most contaminated ground water would not be acceptable for aquatic organisms to live in. Other uses of site land, which are not considered here, should be evaluated upon determination.

5.2.4 Evaluation of the application of supplemental standards

Ground water in the shallow unconfined aquifer is limited-use ground water due to the widespread occurrence of arsenic that is not related to activities at the former processing site. Background ground water from the shallow unconfined aquifer has been found to contain arsenic at all six background locations and at all depths sampled, indicating its widespread occurrence. Arsenic concentrations have ranged up to 0.173 mg/L. Therefore, as discussed in Section 4.0, the shallow ground water is not a current or potential source of drinking water.

Sources of drinking water are readily available from the confined aquifer in the vicinity of the site. The shallow unconfined aquifer is not a viable ground water resource for drinking water. Therefore, it is not reasonable to clean up the shallow ground water using treatment methods employed in public water systems.

Ground water from the shallow aquifer in the vicinity of the site is not currently used. There are no wells currently, nor are there any known historical wells, completed in the shallow aquifer downgradient of the site. Future use of the shallow aquifer as a source of water near the site is not likely, based on historical trends and the rapid expansion of commercial and industrial facilities in the area. Therefore, the current and reasonably projected uses of site-impacted ground water would be preserved with the application of supplemental standards.

The application of supplemental standards at this site would be protective of human health. The only reasonable pathway of exposure to contaminated ground water is incidental dermal contact. This contact would pose no increased risks to human health.

The application of supplemental standards appears to be protective of the environment. There would be negligible site-related impacts to the environment due to the discharge of ground water to Mill Creek or the Jordan River and negligible impacts to terrestrial plants sending roots into site-affected ground water.

Flushing of contaminated ground water at the site is occurring due to dewatering at the CVWRF. This limits the potential for migration of site-affected ground water off-site. In the absence of dewatering, Mill Creek and the Jordan River would act as ground water flow boundaries (under natural conditions) and serve to limit potential migration of contaminants.

5.2.5 Uncertainties

While further refinements to the site conceptual model could be made, there are no critical data gaps pertaining to the classification of the uppermost aquifer at the Salt Lake City Vitro Processing site as limited use.

6.0 LIST OF CONTRIBUTORS

The following individuals contributed to the preparation of this report.

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CODE OF FEDERAL REGULATIONS

- 10 CFR 40, "Domestic Licensing of Source Material," U.S. Nuclear Regulatory Commission.
- 40 CFR Part 192, *Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings*, U.S. Environmental Protection Agency (1994).

ATTACHMENT 1

**SUMMARY OF SUPPLEMENTAL STANDARDS-RELATED
FIELD INVESTIGATION AT THE UMTRA VITRO
PROCESSING SITE
SALT LAKE CITY, UTAH**

Summary of Supplemental Standards-Related Field Investigation at the UMTRA Vitro Processing Site, Salt Lake City, Utah.

Purpose and Objectives

The purpose of the field work was to collect sufficient data to better understand 1) the spatial variations in vicinity background water quality in the shallow, unconfined aquifer (uppermost aquifer), 2) the nature and extent of the UMTRA related contaminants in the uppermost aquifer northwest of the site, and 3) the hydrogeology of the uppermost aquifer. This information was to be used to determine the potential applicability of proposed supplemental standards to the Salt Lake city site based on the presence of limited use ground water due to widespread ambient contamination not caused by activities involving residual radioactive materials at the designated processing site. Also, the information was to help answer questions pertaining to land use planning in the area.

To collect the data, the Hydropunch system was used in an exploratory manner for the collection of subsurface geotechnical data and ground water samples at ten locations. At each location, ground water samples were collected at two separate depths for a total of 19 ground water samples (ground water was not collected at one shallow-depth location because of poor yield). Information collected included lithology, water quality data, and static water levels. Well points were permanently installed adjacent to five of the Hydropunch locations.

