Ground Water Compliance Action Plan for the Salt Lake City, Utah UMTRA Project Site

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E Report of Ground Water Monitoring (DOE 1996)
F Ground Water Mound Resultant from Golf Course Irrigation (DOE 1993)
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H Results of 1999 Field Investigations
I Notice of Residual Radioactive Contamination

1.0 Introduction

This Ground Water Compliance Action Plan (GCAP) will serve as a stand-alone modification to the *Final Environmental Impact Statement -- Remedial Actions at the Former Vitro Chemical Company Site, South Salt Lake, Salt Lake County, Utah* (RAP) (DOE 1984) since no section in the RAP refers specifically to ground water restoration and the deferral of compliance with Subpart B of 40 CFR 192. The initial standards were released by the U.S. Environmental Protection Agency (EPA) in January 1983, just before the RAP was issued, and at that time the focus was primarily on compliance with Subpart A of 40 CFR 192 at the disposal site. The GCAP will be the U.S. Nuclear Regulatory Commission (NRC) concurrence document for compliance with Subpart B of 40 CFR 192 for the Salt Lake City processing site.

The proposed compliance strategy for the Salt Lake City site is based on the "compliance strategy selection framework" following the steps prescribed in Section 2.1 of the *Final Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project* (PEIS) (DOE 1996c) (Figure 1). The proposed action is presented in Section 2.0 of this GCAP because a Site Observational Work Plan (SOWP) was not prepared for the site. Section 3.0 presents implementation plans for monitoring at the site. National Environmental Policy Act (NEPA) issues and environmental concerns are also addressed in Section 4.0 of the GCAP and this information has been made available to public officials and citizens in the area.

2.0 Ground Water Compliance

To achieve compliance with Subpart B of 40 CFR 192 at the Salt Lake City processing site the DOE proposed action is no remediation and application of supplemental standards based on "limited use ground water" (40 CFR 192.21(g)). Ground water in the uppermost aquifer is not a current or potential source of drinking water because widespread, ambient contamination not due to activities involving residual radioactive materials from the designated processing site exists that cannot be cleaned up using treatment methods reasonably employed in public water systems (40 CFR 192.11(e)(2)). The applicability of supplemental standards at the Salt Lake City site has been presented in the *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* (DOE 1996b) (Attachment A), and the potential risk to human health and the environment has been addressed in the *Baseline Risk Assessment of Ground Water Contamination at the Uranium Mill Tailings Site Near Salt Lake City, Utah* (DOE 1995a) (Attachment B). Hydrogeologic information in this document is principally derived from the position paper mentioned above (DOE 1996b). This proposed action has been determined by applying the compliance strategy selection framework from the PEIS, consisting of five evaluative steps that are discussed below.

2.1 Assessment of Environmental Data

The first step in the decision process was an assessment of both historical and new environmental data collected to characterize hydrogeological conditions and the extent of ground water contamination related to uranium processing activities at the site. The site is approximately

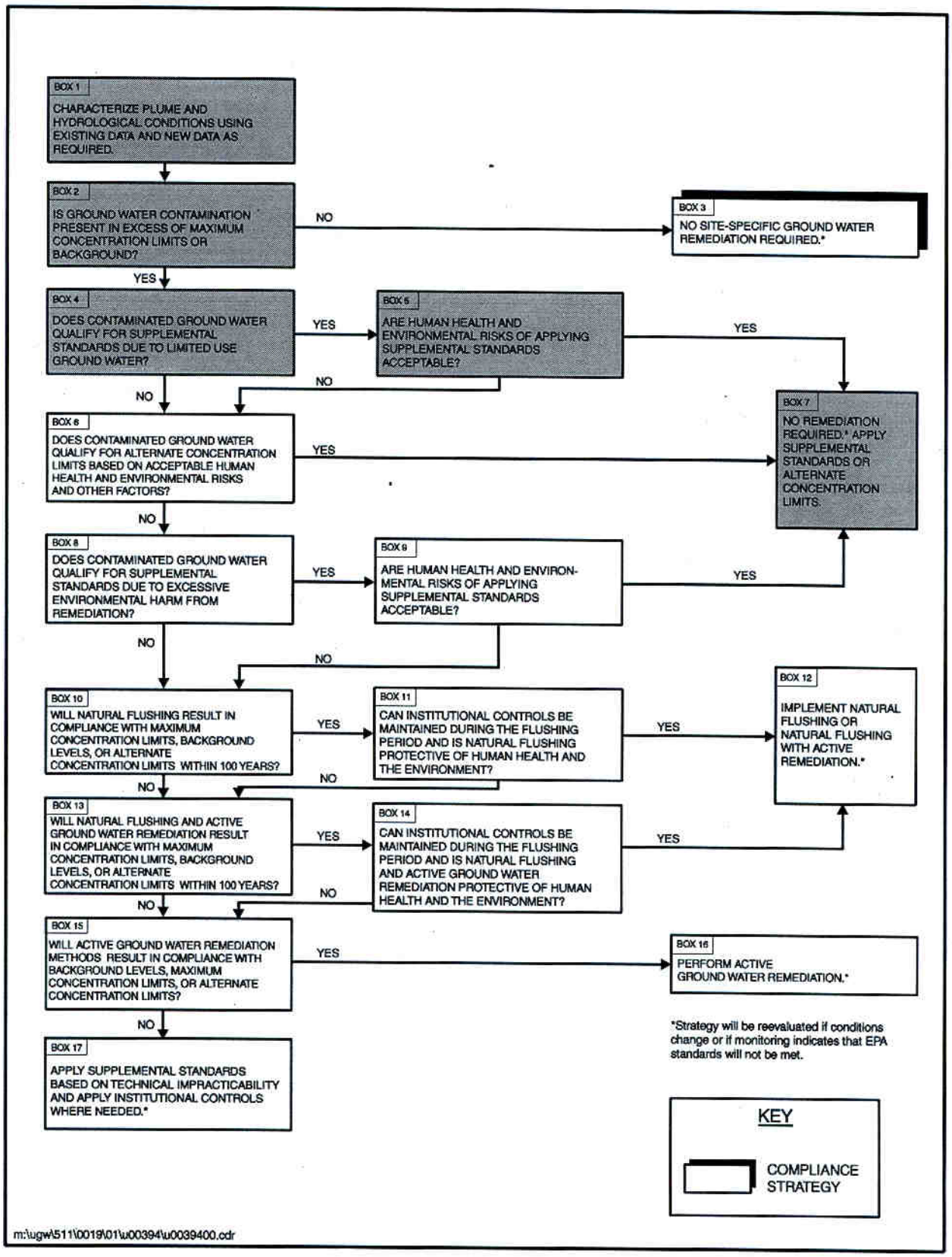

Figure 1. Compliance Selection Framework, Salt Lake City, Utah, Site

4 miles south-southwest of downtown Salt Lake City in an area dominated by commercial and industrial facilities. The area is characterized by very gentle topography in which anthropogenic changes are more apparent than the original topographic features (Figure 2). Surface remedial action at the Salt Lake City site (1984-1987) consisted of removal of uranium mill tailings and tailings-contaminated materials to a disposal cell at Clive, Utah. After surface remediation, the upper 4 to 13 feet (ft) of soil were replaced with clean sandy-gravel fill material. The lithology underlying this fill consists of approximately 700 ft of unconsolidated Quaternary lacustrine and fluvial deposits with minor alluvial overburden. The former processing site is owned by the Central Valley Water Reclamation Facility (CVWRF). The south part of the site has been developed into a golf driving range with a nine-hole golf course currently under construction. The northwest part of the site will be used for expansion of the CVWRF complex.

Ground water occurs in a shallow unconfined system (uppermost aquifer) and a deeper confined system. The shallow unconfined aquifer extends down to approximately 50 ft, with static water levels at 5 to 10 ft below ground level. The deeper confined aquifer begins approximately 70 ft below the ground surface and ground water is under artesian pressure. The two aquifers are separated by approximately 20 ft of interbedded layers of low-permeability clays and silts, and the vertical hydraulic gradient is upwards toward the shallow aquifer. Ground water in the shallow unconfined aquifer flows predominantly to the west-northwest and discharges to Mill Creek and the Jordan River. Mill Creek is a perennial stream that originates in the Wasatch Mountains to the east and flows westerly across the northern boundary of the CVWRF and the former processing site. Ground water is recharged from precipitation and seasonal irrigation (approximately 8 months) of the golf course in the south part of the site (using processed water from the CVWRF plant for the fairways and potable water for the greens).

The ground water flow system beneath the site is periodically affected by CVWRF pumping activities and by the storm drain lift station at the railroad underpass on 3300 South Street near the southeast corner of the site. These activities alter the normal ground water flow system and result in discharge of potentially contaminated ground water to surface water. Ground water is pumped from two dewatering wells by CVWRF for construction and maintenance purposes. One well is pumped continuously at approximately 150 gallons per minute and the other well is pumped as needed. The area is also dewatered periodically for construction projects. Extracted ground water is sent through the treatment plant and then discharged into Mill Creek. Ground water that enters the storm drain sump is pumped mostly through an underground pipe system which ultimately discharges to Mill Creek north of the site. There is a 150-ft section of this discharge pathway that is open to the surface just south of the CVWRF Administration Building.

DOE investigation has shown that ground water in the uppermost aquifer has been contaminated by processing of radioactive materials at the Salt Lake City site and the constituents of potential concern (COPC) with established maximum concentration limits (MCLs) are molybdenum and uranium. Concentrations of arsenic exceed its MCL in ground water in background and crossgradient monitor wells, but are not related to activities at the former processing site (see Section 2.3 below).

2.2 Ground Water Contaminants

The second step compares the COPCs in ground water with MCL or background levels (see Ground Water Quality Data by Parameter in Attachment G). Results of water quality sampling in the shallow unconfined aquifer in August 1998 indicate that concentrations of molybdenum were

below the MCL of 0.10 milligrams per liter (mg/L) and concentrations of uranium were just above the MCL of 0.044 mg/L in monitor wells 134 and 136 (the four existing monitor well locations are shown in Figure 2 and other decommissioned well locations are shown in figures in DOE 1996b). Results of water quality sampling in October 1999 indicate that concentrations of molybdenum were below the MCL in monitor well 134 and just above the MCL in monitor well 144. Concentrations of uranium were just above and below the MCL in monitor wells 134 and 144, respectively. Concentrations of molybdenum and uranium were near or below the detection limit in ground water in the deep confined aquifer (monitor wells 143 and 145). The vertical hydraulic gradient between the two aquifers is upward as indicated by flowing ground water from the two wells in the deep confined aquifer relative to the water table at approximately 10 ft below the surface in the two adjacent wells in the shallow unconfined aquifer (Attachment H). Therefore contamination of ground water in the confined aquifer due to site-related COPCs is highly unlikely.

Dewatering at the CVWRF, in conjunction with natural ground water gradients (controlled by Mill Creek and the Jordan River) and the distribution of channel deposits in the subsurface, has limited the extent of contamination to the site and areas just west of the site (in the area of former monitor wells 011 and 109). Recent field screening of ground water in areas downgradient of the site did not encounter clear evidence of site-related contamination. In all cases, ground water samples had uranium concentrations within the range of both background ground water and sources of surface recharge (Mill Creek and the Jordan River). Ground water samples from monitor wells in the deeper confined aquifer through 1994 indicate no elevated concentrations of site-related constituents (DOE 1996b). A former Vitro water supply well (SSL-8) in the deeper confined aquifer (discontinuously screened from 575 to 848 ft) in the southeast corner of the site was sampled in 1985 and 1989 and likewise showed no site-related contamination in ground water (DOE 1995a) (this well was recently decommissioned—see Section 3.0).

2.3 Applicability of Supplemental Standards

The third step determines whether contaminated ground water in the uppermost aquifer qualifies for supplemental standards based on limited use ground water. Ground water in the shallow unconfined aquifer is of limited use because of the widespread occurrence of arsenic that is not related to activities at the former processing site. Sources of arsenic in ground water include leaching from landfills, and from tailings and slag heaps associated with abandoned smelters in the valley that processed lead, copper, silver, and gold. Background arsenic concentrations in ground water range up to 0.173 mg/L (DOE 1996b).

Ground water from the shallow unconfined aquifer is not a current or potential source of drinking water, thus it is not reasonable to clean up the water using treatment methods employed in public water systems. Ground water from the shallow aquifer is not currently used and there is no historical record of wells completed in this unit downgradient of the site. Future use of ground water from the shallow aquifer is unlikely 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.

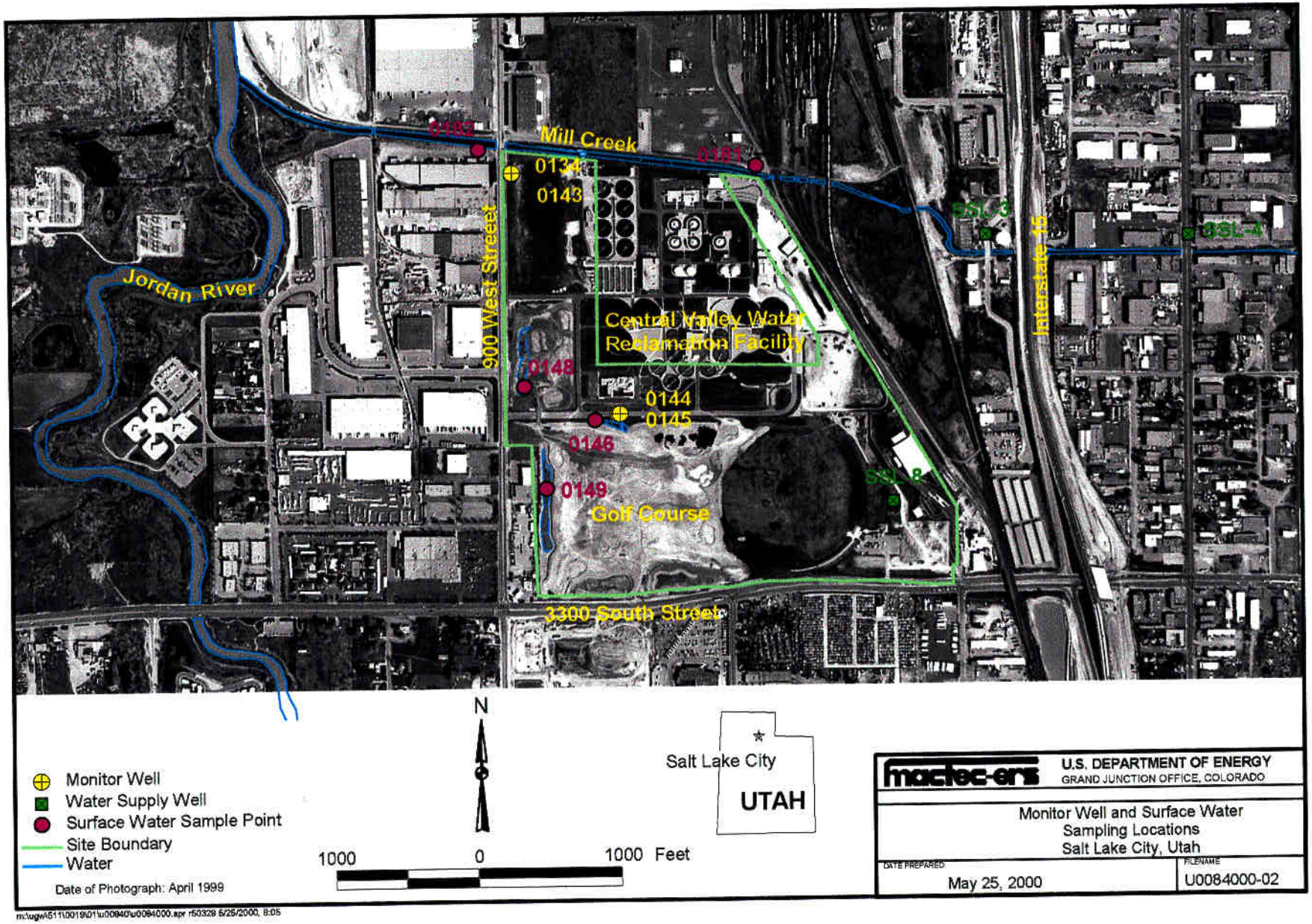

Figure 2. Monitor Well and Surface Water Sampling Locations, Salt Lake City, Utah, Site

Sources of potable water are readily available from municipal water supply systems, which obtain water from the deep confined aquifer in the vicinity of the site. The nearest water supply wells (SSL-3 and SSL-4) are more than one-half mile northeast of the site in a cross-gradient direction (CH2M HILL 1996) (Figure 2).

2.4 Human Health and Environmental Risks

The fourth step considers whether the human health and environmental risks of applying supplemental standards are acceptable. Assessment of site conditions and consideration of potential impacts on environmental resources indicate that supplemental standards will be protective of human health and the environment.

Because of the poor ambient quality of the shallow unconfined ground water in the area, it will not be used as a source of drinking water. The only reasonable exposure pathway to ground water for humans would be where it discharges to Mill Creek, where water from the storm drain lift station surfaces, or in ponds on the golf course that may intermittently contain ground water. Exposure to water in these instances would primarily be dermal and would be incidental in nature. This would pose no unacceptable human health risks because of the short exposure duration and because concentrations of uranium in ground water are low (close to the MCL of 0.044 mg/L). Additionally, as ground water is discharged to the surface at both the storm drain lift station and Mill Creek, significant dilution would occur through mixing with storm water and creek water, respectively. This would result in uranium concentrations decreasing to well below the MCL, as evidenced by surface water sampling adjacent to and downstream from the site.

Likewise, impacts on ecological receptors through exposure to site ground water are not expected. Dilution effects in Mill Creek and the storm water drain are protective of aquatic receptors. The low contaminant concentrations in ground water would have no negative impacts on plants that might root into the contaminated ground water. Furthermore, contaminants are being flushed from the aquifer because of the periodic dewatering at the CVWRF and are being further diluted from irrigation of the golf course.

The upward vertical hydraulic gradient between the limited use shallow unconfined aquifer and the deeper confined aquifer prevents migration of contaminants downward. In the unlikely event of gradient reversal, the relatively low concentrations of COPCs would be likely attenuated or diluted and would not impact ground water in the deeper aquifer.

Since the former processing site is owned by CVWRF access to the land and to potentially contaminated ground water in the shallow aquifer beneath the site is controlled, which will enhance protection of human health and the environment. In 1983 DOE and the State of Utah entered into a Cooperative Agreement (Number DE-FC04-81AL616309) for the remediation of the Salt Lake City processing site. Between 1985 and 1987 excavation and disposal of the uranium mill tailings and site restoration were performed. Under the agreement, several areas of elevated radioactive contamination were allowed to remain in place. The *Completion Report for the UMTRA Project Vitro Processing Site, Salt Lake City, Utah* (DOE 1997) provides a discussion of the contaminated areas including an estimate of mass, location, and a health assessment resulting from exposure to the contamination. Based on this contamination, a *Notice of Residual Radioactive Contamination* (Attachment I) was developed and signed by DOE, the State, and CVWRF. This notice functions as an institutional control in support of land-use

restrictions to prohibit any construction in contaminated areas. As a result of this enforcement, contaminated ground water access and use are also restricted within the site boundaries. Additionally, the CVWRF representative indicated that the facility has no intention of selling this property. CVWRF is currently in the process of completing a golf course, which consumes the majority of the former processing site, making the land and the ground water inaccessible for other uses.

2.5 Compliance Strategy Selection

The fifth and final step in the framework is the selection of an appropriate compliance strategy to meet the EPA ground water protection standards. The selected strategy is no remediation and application of supplemental standards based on limited use ground water (40 CFR 192.21(g)). Ground water in the uppermost aquifer is not a current or potential source of drinking water because 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 (40 CFR 192.11(e)(2)).

3.0 Implementation

Ground water and surface water monitoring will be continued at the Salt Lake City site as a best management practice (Table 1 and Figure 2). This monitoring will continue for a minimum period of 5 years (through 2004). At the end of this period an evaluation will be made in consultation with NRC and the State of Utah to determine the need for future monitoring at the site. Criteria for terminating monitoring will be no significant reversal of the hydraulic gradient, a decrease in COPC concentrations in ground water as anticipated, and no unacceptable risks related to pumping of ground water by CVWRF or the storm drain sump. DOE will receive NRC approval prior to termination of monitoring.

Table 1. Ground Water and Surface Water Monitoring, Salt Lake City, Utah, Site

Well/Stn	Location	Interval[a]	Analytes	Water Level[b]	Frequency
134	Downgradient	Shallow	U and Mo	Datalogger	Annual
143	Downgradient	Deep	[c]	Manual	[d]
144	Onsite	Shallow	U and Mo	Datalogger	Annual
145	Onsite	Deep	[c]	Manual	[d]
146	Open ditch onsite	Surface	U and Mo	N/A	Annual
148	Pond west of CVWRF	Surface	U and Mo	N/A	Annual
149	Pond southwest of CVWRF	Surface	U and Mo	N/A	Annual
181	Mill Creek - upstream	Surface	U and Mo	N/A	Annual
182	Mill Creek - downstream	Surface	U and Mo	N/A	Annual

[a] Shallow unconfined aquifer and deep confined aquifer.
[b] Dataloggers in shallow wells will be downloaded quarterly—deeper wells will be observed visually (and water level measured as applicable) at the same time. Dataloggers record water level every 4 hours.
[c] Samples will be analyzed for same constituents if vertical hydraulic gradient reverses.
[d] Wells in deep aquifer will be sampled only if vertical hydraulic gradient reverses.

The primary State concern was possible migration of potentially contaminated ground water in the shallow unconfined aquifer downward into the deeper confined aquifer if the upward vertical hydraulic gradient were to reverse. This will be monitored by measuring ground water levels in pairs of wells completed in the shallow (monitor wells 134 and 144) and deep (monitor wells 143

and 145) aquifers respectively, at two locations onsite and downgradient (Figure 2). DOE will also monitor ground water quality annually in the two wells in the shallow unconfined aquifer (monitor well 134 downgradient and 144 onsite) to ensure that concentrations of COPCs (molybdenum and uranium) continue to decrease. If there is an indication that the vertical hydraulic gradient is reversed, ground water in the deep confined aquifer will be sampled and analyzed to ascertain that no site-related constituents migrate into the deeper aquifer. Baseline monitoring in October 1999 shows that there is a strong upward vertical hydraulic gradient and that concentrations of uranium and molybdenum in ground water in the deeper confined aquifer are near or below the detection limit (Attachments G and H).

The NRC was concerned with the potential exposure pathway of contaminated ground water pumped from the shallow unconfined aquifer during CVWRF activities or from the storm drain sump southeast of the site. Ground water that is periodically extracted by CVWRF for construction and maintenance purposes is run through the treatment plant and then discharged into Mill Creek. Although treatment does not include metals removal, the low initial concentrations of COPCs in ground water and the subsequent dilution during the process preclude any unacceptable risk at the discharge point in Mill Creek. Sampling of surface water in 1994-1995 from Mill Creek upstream and downstream of the discharge point from the plant, as well as water from the plant, showed maximum concentrations of uranium of 0.005 mg/L (DOE 1996b). Ground water that enters the storm drain sump (inaccessible at the railroad underpass) is pumped mostly through an underground pipe system, which ultimately discharges to Mill Creek north of the site. There is a 150-ft section of this discharge pathway that is open to the surface just south of the CVWRF Administration Building. To ensure that these potential exposure pathways of contaminated ground water do not pose a risk to human health and the environment, DOE will monitor surface water annually at the west end of the open ditch onsite (location 146), and Mill Creek upstream (location 181) and downstream (location 182) of the site (Figure 2) (Table 1). There are also several ponds on the golf course, which intermittently contain ground water that will be sampled at the same time (locations 148 and 149). These samples will be analyzed for COPCs.

As an added precaution against potential contamination of ground water in the deeper aquifer the Vitro water supply well (SSL-8) in the southeast corner of the site was decommissioned in September 1999 (Figure 2 and Attachment H). The well had been in place for a number of years and the integrity of the annular seal was unknown. The well belonged to the City of South Salt Lake who was not using the well and had no plans to do so. The City of South Salt Lake granted DOE authorization to decommission the well.

Monitor wells at the site no longer determined to be part of the monitoring network were decommissioned in September 1999. The remaining four monitor wells will be decommissioned upon termination of monitoring as discussed above.

The Long-Term Management Plan (LTMP) (DOE 2000) will also contain the information on ground water and surface water monitoring as well as specifying all other long-term surveillance activities and reporting requirements necessary for the site. The LTMP will be a stand-alone document to guide long-term surveillance activities at the Salt Lake City processing site. Other activities will include inspection and maintenance of monitor wells at the site and continuation of the access agreement for sampling and maintenance of the wells.

4.0 Environmental Considerations

To comply with NEPA requirements DOE prepared the PEIS, which was issued in October 1996 (DOE 1996c). The PEIS assesses the potential programmatic effects of conducting the ground water project, provides a method for determining the site-specific ground water compliance strategies, and provides data and information that can be used to prepare site-specific environmental impact analyses more efficiently. In the proposed action (preferred alternative), ground water compliance strategies are tailored to each site to achieve conditions that protect human health and the environment. The selection framework for determining an appropriate compliance strategy at each site is presented in Section 2.1 of the PEIS and is discussed in Section 2.0 of this GCAP. Relevant areas of environmental concern are discussed below.

Environmental issues and resources potentially affected by the proposed action may include the following:

- Risk to human health and the environment
- Ground water use
- Surface water use
- Land use
- Exposure to potentially contaminated ground water
- Environmental site restoration

Environmental impacts from the proposed action on these issues and resources have been assessed in several of the referenced documents (DOE 1984, 1993a, 1993b, 1995a, 1995b, 1996a, and 1996b). Results are summarized below.

- There is no unacceptable risk to human health and the environment. Access to the land and potentially affected ground water is controlled by the current land owner and the planned use of the property. There is no apparent risk to ecological receptors from contaminants in ground water, surface water, or sediments. There is also an institutional control in support of land-use and ground water access restrictions within the site boundaries.

- Ground water from the shallow unconfined aquifer is not a drinking water resource in the area, and access to potentially contaminated ground water is restricted. Surface water at the site is likewise not used as a water resource.

- The former processing site is owned by CVWRF. They control access to the site and this limits any exposure to potentially contaminated ground water beneath the site.

- The Salt Lake City site underwent surface remedial action from 1984-1987. The upper 4 to 13 ft of soil were replaced with clean fill material. Uranium mill tailings and tailings-contaminated materials were hauled to a disposal cell at Clive, Utah. Therefore, no source materials remain at the site.

To accommodate the NEPA obligation to make relevant environmental information available to public officials and citizens before decisions are made and before actions are implemented, DOE has distributed relevant environmental documents (including this document and attachments) to

the Division of Radiation Control of the Utah Department of Environmental Quality, the City of South Salt Lake, and the Central Valley Water Reclamation Facility (owner of the site).

5.0 References

CH2M HILL, 1996. *City of South Salt Lake Well Delineation Report*, prepared by CH2M HILL, Salt Lake City, Utah, August 1996.

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———, 1997. *Completion Report for the UMTRA Project Vitro Processing Site, Salt Lake City, Utah.*

———, 2000. *Long-Term Management Plan for the Salt Lake City, Utah UMTRA Processing Site*, Document Number S0041600.

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Attachment A

DOE/AL/62350-227
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POSITION PAPER ON THE APPLICABILITY OF SUPPLEMENTAL STANDARDS TO THE UPPERMOST AQUIFER AT THE URANIUM MILL TAILINGS VITRO PROCESSING SITE, SALT LAKE CITY, UTAH

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LIST OF ACRONYMS

Acronym	Definition
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.

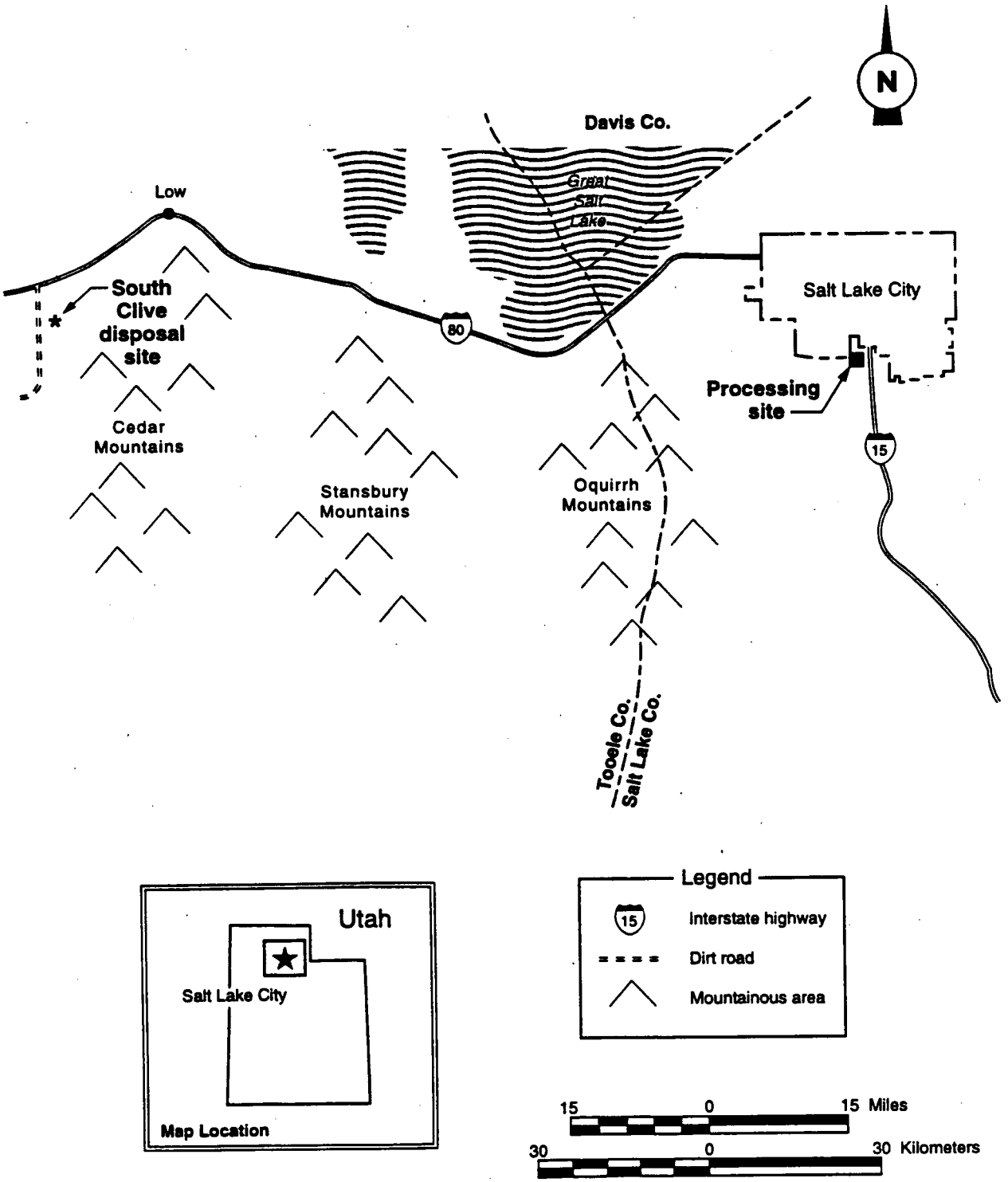
2.2 SITE HISTORY

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.