Summary of Hydropunch Activities

Choice of sampling locations

To meet data objectives, 9 locations were chosen downgradient (to the north, northwest, and west) of the site and 8 locations were chosen upgradient (to the east and south) of the site. These preliminary locations were chosen to provide lateral coverage of the area. The preliminary locations included several alternate choices. Landowners were then contacted and, as anticipated, access was denied at several of the chosen locations upgradient and downgradient of the site. Ultimately, access agreements were obtained for 11 of the original 17 locations. Of these, one location to the northwest was determined to be inaccessible during because of its location in a low, muddy area adjacent to the Jordan River. The remaining 10 locations were determined to be accessible during the field effort, and sampled using Hydropunch. These included 5 upgradient and 5 downgradient locations.

Hydropunch sampling and well point installation

The Hydropunch field work was done in three phases: 1) collection of geotechnical data, 2) collection of ground water samples, and 3) installation of well points. During the first phase, cone penetrometer testing (CPT) data were collected from each location to a depth of 40 feet. Data collected were standard CPT data (ASTM D3441-86) for cone tip resistance, sleeve friction ratio and geotechnical parameters derived from these measurements. Logs of the data were generated by computer during operation of the tests. These logs were used to determine the depth and distribution of several lithologic

types - gravely sands, sands, interbedded (mixed) sand and silty clay, and silty clay (see attached logs). Pore pressure dissipation logs were used to determine the relative permeability of each lithologic type. Equilibrium pore pressure testing was used to measure the hydrostatic water at a given depth (see attached logs), and thus the approximate depth to the water table.

CPT data at location HP-1 were compared to borehole lithologic logs in adjacent monitoring well SLC-01-133. This comparison found good agreement between the penetrometer data and the borehole log. Surveyed water levels in Mill Creek and the Jordan River were compared to the water table computed from a pressure tests at adjacent Hydropunch locations. It was assumed that the water levels at these Hydropunch locations, both within 100 feet of the rivers, would closely reflect those of the nearby surface water. The results of this QC check indicated that the Hydropunch water level was accurate to no more than ± 2 ft [0.6m].

The second phase was to collect water samples from two depths at each location. It was anticipated, based on results from DOE monitoring wells, that ground water quality would vary with depth on and around the site. Therefore, the intent was to collect a sample near the surface (between 11 and 14 feet [3.3 - 4.3 m] below the surface), and at a greater depth (between 22 and 38 feet [6.7 - 11.6 m]). Results from the first phase of work were used to identify sands which could produce ground water and guide the choice of the two sampling depths. Samples were collected, filtered (0.45 micron filter), and analyzed for field parameters, including temperature, specific conductivity, pH, oxidation-reduction potential, alkalinity, sulfate, chloride, and molybdenum.

In one case (HP-1) no shallow sand was present, and only one sample was collected from the sand encountered (at about 35 ft [11.7 m]). Two samples were collected at each of the other locations. At 5 locations, two discrete sands were sampled; a shallow, relatively thick sand, and a deeper zone of relatively thin sands (locations HP-2, -4, -14, -15, and -16). Sampling of these two lithologic types determined that ground water in the shallower sands generally had higher chloride and sulfate than ground water in the deeper zone. In fact, sulfate was generally not present in the deeper zone. The deeper sand at location HP-4 was an exception, having water quality similar to that in the shallow sands (see attached table).

The thickest (up to 35 feet [11.7 m]) and coarsest sand units were encountered in the upper portions of the shallow aquifer at the remaining 4 locations (HP-6, -10, -12, and -13). In these cases, samples were collected from the most permeable zone located nearest the surface (zones at 11 to 13 ft [3.4 - 4.0 m]) and the most permeable zone closest the base of the sand unit (zones at 21 to 28 ft [6.4 - 8.5 m]). Sampling at these depths indicated that, at three locations, the deeper zone had the higher concentrations of sulfate and chloride. However, at location HP-10, water quality was similar in both the shallow and deep zones.

Field analyses for uranium were planned. However, problems with the spectroscopic equipment were encountered. Time constraints prevented fixing the problem and performing the analyses. However geology and available water quality results were sufficient to guide the placement of well points and to determine which samples should be analyzed for uranium in the lab.