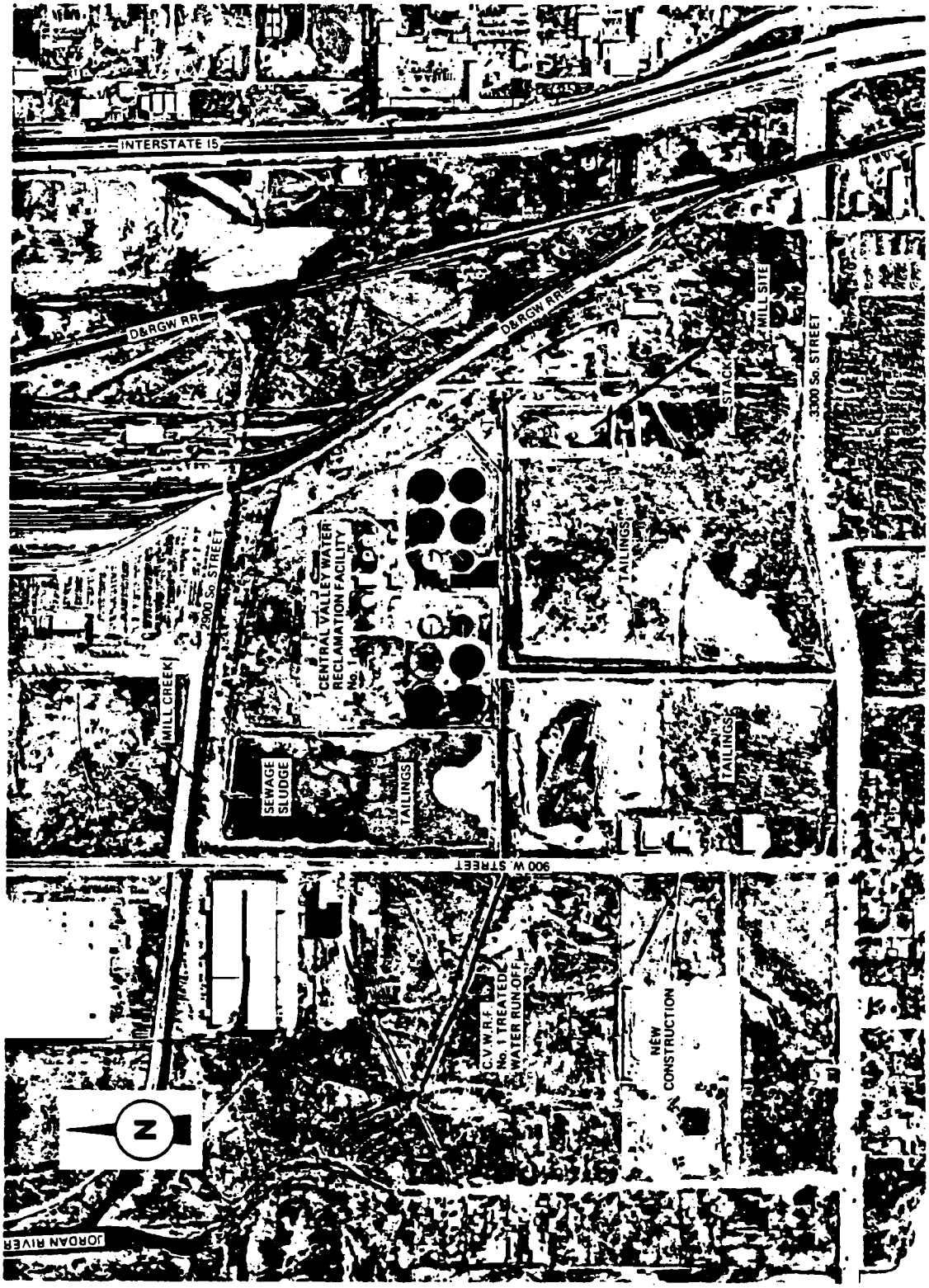
Remedial action at the Vitro site occurred from January 1985 to March 1987. A total of 2,798,000 cubic yards (yd^3) (2,139,000 cubic meters [m^3]) of tailings was removed from the site and stabilized in a disposal cell at Clive, Utah (approximately 85 mi [140 km] west of Salt Lake City). The state of 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

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

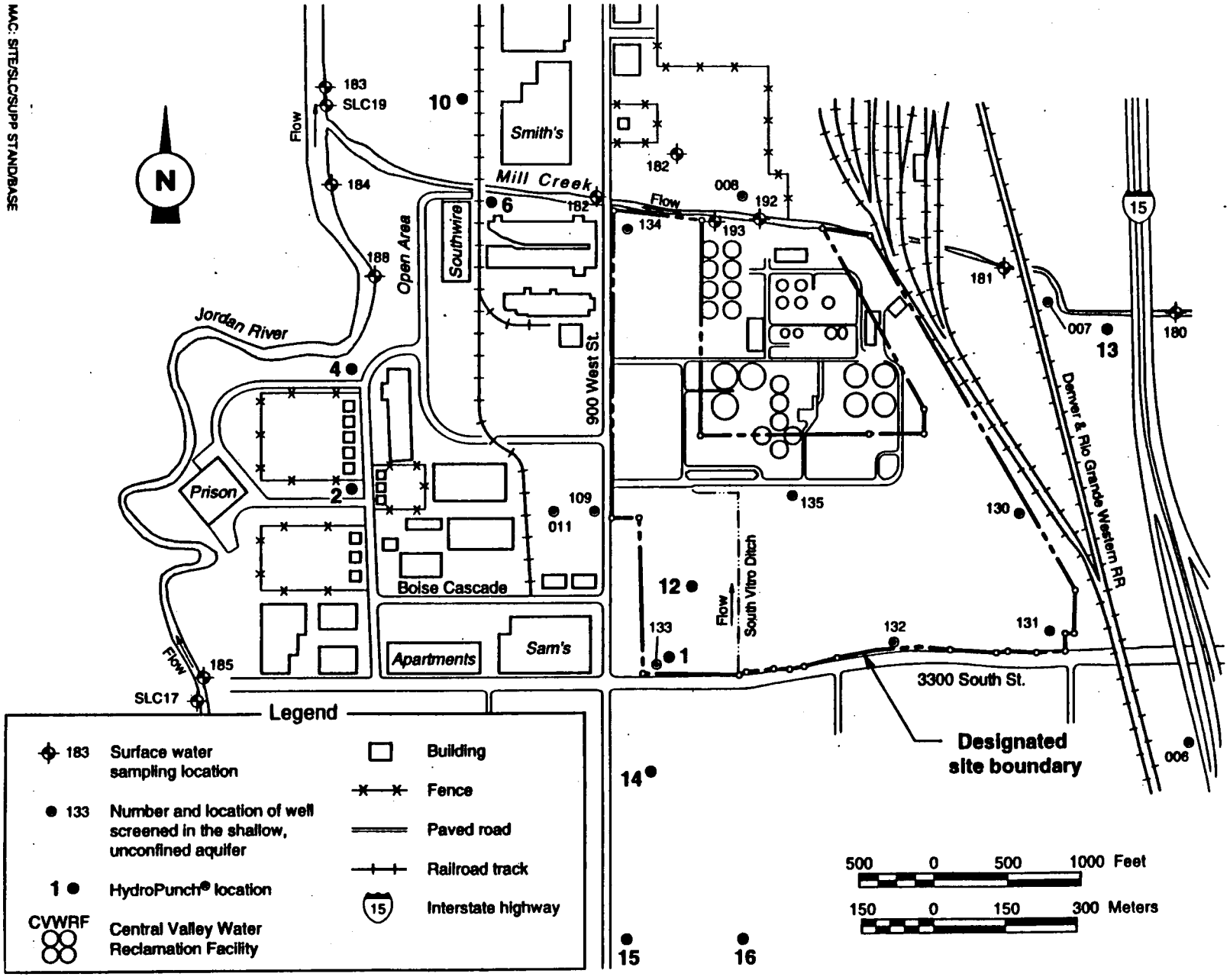
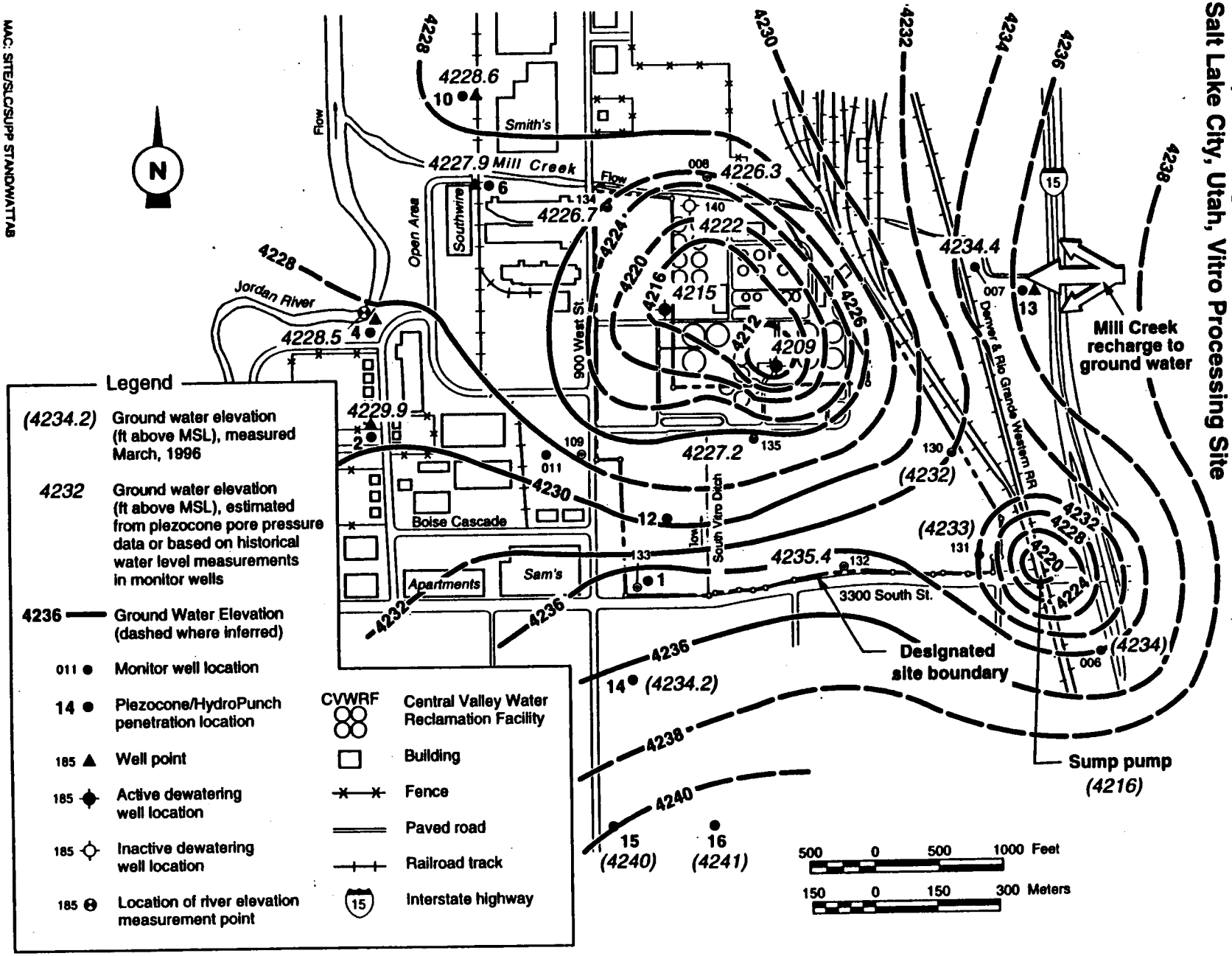


Figure 3.2
Site Map Showing Water Table in the Shallow, Unconfined Aquifer
Salt Lake City, Utah, Vitro Processing Site



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-dichoroethane, 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	-

[a]Inorganic constituent concentrations are reported in milligrams per liter. pH is reported in standard units. Radionuclide concentrations are reported in picocuries per liter.
[b]Background 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.
[c]Number of samples with detected concentrations/total number of samples.
[d]Constituents 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 180	West of railroad tracks 181	West of railroad tracks 192	Treated sewage outfall 193	Downstream of treated sewage outfall 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

	Jordan River			
	Upstream	Downstream		
Contaminant	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).

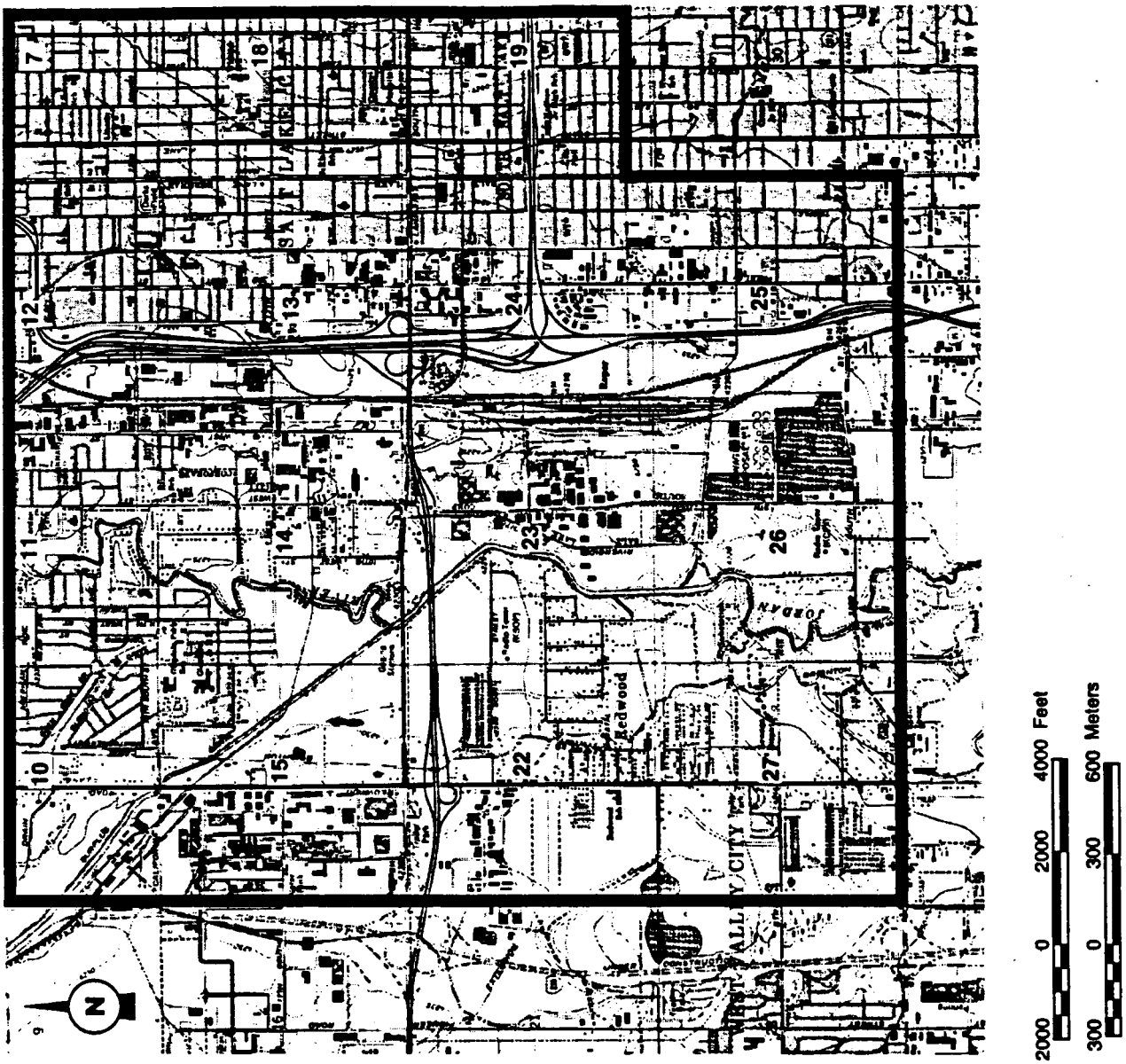
Fourteen shallow wells are located within about 2 miles (3 km) upgradient and crossgradient of the site and are used for domestic and agricultural purposes. These wells were drilled in early 1900s (except for one crossgradient well drilled in 1979).

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

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

[a]Both 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 IE-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

	Off-site ground water concentration (mg/L)				
Constituent	West MW 011	Off-site MW 109	North MW 008	Northwest MW 134	Screening Benchmark Concentration for Plants
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:

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

Where:

Cw = Constituent concentration in water (mg/liter); a) constituent-specific value.
SA = Skin surface area available for contact (cm^2) (surface area at forearms and hands [1140 cm^2 + 840 cm^2 = about 2,000 cm^2] for an adult man) assumed to come in contact with shallow ground water.
PC = Dermal permeability constant for water (0.001 cm/hr)
ET = Exposure time (1 hour per day)
EF = Exposure frequency (10 days per year)
ED = Exposure duration (2 years)
CF = Volumetric conversion factor for water (1 liter/1000 cm^3)
BW = Body weight (70 kg adult men)
AT = 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.
[a]Median 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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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.

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.

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.

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.

Location	Casing Depth (ft)	Screened Interval (ft)
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.

Location	Depth to Water (ft BTC)	Comments
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.

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

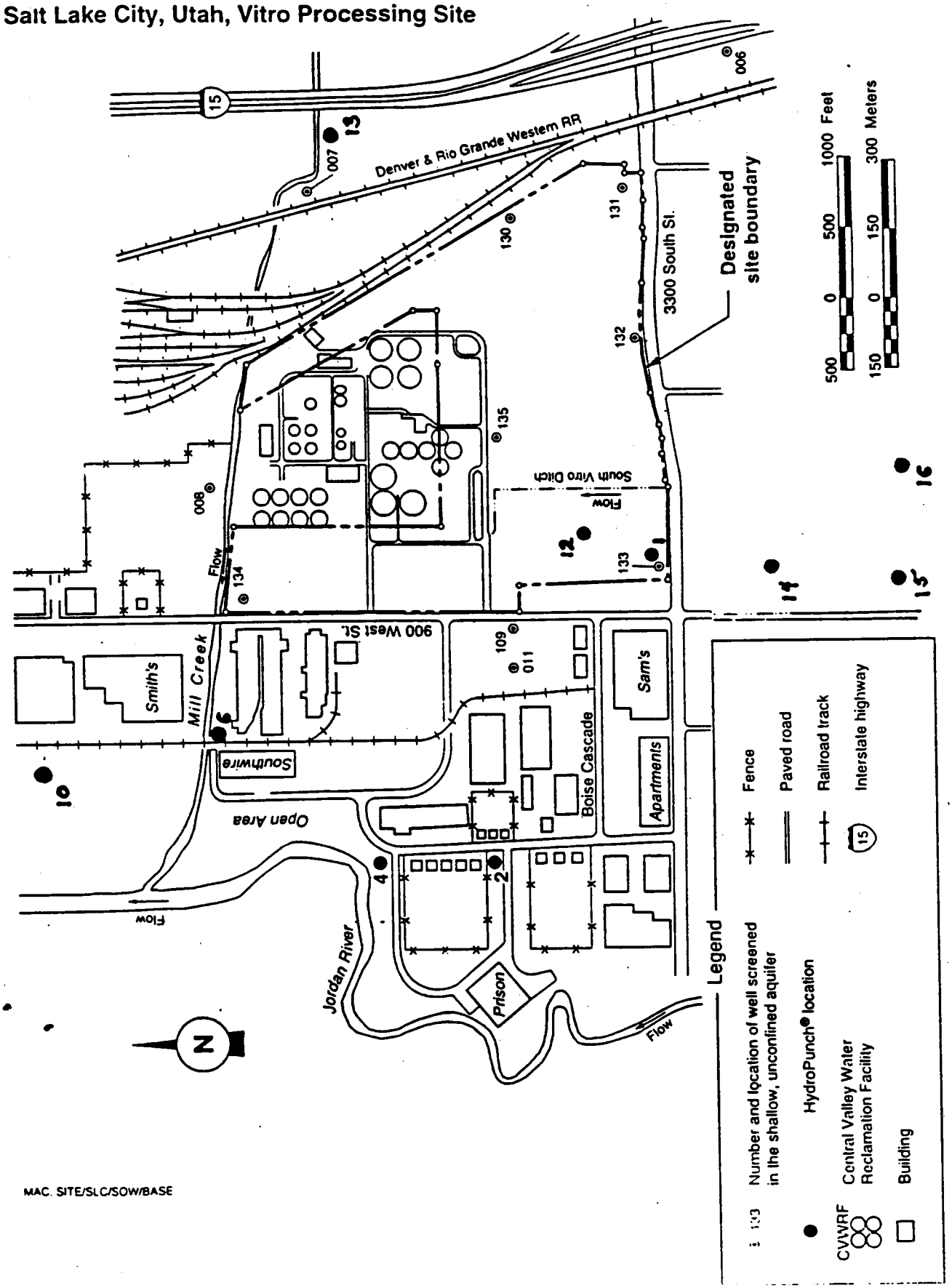
Location	Sample ID	Depth (ft)	Temp. (C)	Specific Conductance (µmhos/cm)	pH	Oxydation-reduction potential (mvolts)	Alkalinity (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Molybdenum (mg/L)	Uranium (mg/L)	Arsenic (mg/L)
Upgradient												
13	408	13	11.1	1120	7.43	NA	490	90	280	0.01	0.002	0.029
	409	22	14.3	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

Figure 1.

Site Map Showing

Logging and Sampling Locations

Salt Lake City, Utah, Vitro Processing Site



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CPT-1 ALTA GEO 03/01/96

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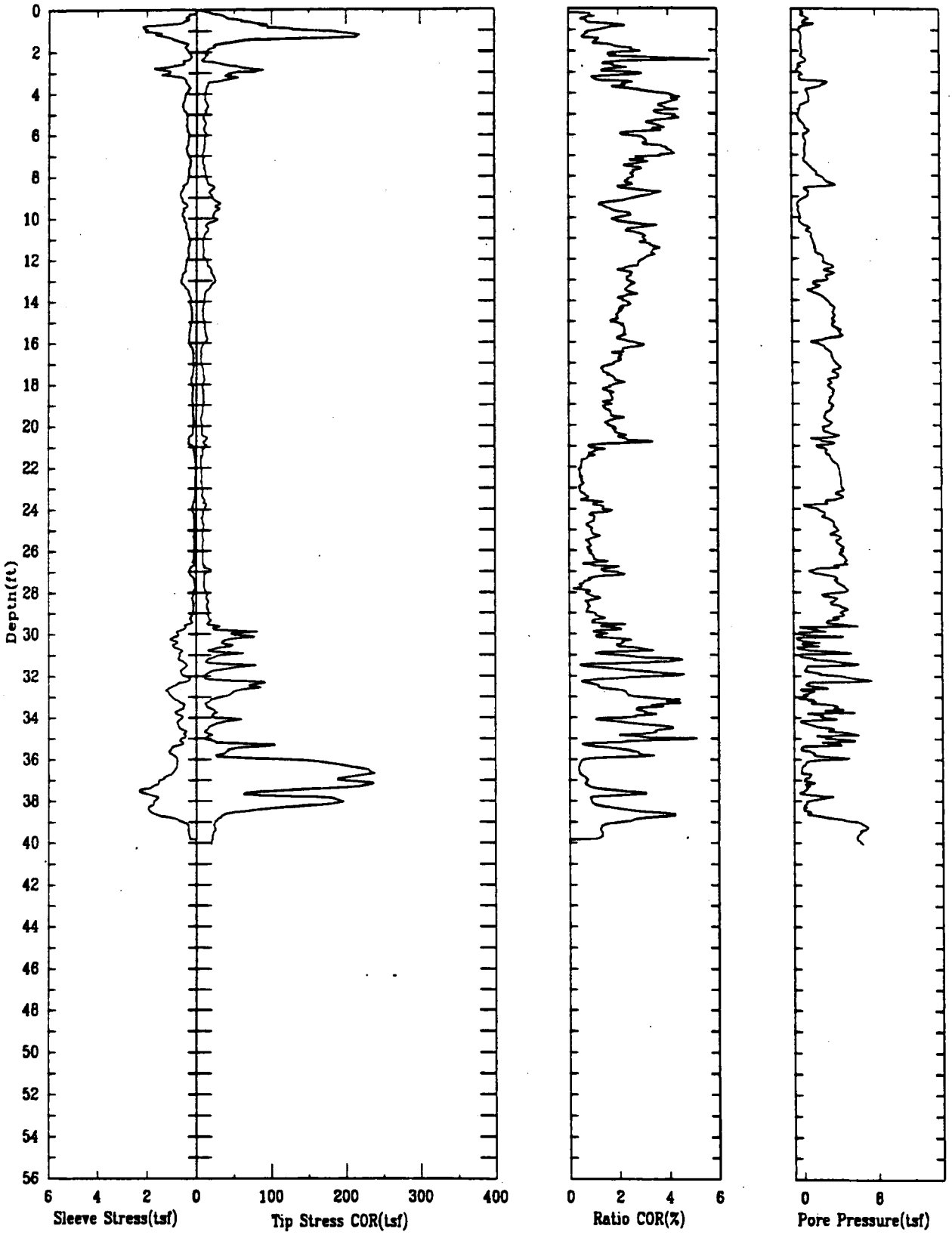

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CPT-1 ALTA GEO 03/01/96

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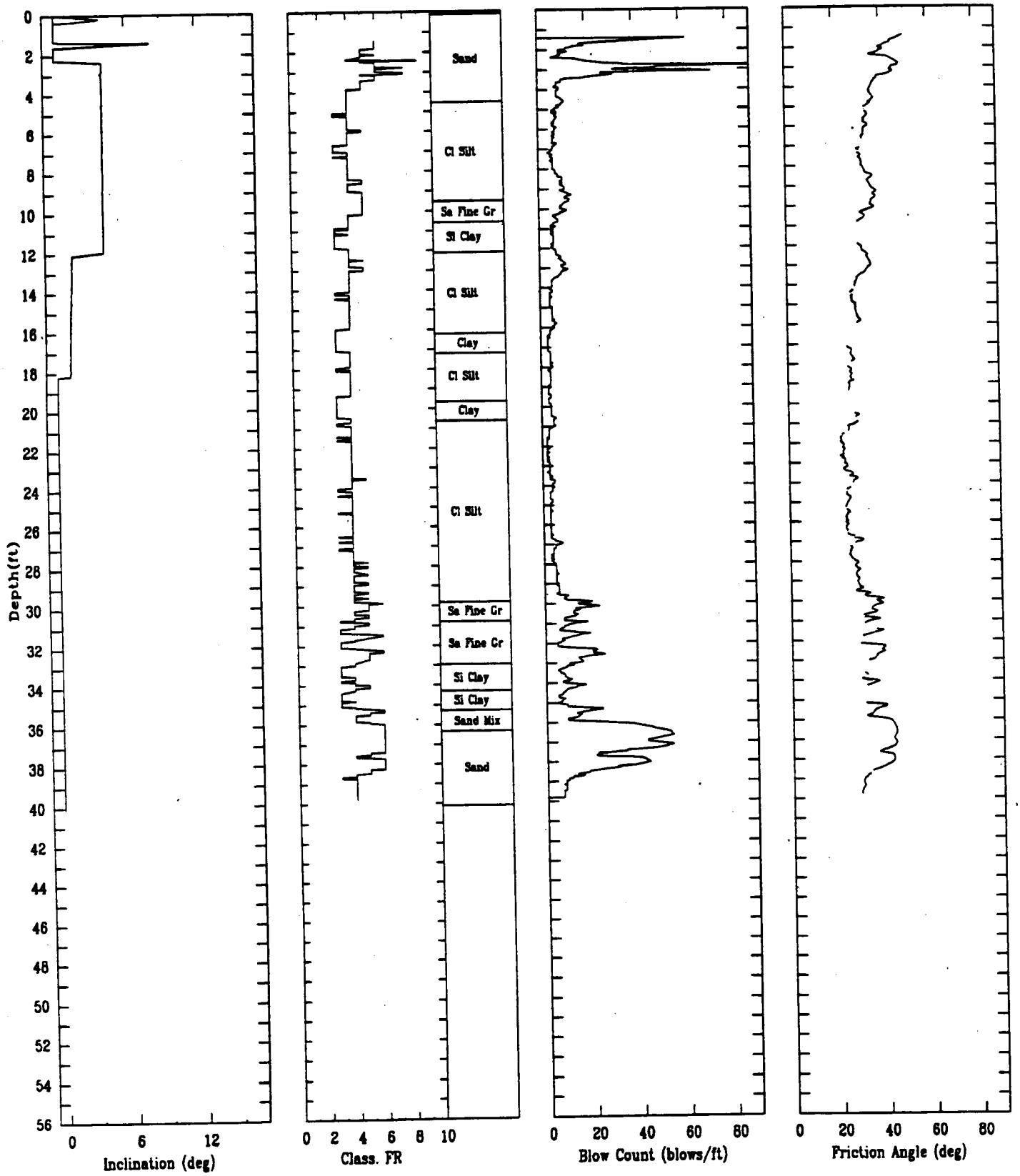

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APPLIED RESEARCH ASSOCIATES INC.