Thursday, February 29

- 1. Tim Jackson arrives onsite.**
- 2. Performed utilities clearance with representatives from US West.**
- 3. Completed piezocone probe holes at locations 2, 4, 6, and 14. Each hole was punched to a depth of 40 ft BGS.**
- 4. Gary Black (Condi Foods) signed access agreement for location 10.**
- 5. Surveyed locations 2, 4, and 6, and water elevation of Mill Creek and Jordan River.**
- 6. Obtained authorization from Lee Colvin (Salt Lake County representative) to install additional HydroPunch holes on county property located south of 3300 South and east of 900 West. Current access agreement for location 14 will also cover proposed additional locations. Colvin requested that the county receive a summary of the data collected in this area.**
- 7. Performed reconnaissance of Condi Foods property. Determined that CPT rig can access this property to perform piezocone push, collect ground water samples, and install well point.**
- 8. Performed reconnaissance of county property described in item 5 above. Chose two potential background locations for piezocone data and water sample collection. Also discovered that the county has completed two well clusters (assumed to be used for pump tests) on the county property.**

Friday, March 1

- 1. Received authorization to install two additional background HydroPunch holes on county prison property.**
- 2. Set up account with Adler Construction to provide bulldozer services if CPT rig gets stuck in Vitro field.**
- 3. Completed piezocone probe holes at locations 1, 10, 12, 15, and 16. Each hole was punched to a total depth of 40 ft.**
- 4. Continued survey activities.**

Note: Alta Geo rig was able to access locations 1 and 12 in Vitro field. Bulldozer services were not needed.

Saturday, March 2

1. Collected and analyzed ground water samples from selected depths at location 14, 15, and 16. Ground water quality results are listed in Table 1. A sample duplicate and equipment blank was collected and is associated with sample ID 418 at location 15.

2. Continued survey activities.

Sunday, March 3

1. Collected ground water samples from selected depths at location 10, 13, and 14. Ground water quality results are listed in Table 1.

Average time to complete a sample round at each location is approximately 3.5 hrs. At least 2/3 of this time involves rig setup, tripping rod, decon activities, and hole grouting. Average analytical time for alkalinity, chloride, sulfate, molybdenum, and alkalinity is one hour per sample.

2. The PCMIA data link (used for uranium analyses) between the computer and spectrophotometer is not responding and uranium analysis cannot be performed. However, chloride, sulfate, and piezocone geology data are sufficient to screen ground water for lab analyses and well point completion.

Monday, March 4

1. Collected ground water samples from selected depths at locations 1 and 12 in Vitro field. Ground water quality results are listed in Table 1.

Entrance to Vitro field was muddy - CPT rig got stuck. A bulldozer was supplied by Adler Construction which logged approximately 15 minutes to tow out CPT rig. Not sure how much Adler will bill Jacob's. Left message with Bill Horodus (Adler project manager) to contact Terry Rodriguez to obtain PR No. for invoicing and discuss charges.

Late in the day, attempted to collect ground water sample from location 2 (Oxbow Prison Facility) at a depth of 11 ft BGS. Formation produced no ground water. Decided to secure rig with sample chamber still at depth and see if sample chamber fills overnight.

2. Tim Jackson successfully downloaded 3 of the 4 data loggers onsite. The batteries in the fourth data logger (DH-20) are apparently dead which prevented download of the data.

APPLIED RESEARCH ASSOCIATES INC.

New England Division
Data Acquisition System
Version 6.00

Pore Pressure Dissipation Test

Test Id : CPT-1
Depth = 34.ft

Filename : A01M607P.034
Total Test Duration 5. minutes_

CPT-2 ALTA GEO
OXBOW

02/29/96
GW

APPLIED RESEARCH ASSOCIATES INC.

New England Division
Data Acquisition System
Version 6.00

Pore Pressure Dissipation Test

Test Id : CPT-2
Depth = 15.ft

Filename : A29F605P.015
Total Test Duration 8. minutes_

The third phase was to install monitoring well points. The locations for the well points were driven by practical considerations. There was a greater need for water quality and water level data off-site as compared to on-site. Therefore all well points were completed off-site. Background locations south of the site, on a large tract of county land, were in an area of ongoing construction activities. These activities prevented the placement of well points at these locations. Therefore, well points were placed at all of the remaining 5 off-site locations.