New England Division
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Version 6.00

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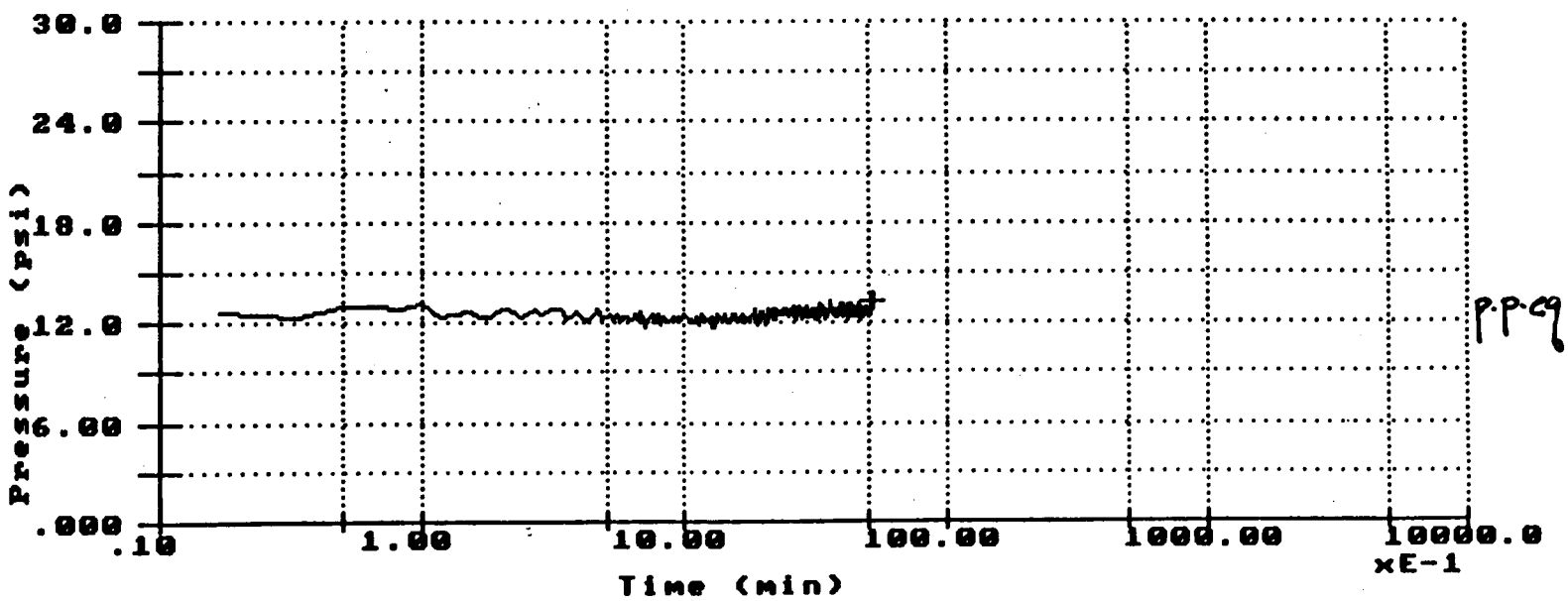

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CPT-2 ALTA GEO 02/29/96

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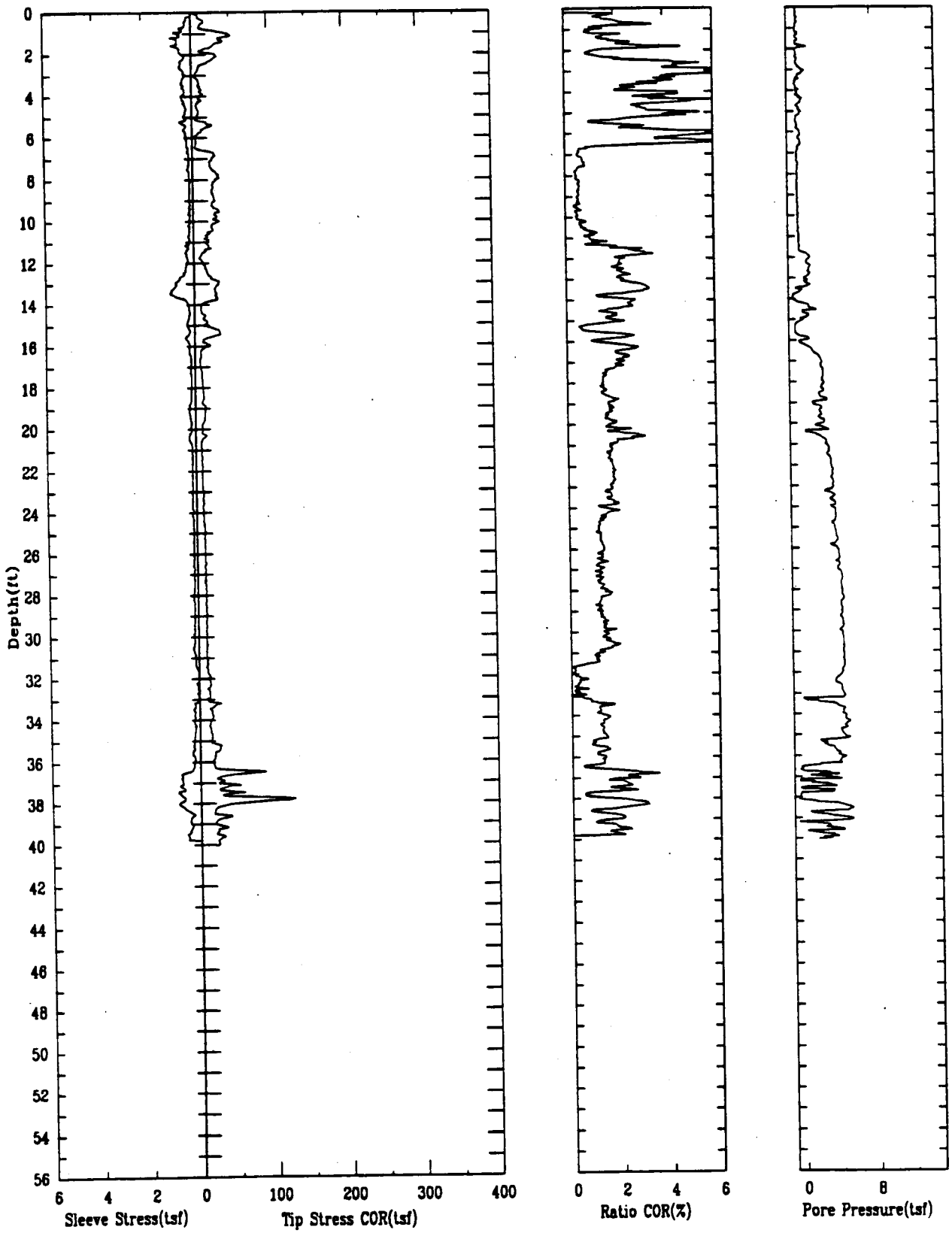

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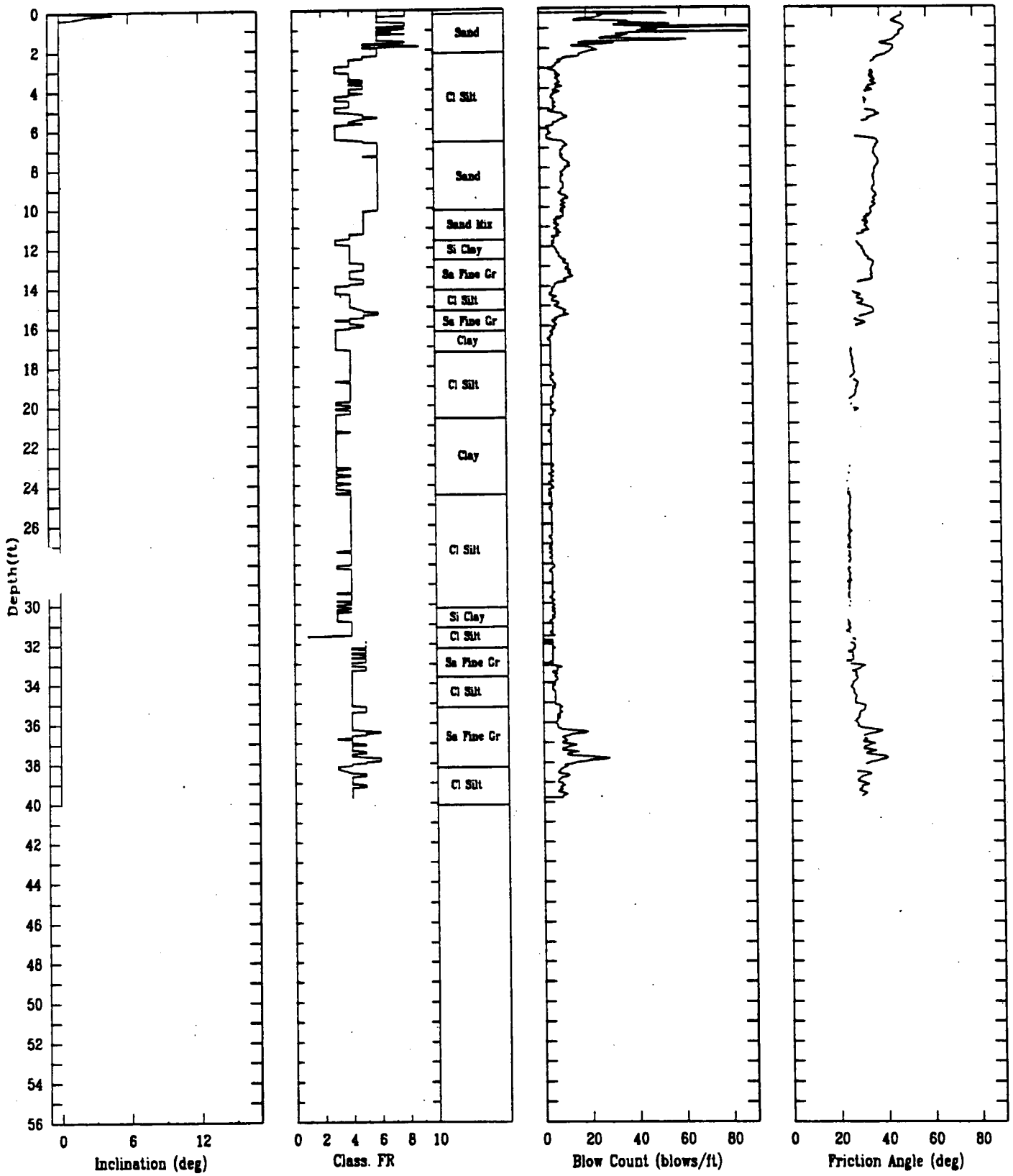

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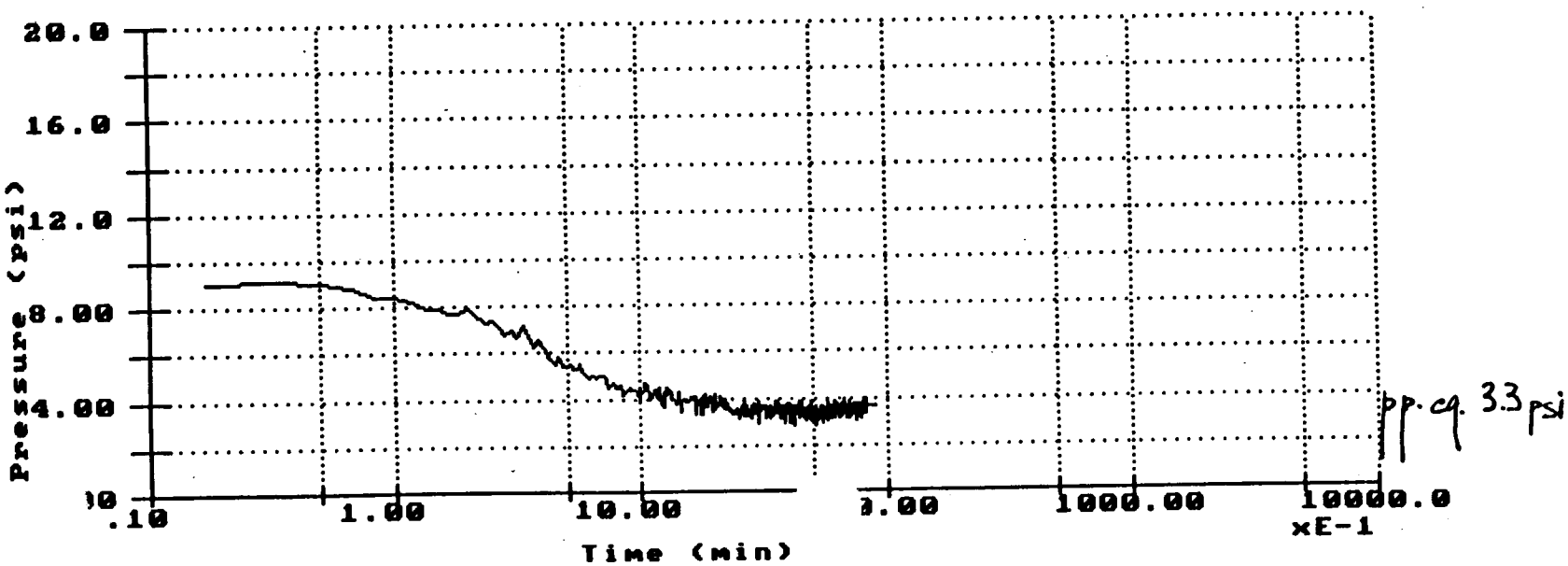