Water quality data and lithologic data were used to determine the depth of well point screens at each location. Based on historical data, it was known that site-related contamination of shallow ground water is generally associated with higher concentrations of sulfate, chloride, molybdenum, and uranium. Therefore, well points were completed at each location in the sand having the highest concentrations of these site-related indicator parameters (except for uranium). For consistency in comparisons to background, the same criteria were used to place the background well point at location HP-13. These criteria were also used to choose ground water samples to be analyzed for uranium in the laboratory.

All 8 background water quality samples were analyzed for arsenic and uranium to provide a full set of data for determining the concentrations and spatial distribution of these constituents in background.

Results of field and laboratory water quality analyses are presented in the attached table. QC tests of field analyses indicate that all results are accurate to within at least 10 percent, based on analyses of standards, duplicate samples, equipment blanks, and spiked-samples.

Surface completion of all well points were made using flush-mount vaults having bolt-down manhole-type covers set in a 2 by 2 ft [0.6 by 0.6 m] concrete pad. The integrity of the well points was assured by placing locked caps on the riser within each man-hole vault.

All locations were surveyed using a surveyors level. The surveys used the top of PVC casing in existing monitor wells (known points) as benchmarks for elevations and locations. Closure on two known points indicated that the surveyed elevations are accurate to within 0.1 ft [0.03 m] elevation and the locations (northings and eastings) to within 50 ft [15 m]. Also, water level elevations were determined in each well point, and at several locations along Mill Creek and the Jordan River.

SLC Supplemental Standards-Related Field Work

Daily Field Activity Reports

Monday, February 26

1. Eric Larsen mobilizes to Salt Lake City.

Tuesday, February 27

1. Contacted Ron Roberts (CVWRF representative) and informed him of our field schedule.
2. Performed site reconnaissance of all proposed HydroPunch and well point locations.
3. Steve Liston (owner of Valley Forklift) signed access agreement for well point to be installed at location 13.
4. Met with Alta Geo staff and gave them a tour of each HydroPunch and well point location and performed utilities clearance with representative from Utah Power and Light.
5. Performed utilities clearance with representatives from SLC Sewer and Water and SLC Natural Gas.
6. Location 9 was determined to be inaccessible due to very muddy conditions.

Wednesday, February 28

1. Performed utilities clearance with representatives from South SLC Sewer and Water and SLC Suburban Sanitary District #1.
2. Determined depth and direction of 42-in.-diameter Grainger/CVWRF intercept conduit. Flagged location 2 approximately 3 ft south of center of conduit.
3. Completed piezocone probe hole at location 13. Hole was punched to a depth of 40 ft BGS. Obtained verification from property owner that telephone line was not in the vicinity of the hole location.
4. Performed reconnaissance of 40 acre tract of county property located south of 3300 South and east of 900 West.

Tuesday, March 5

1. Collected ground water samples from selected depths at locations 2, 4, and 6. Ground water quality results are listed in Table 1.

Returned to location 2 (Oxbow Prison Facility); no ground water had collected in sample chamber which had sat overnight at a depth of 11 ft BGS. Pushed chamber to 16 ft BGS and collected a ground water sample from that depth.

By the end of the day at location 6, attempted to collect a ground water sample from 22 ft BGS. Very little ground water was flowing into sample chamber. Secured rig with chamber at depth to see if it fills overnight.

2. Tim Jackson ordered a battery pack for the DH-20 data logger to allow data logger to be downloaded. Jackson also performed analyses for chloride, sulfate, and molybdenum on ground water samples collected on Monday (3/4).

Wednesday, March 6

1. Collected last ground water sample from 21 ft BGS at location 6 (Sample ID 407). Formation production was very poor. Suspect sample chamber was not fully open or clogged. Ground water quality results are listed in Table 1.