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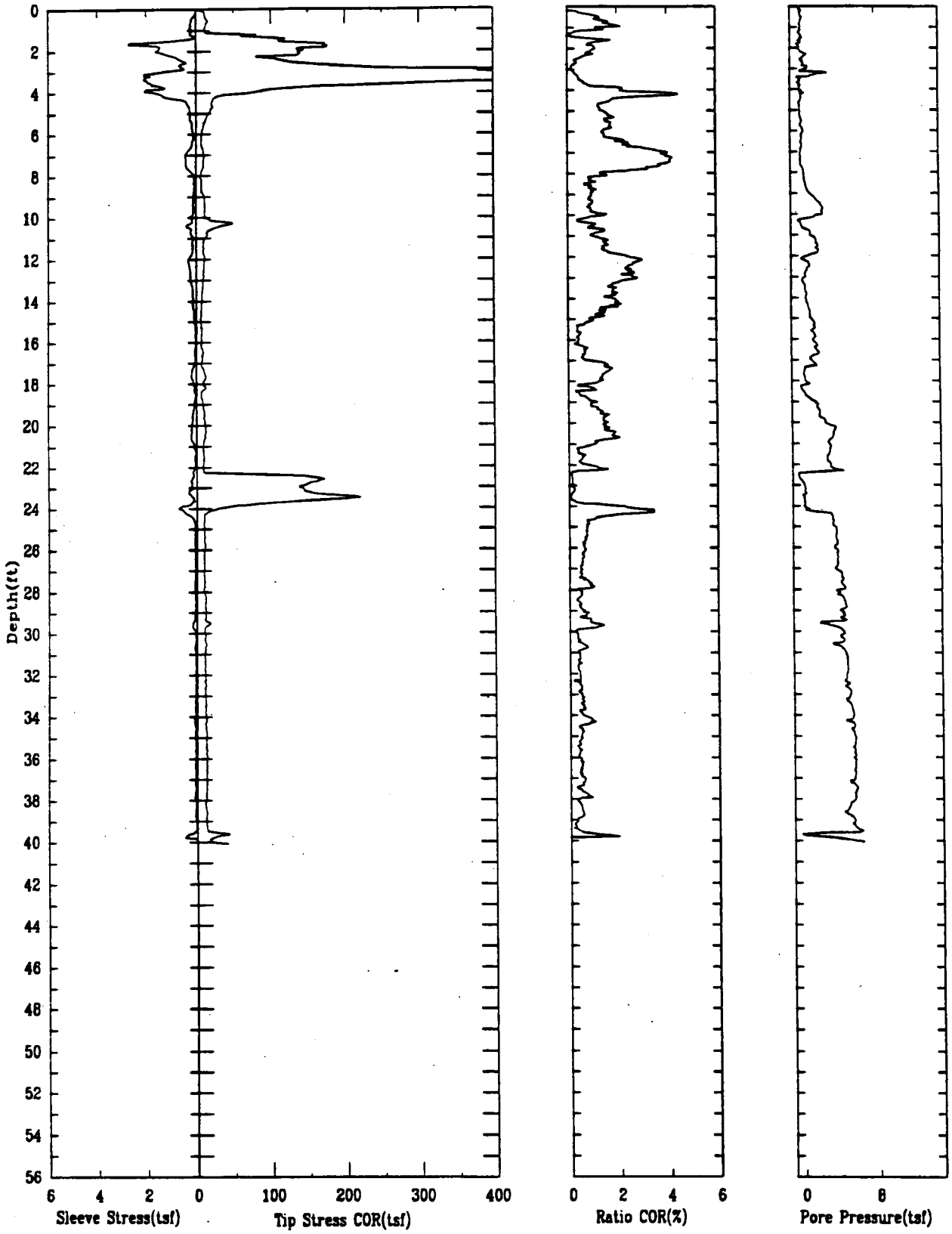

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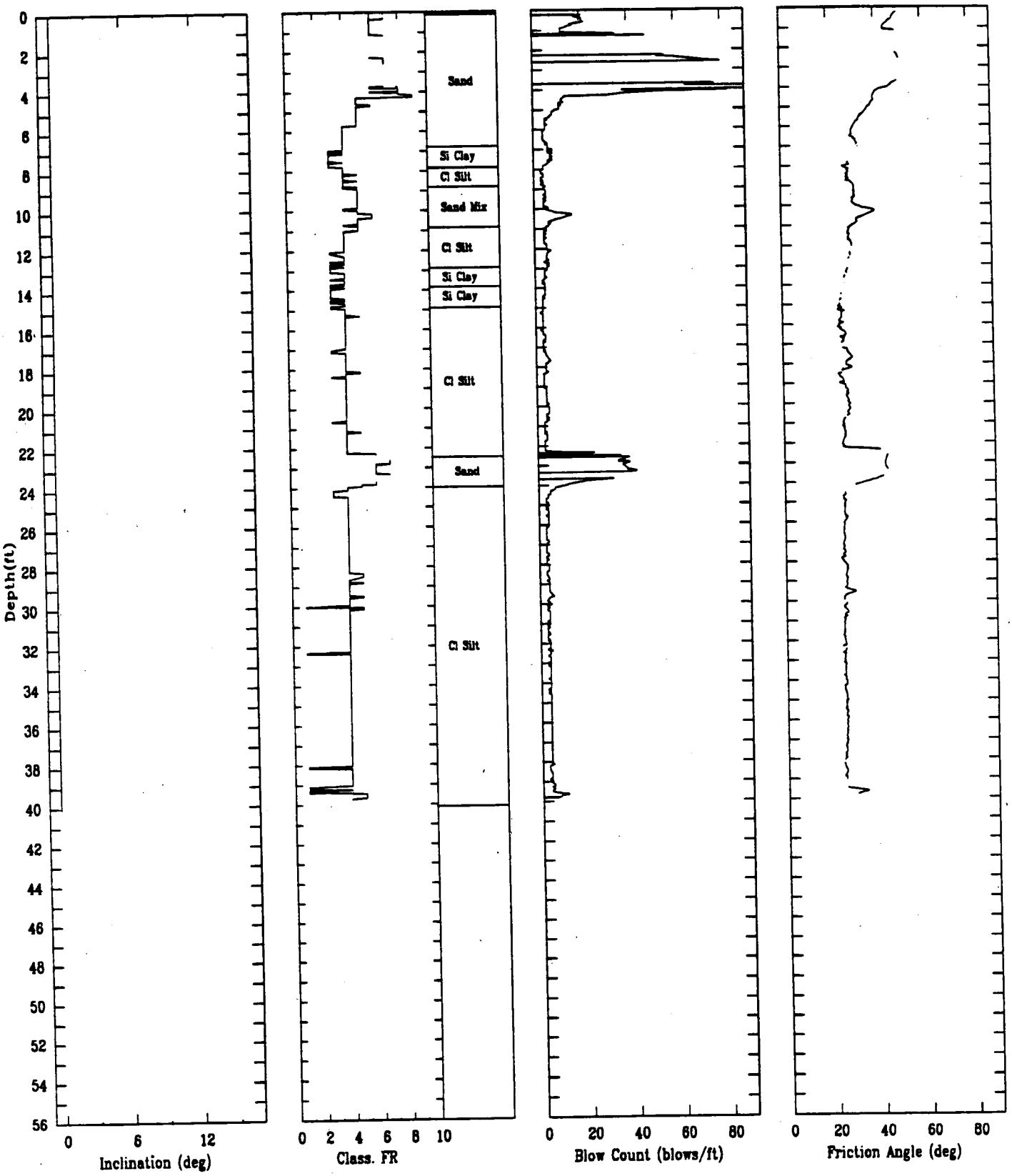

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APPLIED RESEARCH ASSOCIATES INC.

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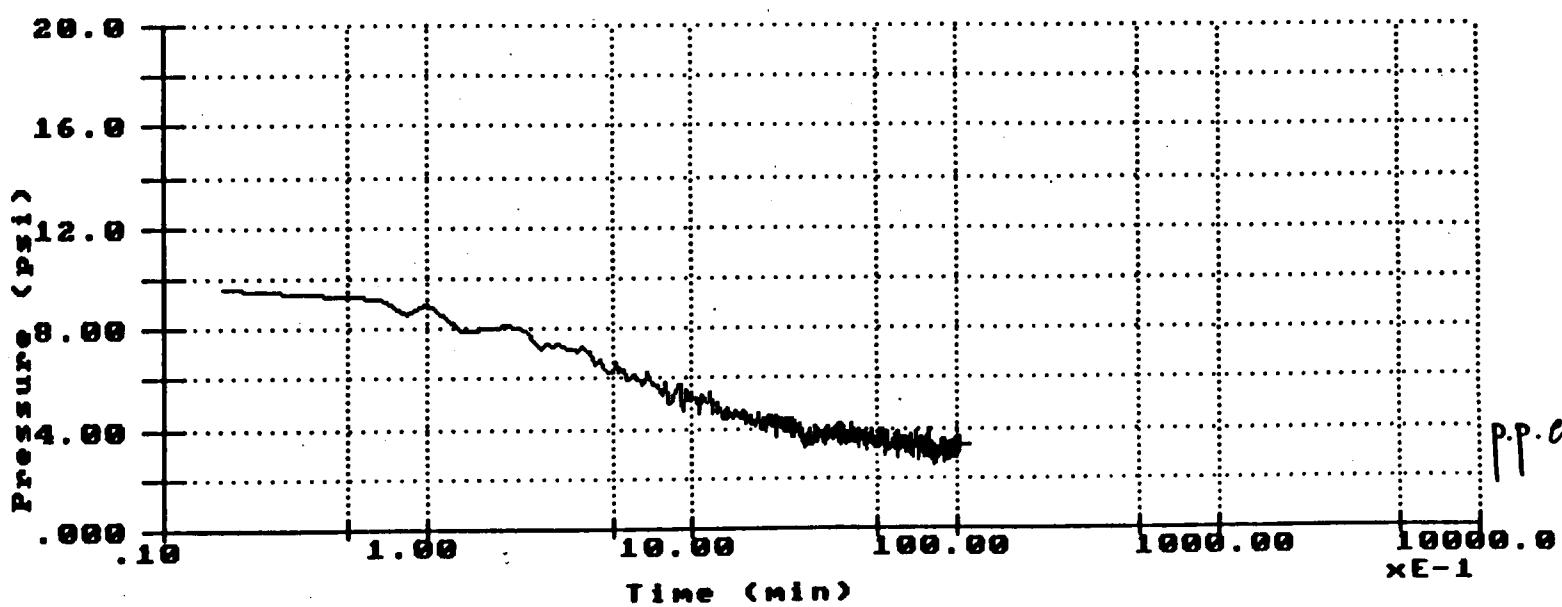

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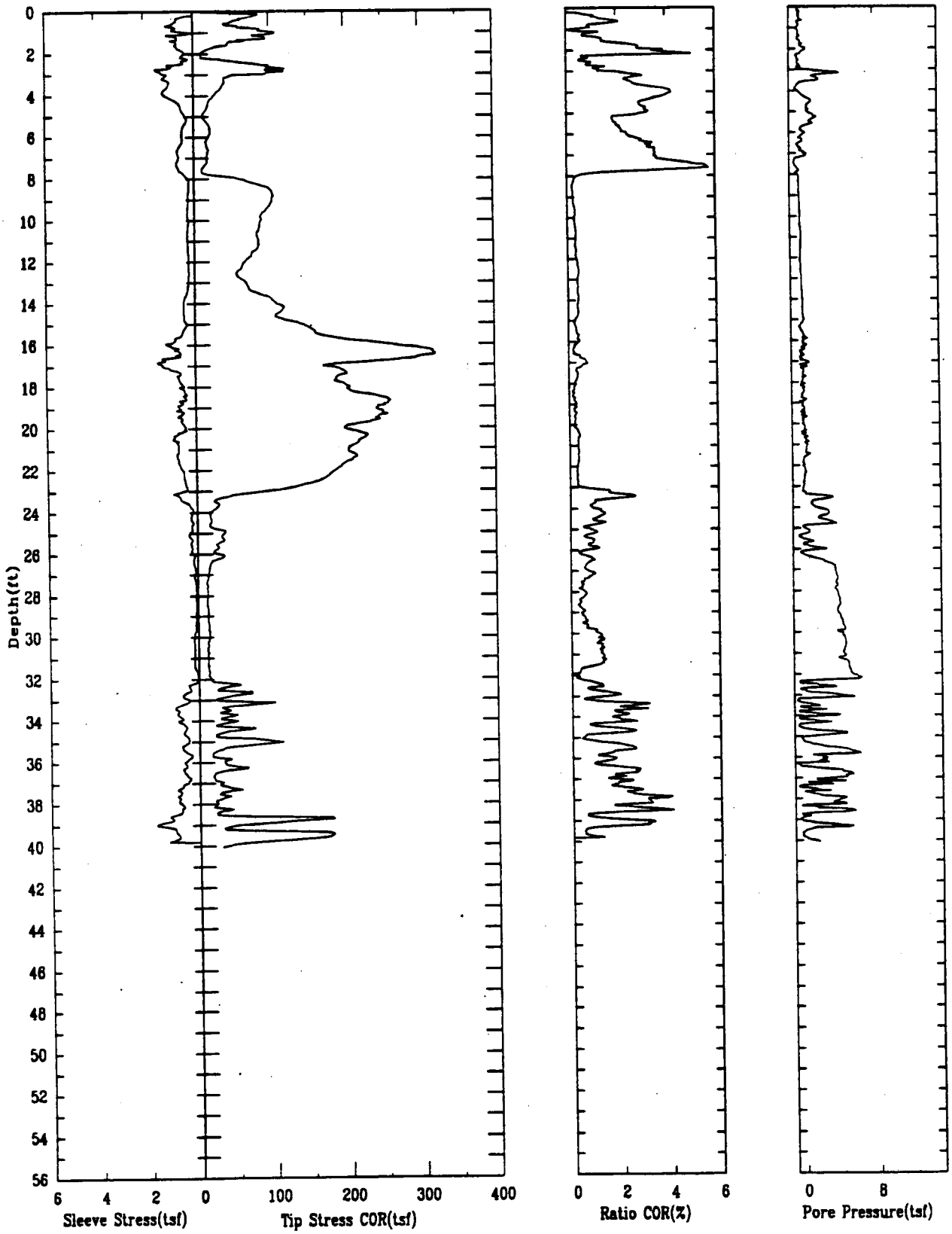