2. Installed 1^{7/8} in. I.D. well points at locations 2, 4, 6, and 13. Completion depths listed below.

<u>Location</u>	<u>Casing Depth (ft)</u>	<u>Screened Interval (ft)</u>
2	16.0	9.5 - 16.0
4	24.0	17.5 - 24.0
6	23.0	16.5 - 23.0
13	22.0	15.5 - 22.0

Well screen and riser sections were 1 meter in length. Each well screen consisted of two 1 meter sections. Well point installation proceeded very smoothly. Average time to install each well point was approximately 1.5 hrs.

3. Called Gary Black (representative for Condi Foods property on which well point 10 will be installed) - verified that the proposed location for well point 10 was on Condi property.

4. Battery pack for the DH-20 data logger arrived.

5. Jackson completed analyses for chloride, sulfate, and molybdenum on all ground water samples collected. He shipped all selected sample to respective offsite laboratories for arsenic and uranium analyses.

6. Continued survey activities.

Thursday, March 7

1. Installed well point 10. Casing depth at 31.0 ft BGS; screened interval at 25.5 - 31.0 ft BGS.
2. Performed alkalinity analyses on all ground water samples collected.
3. Attempted to download data from DH-20 data logger. Experienced communication problems between data logger and laptop computer. Decided to remove data logger and ship it back to Albuquerque for download and repair.
4. Completed survey loop. Data includes location and elevation of all well points installed.
5. Measured water levels in all well points.

<u>Location</u>	<u>Depth to Water (ft BTC)</u>	<u>Comments</u>
WP-2	5.79	Water level stabilized
WP-4	23.90	Screen clogged - well requires development
WP-6	6.94	Water level stabilized
WP-10	3.55	Water level stabilized
WP-13	18.06	Water level equilibrating

6. Installed well vaults and locking well caps; poured concrete pads at all well point locations.
7. Demobilized.

Figure 1.
 Site Map Showing
 Logging and Sampling Locations
 Salt Lake City, Utah, Vitro Processing Site

MAC. SITE/SLC/SOW/BASE

Table 1 Ground water quality results, Salt Lake City Hydropunch Investigation

Location	Sample ID	Depth (ft)	Temp. (C)	Specific Conductance (µmhos/cm)	pH	Oxydation-reduction potential (mvolts)	Alkalinity (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Molybdenum (mg/L)	Uranium (mg/L)	Arsenic (mg/L)
Upgradient												
13	408	13	11.1	1120	7.43	NA	490	90	280	0.01	0.002	0.029
	409	22	14.3	6730	6.94	54	661	1320	4000	0.03	0.021	0.053
16	416	11	11.1	1536	7.45	114	461	345	370	<0.01	0.007	0.012
	417	35	12.1	875	7.82	60	476	98	0	<0.01	<0.001	0.173
15	418	14	4.4	1452	6.84	110	495	290	340	<0.01	0.003	0.009
	419	35	11.3	670	7.83	85	44	47	2	<0.01	<0.001	0.023
14	414	11	9	1676	7.35	126	493	530	430	0.01	0.010	0.021
	415	35	11.2	476	7.79	-12	329	17	0	<0.01	<0.001	0.082
Downgradient												
1	401	37	13.2	537	8.07	118	337	18	0	<0.01	na	na
12	412	12	9.3	3250	7.04	48	732	498	1200	0.02	0.008	na
	413	28	13.7	7930	7.23	-45	1883	750	5000	0.09	0.008	na
2	402	16	11.4	2450	7.19	60	505	505	580	<0.01	0.012	na
	403	38	12.8	421	8.03	-199	272	130	2	<0.01	na	na
4	404	12	11.8	2230	6.8	99	950	393	570	0.03	na	na
	405	24	14.2	2270	7.24	71	560	390	500	0.02	0.003	na
6	406	11	9.5	764	7.04	91	430	54	120	0.02	na	na
	407	21	9.0	2820	7.51	-83	505	498	1300	<0.01	0.004	na
10	410	11	10.7	4600	7.01	-11	579	1058	1700	<0.01	na	na
	411	27	12.2	4930	7.12	-54	612	1115	1650	<0.01	0.018	na

CPT-1 ALTA GEO
WELL 133

03/01/96
GW

CPT-1
WELL 133

ALTA GEO

03/01/96

GW

CPT-4 ALTA GEO
JORDAN RIVER TRAIL

02/29/96
GW

APPLIED RESEARCH ASSOCIATES INC.

New England Division
Data Acquisition System
Version 6.00

Pore Pressure Dissipation Test

Test Id : CPT-4
Depth = 18.ft

Filename : A29F607P.018
Total Test Duration 10. minutes_

CPT-6 ALTA GEO
PAUL BUEHNER

02/29/96
GW

APPLIED RESEARCH ASSOCIATES INC.

New England Division
Data Acquisition System
Version 6.00

Pore Pressure Dissipation Test

Test Id : CPT-6
Depth = 15.ft

Filename : A29F603P.015
Total Test Duration 8. minutes_

APPLIED RESEARCH ASSOCIATES INC.

New England Division
Data Acquisition System
Version 6.00

Pore Pressure Dissipation Test

Test Id : CPT-6
Depth = 35.ft

Filename : A29F603P.035
Total Test Duration 5. minutes_

CPT-10 ALTA GEO
COUNTY FIELD

03/01/96
GW

APPLIED RESEARCH ASSOCIATES INC.

New England Division
Data Acquisition System
Version 6.00

Pore Pressure Dissipation Test

Test Id : CPT-10
Depth = 18.ft

Filename : A01M601P.018
Total Test Duration 5. minutes_

CPT-10 ALTA GEO
COUNTY FIELD

03/01/96

GW

CPT-12 ALTA GEO
VITRO FIELD

03/01/96
GW

APPLIED RESEARCH ASSOCIATES INC.

New England Division
Data Acquisition System
Version 6.00

Pore Pressure Dissipation Test

Test Id : CPT-12 Filename : A01M609P.018
Depth = 18.ft Total Test Duration 13. minutes_

CPT-13 ALTA GEO
VALLEY FORKLIFT

02/28/96
GW

CPT-13 ALTA GEO
VALLEY FORKLIFT

02/28/96
GW

APPLIED RESEARCH ASSOCIATES INC.

New England Division
Data Acquisition System
Version 6.00

Pore Pressure Dissipation Test

Test Id : CPT-13 Filename : A28F601P.015
Depth = 15.ft Total Test Duration 8. minutes_

CPT-14 ALTA GEO
CONSTRUCTION OFFICE

02/29/96
GW

APPLIED RESEARCH ASSOCIATES INC.

New England Division
Data Acquisition System
Version 6.00

Pore Pressure Dissipation Test

Test Id : CPT-14
Depth = 15.ft

Filename : A29F601P.015
Total Test Duration 21. minutes_

APPLIED RESEARCH ASSOCIATES INC.

New England Division
Data Acquisition System
Version 6.00

Pore Pressure Dissipation Test

Test Id : CPT-14
Depth = 32.ft

Filename : A29F601P.032
Total Test Duration 6. minutes_

CPT-15 ALTA GEO
SW CORNER COUNTY PRISON

03/01/96

GW

APPLIED RESEARCH ASSOCIATES INC.

New England Division
Data Acquisition System
Version 6.00

Pore Pressure Dissipation Test

Test Id : CPT-15
Depth = 15.ft

Filename : A01M603P.015
Total Test Duration 16. minutes_

CPT-16 ALTA GEO
SE CORNER COUNTY PRISON

03/01/96

GW

CPT-16 ALTA GEO
SE CORNER COUNTY PRISON

03/01/96

GW

APPLIED RESEARCH ASSOCIATES INC.