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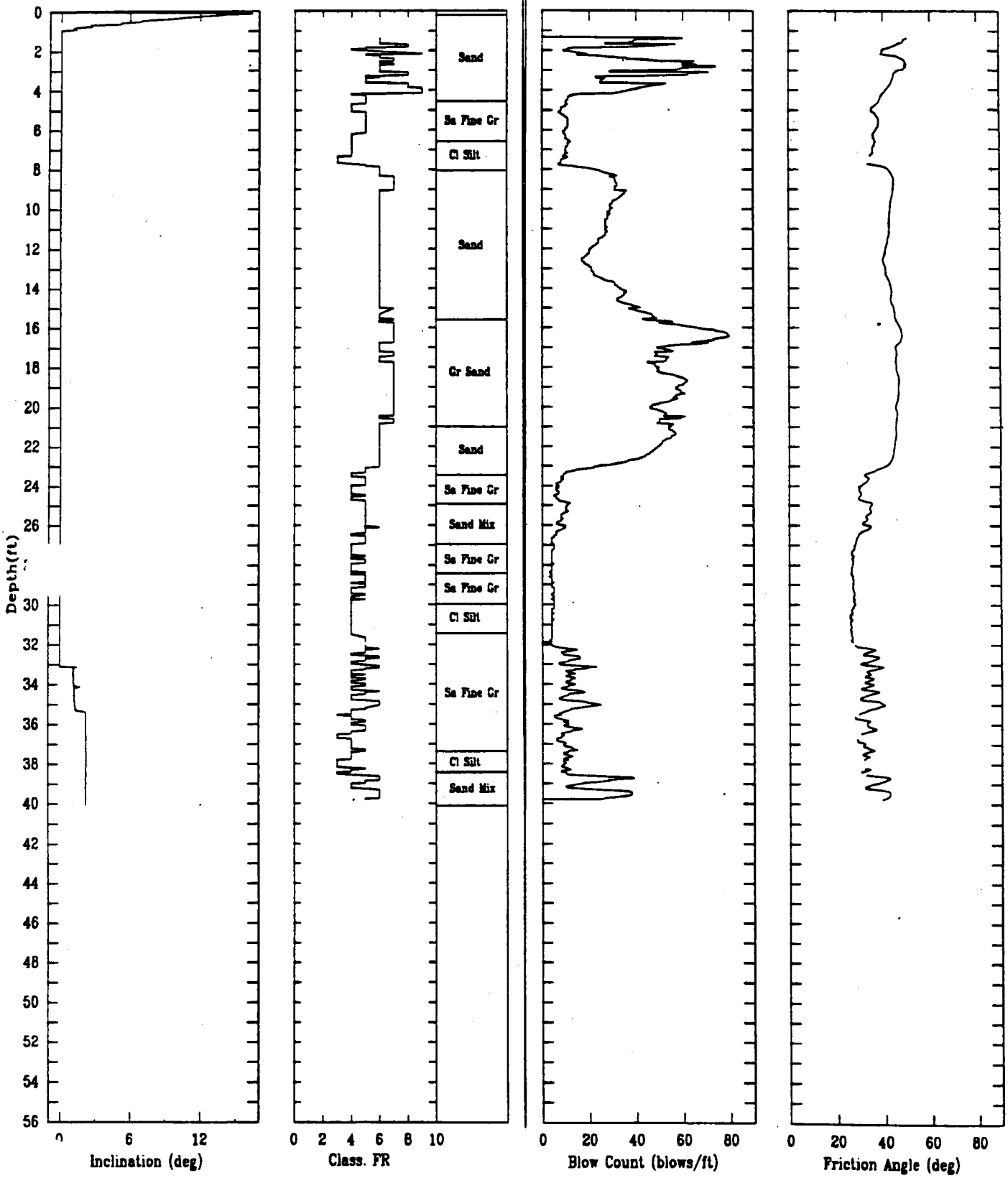

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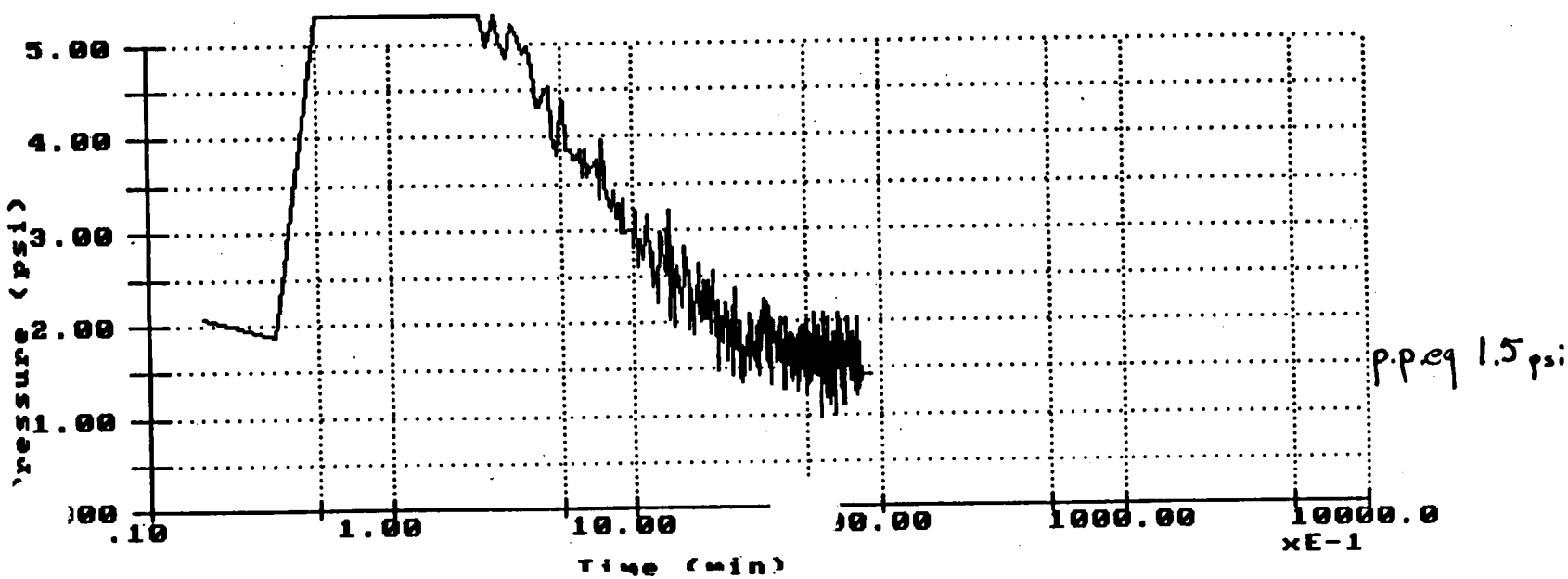

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New England Division
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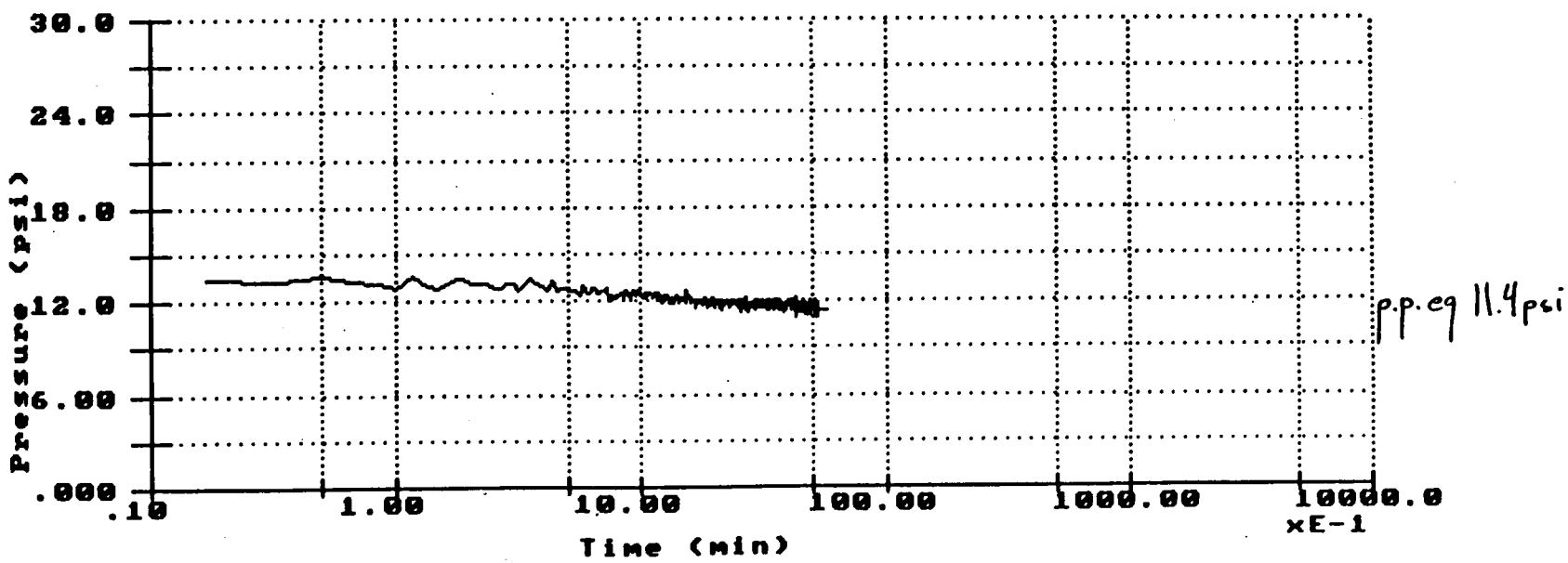

CPT-10 ALTA GEO 03/01/96

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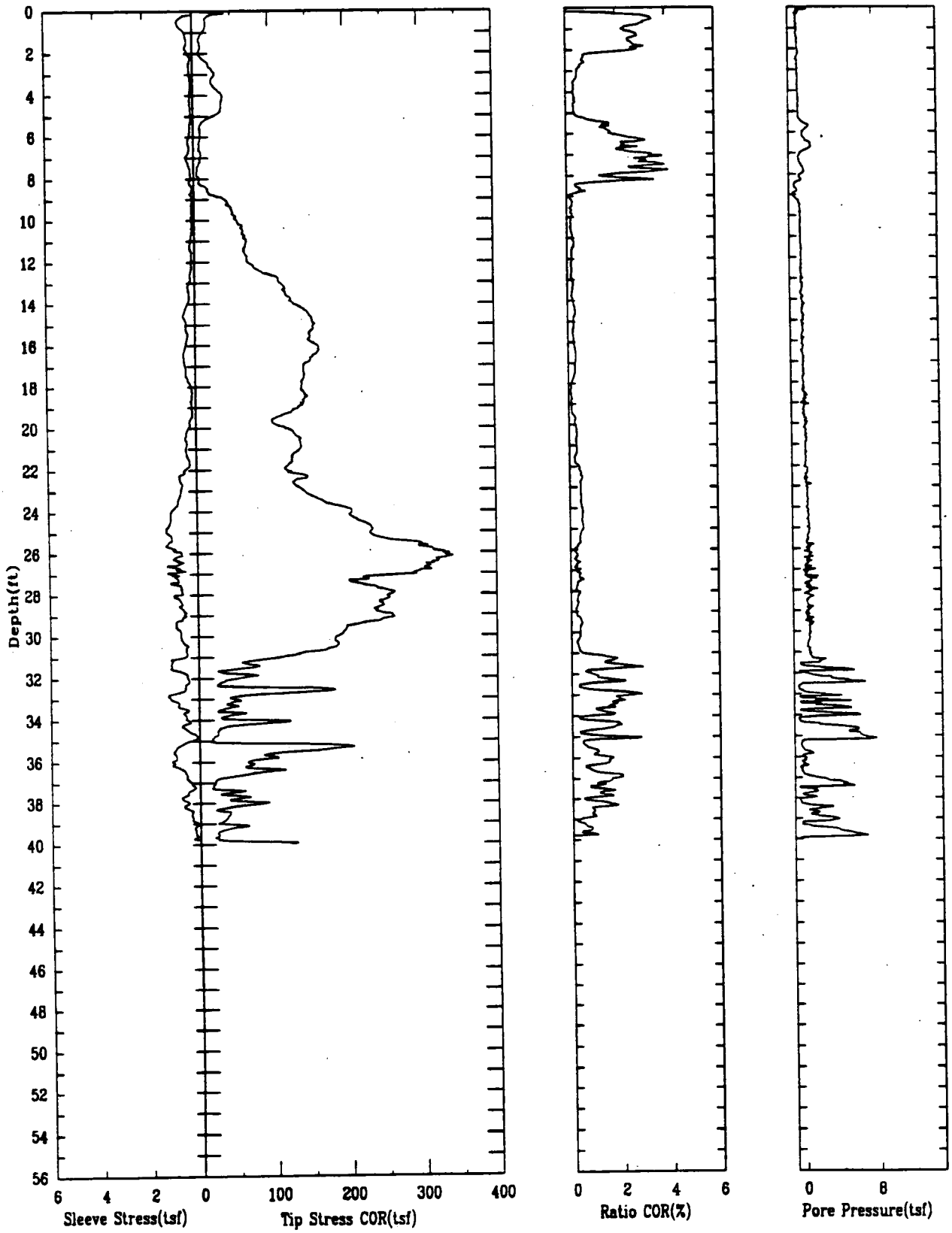

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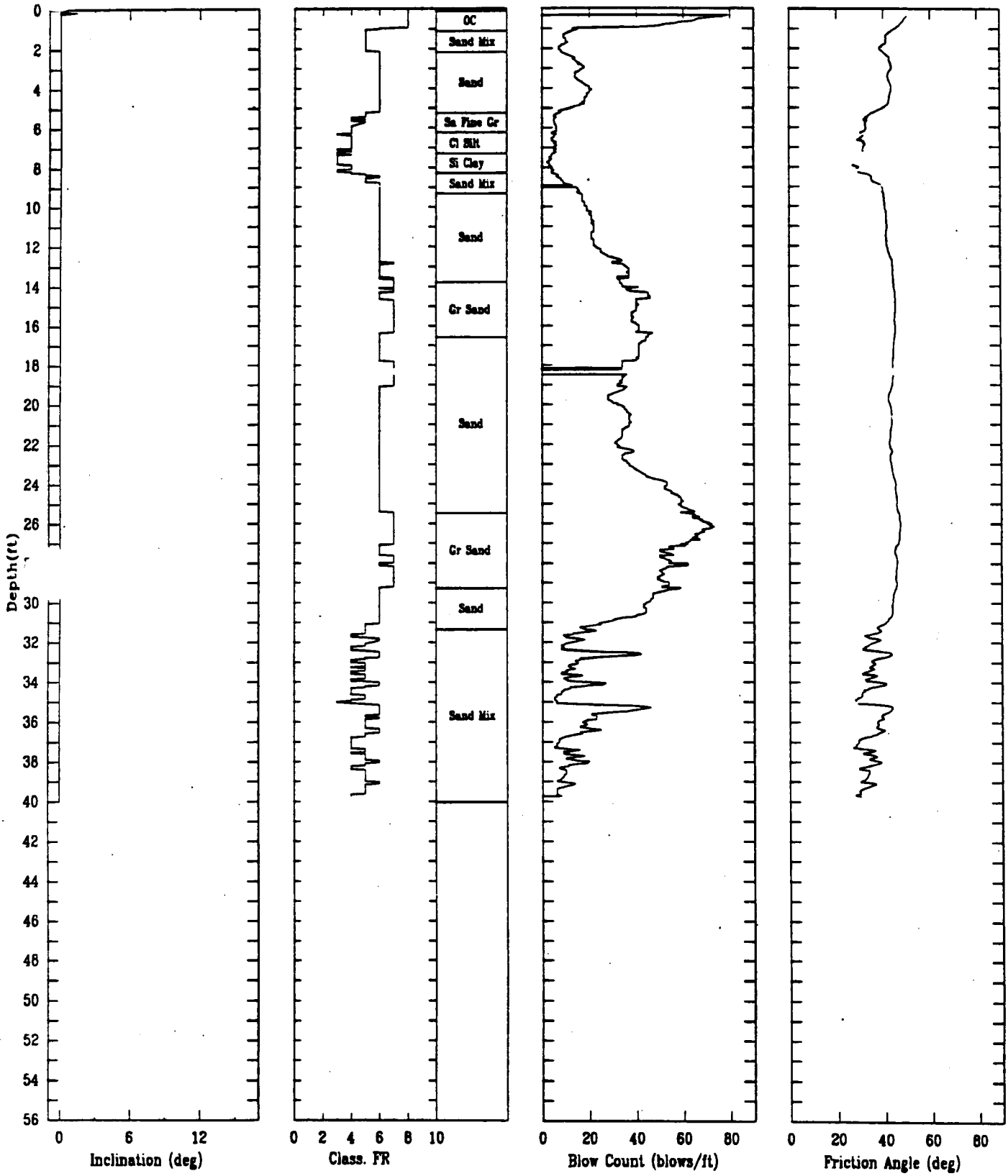

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APPLIED RESEARCH ASSOCIATES INC.