New England Division
Data Acquisition System
Version 6.00

Pore Pressure Dissipation Test

Test Id : CPT-16
Depth = 35.589 ft

Filename : A01M605
Total Test Duration 9.100 minutes_

EQ PP. = 12.0 psi

Survey Results, Salt Lake City HydroPunch Field Effort

Sta.	Point	Description	Rod	Chord		Azimuth degrees	Distance feet	Easting	Northing	Elevation feet
L		Station L						1,839,654	817,608	4241.7
	L1	Well 134 PVC casing	-2.19	3.07	1.32	170	175	1,839,684	817,436	4239.5
	L2	900 W bridge - pt A1	-4.51	4.92	4.10	310	82	1,839,591	817,661	4237.2
	L3	WL in Mill Creek at L2/A1	-13.89	na	na	310		1,839,591	817,661	4227.8
A		Station A						1,838,930	817,719	4239.8
	A1	900 W bridge - pt L2	-2.64	5.96	2.64	95	664	1,839,591	817,661	4237.2
	A2	SE corner of RR bridge	-3.94	4.86	3.02	280	184	1,838,748	817,751	4235.9
	A4	CPT-6	-5.89	6.85	4.91	241	194	1,838,760	817,625	4233.9
L		STA M						1,838,608	817,726	4240.4
	M1	Backshot to A2	-4.53	5.25	3.82	12	143	1,838,748	817,751	4235.9
	M2	WL Mill Creek at RR bridge	-12.8	5.76	5.43	80	33	1,838,640	817,732	4227.6
	M3	WP-6 top of PVC casing	-6.41	na	na	na	0	1,838,760	817,625	4234.0
		WL WP-6	-6.13	na	na	na		1,838,760	817,625	4227.9
D		Station D						1,838,391	817,925	4242.6
	D1	Backshot to A2	-6.67	8.67	4.69	116	398	1,838,748	817,751	4235.9
	D2	backshot to C2	-5.02	8.76	1.3	182	746	1,838,365	817,180	4237.5
	D3	RR behind Smith's	-8.72	11.4	6	36	540	1,838,708	818,362	4233.8
	D4	WL, Mill Creek, by STA D	-15.18	15.43	14.91	202	52	1,838,371	817,877	4227.4
	D5	WL confluence Jordan - Mill Cks	-15.2	15.2	12.3	297	580	1,837,874	818,188	4227.4
E		STA E						1,838,583	818,951	4237.2
	E1	Backshot to D3	-3.4	6.42	0.4	168	602	1,838,708	818,362	4233.8
	E2	Levy, NW corner Condie Prop	-1.89	4.66	1.89	257	554	1,838,043	818,826	4235.3
	E3	RR, by NE corner Condie Prop	-6.09	6.59	5.58	75	101	1,838,681	818,977	4231.1
	E4	CPT-10 (approximate)	-4.91	na	na	30	270	1,838,718	819,185	4232.3
P		Station P						1,838,557	818,928	4236.9
	P2	Backshot to pt D3	-3.02	5.95	3.02	165	586	1,838,708	818,362	4233.8
	P1	WP-10 top of PVC casing	-4.75	4.855	4.64	30	22	1,838,567	818,947	4232.1
	P3	Low spot on floodplain	-7.16	7.7	6.64	191	106	1,838,536	818,824	4229.7
		WL WP-10	-3.55	na	na	na		1,838,536	818,824	4228.6
C		Station C						1,838,043	816,587	4241.7
	C2	Turn Pt = D2	-4.18	7.55	4.18	28.5	674	1,838,365	817,180	4237.5

Survey Results, Salt Lake City HydroPunch Field Effort

	C1	Backshot to B3	-6.1	7.64	4.56	204	308	1,837,918	816,306	4235.6
	C3	WL, Jordan River by CPT-4	-13.17	13.97	12.38	320	159	1,837,941	816,709	4228.5
	C4	CPT-4	-4.28	4.95	3.625	315	133	1,837,949	816,681	4237.4
O		Station O						1,838,024	816,545	4241.4
	O1	Backshot to B3	-5.74	7.05	4.43	204	262	1,837,918	816,306	4235.6
	O2	WP-4 top of PVC riser	-4.27	4.48	3.17	329	131	1,837,957	816,658	4237.1
	O3	WL WP-4 top of PVC riser	-23.9	Not equilibrated					na	
B		Station B						1,837,971	815,930	4239.8
	B3	Turnpoint = C1	-4.15	6.05	2.25	352	380	1,837,918	816,306	4235.6
	B1	CPT-2	-4.56	5.13	3.4	210	173	1,837,884	815,780	4235.2
	B2	Benchmark - manhole cover	-4.64	5.185	4.09	200	110	1,837,933	815,827	4235.1
N		Station N						1,837,915	815,806	4241.0
	N2	backshot to pt B2	-5.85	5.99	5.71	41	28	1,837,933	815,827	4235.1
	N1	WP-2 top of PVC	-6.03	5.36	5.17	337	19	1,837,907	815,823	4234.9
	N3	WL WP-2 below top of PVC	-5.03	na	na	na		1,837,907	815,823	4229.9
F		Station F						1,840,165	814,938	4240.2
	F2	MW 133 top PVC casing	-1.35	3.94	1.35	214	518	1,839,876	814,508	4238.8
	F1	GL at MW 133	-3.64	6.22	1.05	214	517	1,839,876	814,509	4236.5
	F3	CPT-1	-3.73	6.23	1.23	212	500	1,839,900	814,514	4236.5
	F4	Well 135 Top of PVC casing	-4.09	7.8	0.35	32.5	745	1,840,565	815,566	4236.1
		Expected well 135						1,840,523	815,578	4236.1
		Error								0.0
	F5	GL well 135	-6.33	10	2.68	32.5	732	1,840,558	815,555	4233.9
	F6	Fence, west side of site	-5.12	6.92	3.32	287	360	1,839,821	815,043	4235.1
	F7	CPT-12	-5.32	5.66	4.98	9	68	1,840,176	815,005	4234.9
G		Station H						1,840,369	814,279	4246.2
	G1	Backshot to F1	-9.65	12.37	6.93	295	544	1,839,876	814,509	4236.5
	G2	4" County Well, top of PVC	-4.32	7.13	1.49	211	564	1,840,079	813,796	4241.9
H		Station H						1,839,949	813,475	4248.8
	H1	Backshot to G2	-6.94	8.66	5.2	22	346	1,840,079	813,796	4241.9
	H2	CPT-14	-8.5	10.65	6.35	326	430	1,839,709	813,831	4240.3
	H3	Turnpt	0	1.76	0	186	352	1,839,912	813,125	4248.8

Survey Results, Salt Lake City HydroPunch Field Effort

I		Station I					1,840,003	812,938	4254.6
	I1	Backshot to H3	-5.76	6.81	4.73	334	208 1,839,912	813,125	4248.8
	I3	CPT-16	-5.79	8.13	3.52	96	461 1,840,462	812,890	4248.8
	I4	CPT-15	-5.57	7.28	3.88	259	340 1,839,670	812,873	4249.0
	I2	4" County well top PVC	-4.28	4.73	3.83	15	90 1,840,027	813,025	4250.3
J		Station J					1,842,561	816,829	4243.6
	J2	MW 007 - GL	-5.75	6.13	5.37	41	76 1,842,610	816,886	4237.9
	J1	Mainhole cover by WP-13	-1.24	3.26	1.24	100	404 1,842,958	816,759	4242.4
K		Station K					1,842,927	816,790	4248.0
	K1	Backshot to J1	-5.61	5.83	5.39	135	44 1,842,958	816,759	4242.4
	K2	Water level, Mill Creek bridge	-13.85	14.02	13.68	354	34 1,842,924	816,824	4234.1
Q		Station Q					1,842,974	816,711	4247.1
	Q2	Backshot to J1	-4.69	4.94	4.44	342	50 1,842,958	816,759	4242.4
	Q1	WP-13	-5.26	4.67	4.26	353	41 1,842,969	816,752	4241.8
		WL WP-13	-18.06 not equilibrated						
R		Station R - water levels in MW 108					1,840,441	817,579	4242.9
	R1	MW 108 top of PVC riser	-8.97	9.5	8.44	0	106 1,840,441	817,685	4234.0
	R2	GL at MW 108	-8.97	8.45	8.39	0	6 1,840,441	817,585	4234.0
	R3	Low spot by well	-10.65	11.47	9.8	346	167 1,840,400	817,741	4232.3
	R4	Water level in Mill Creek	-13.25	13.35	13.14	180	21 1,840,441	817,558	4229.7
		WL in MW 108	-7.67 na	na	na		1,840,441	817,685	4226.3