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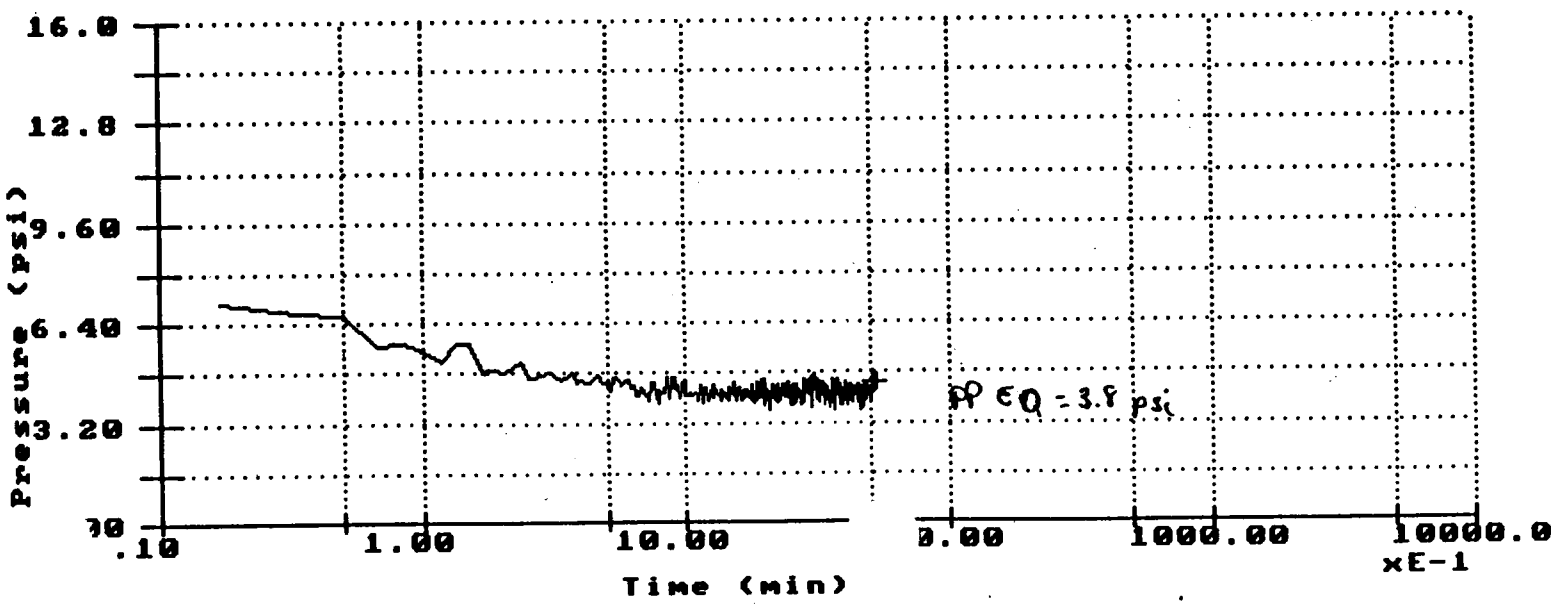

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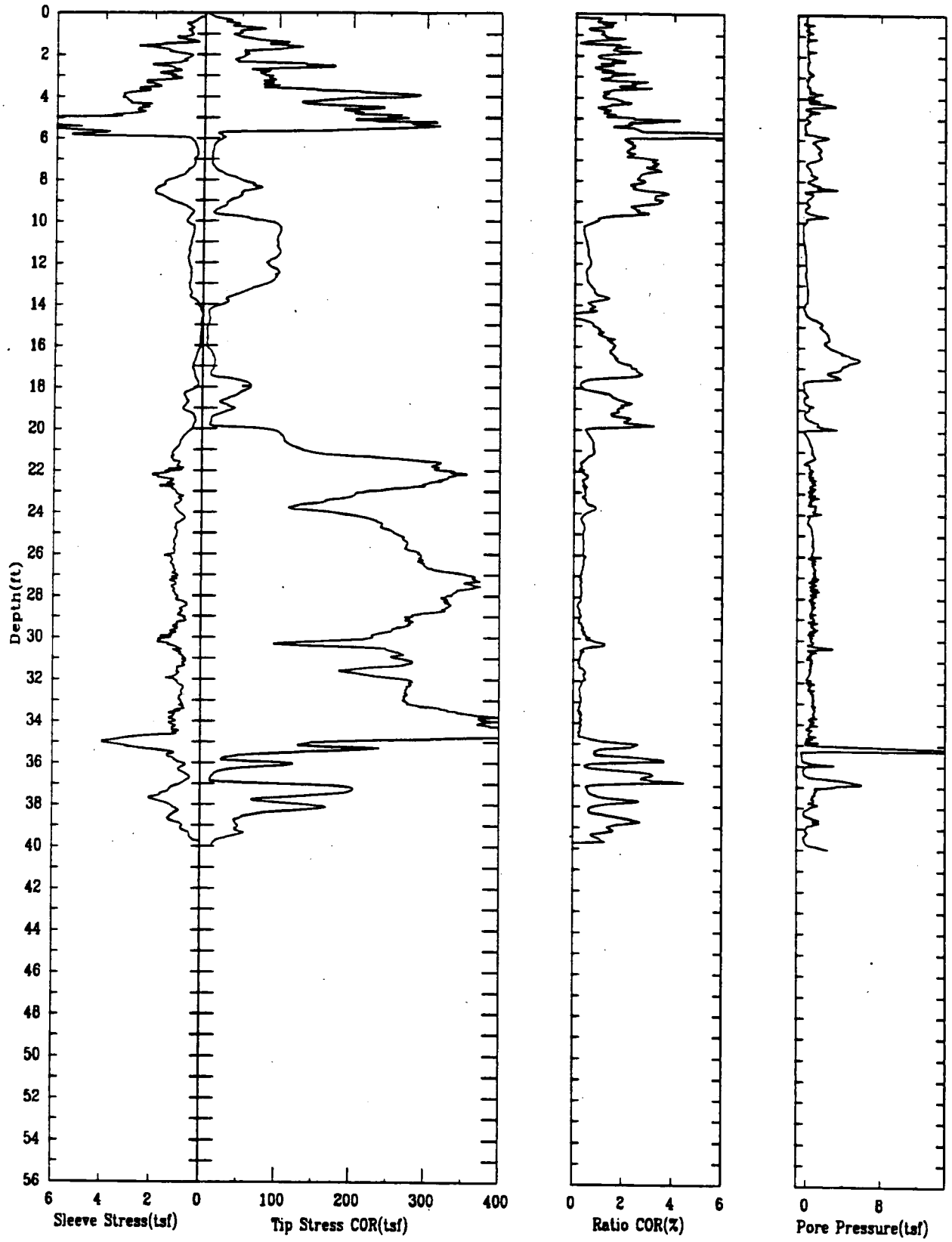

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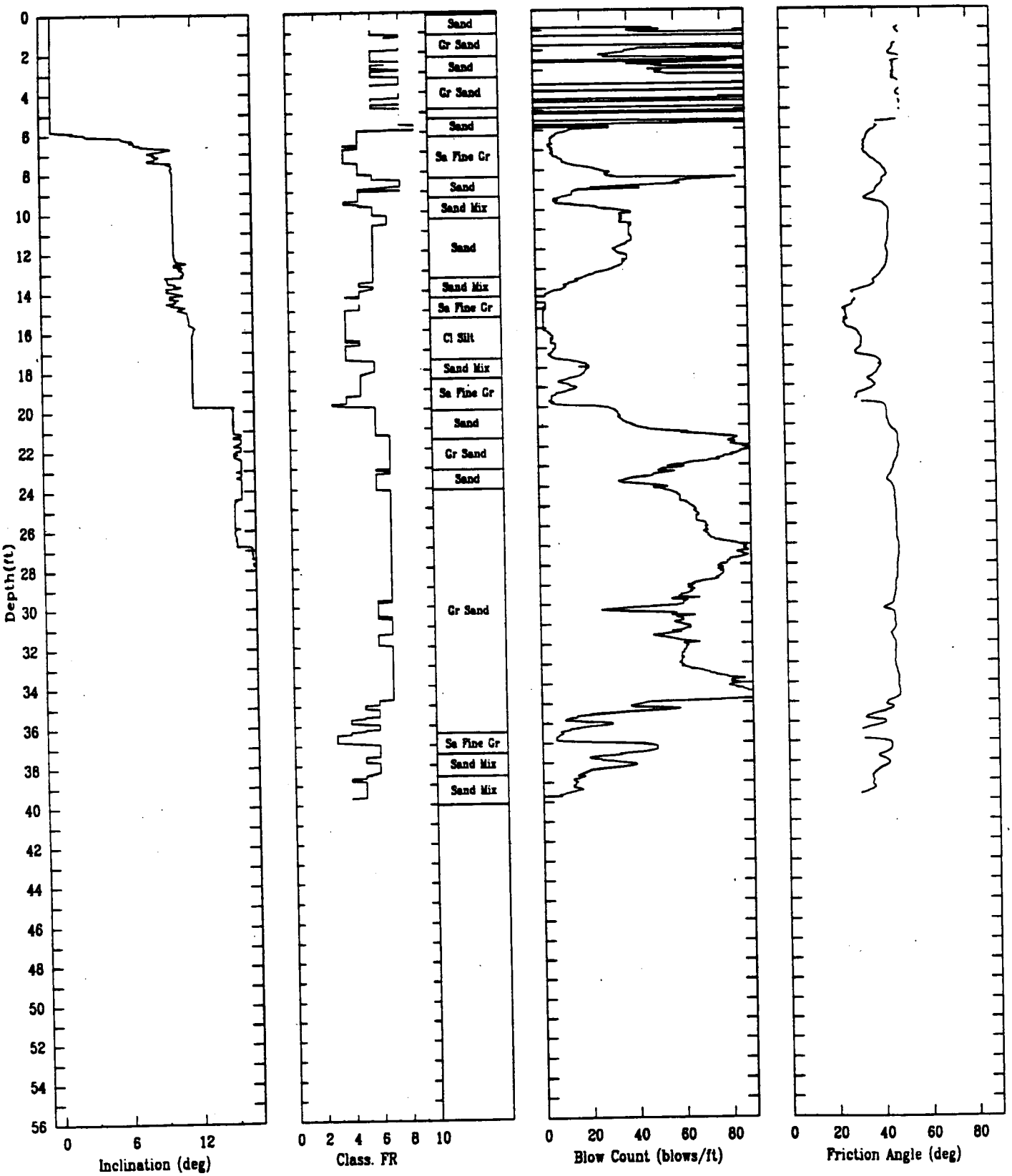

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APPLIED RESEARCH ASSOCIATES INC.

New England Division
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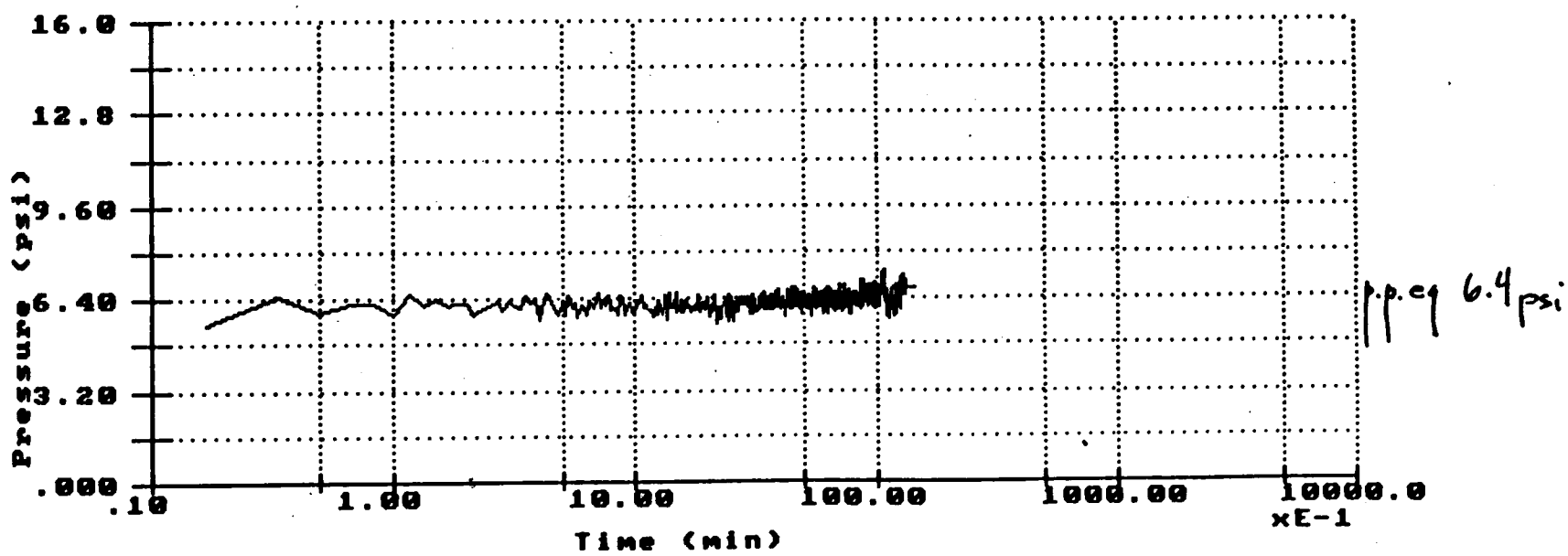

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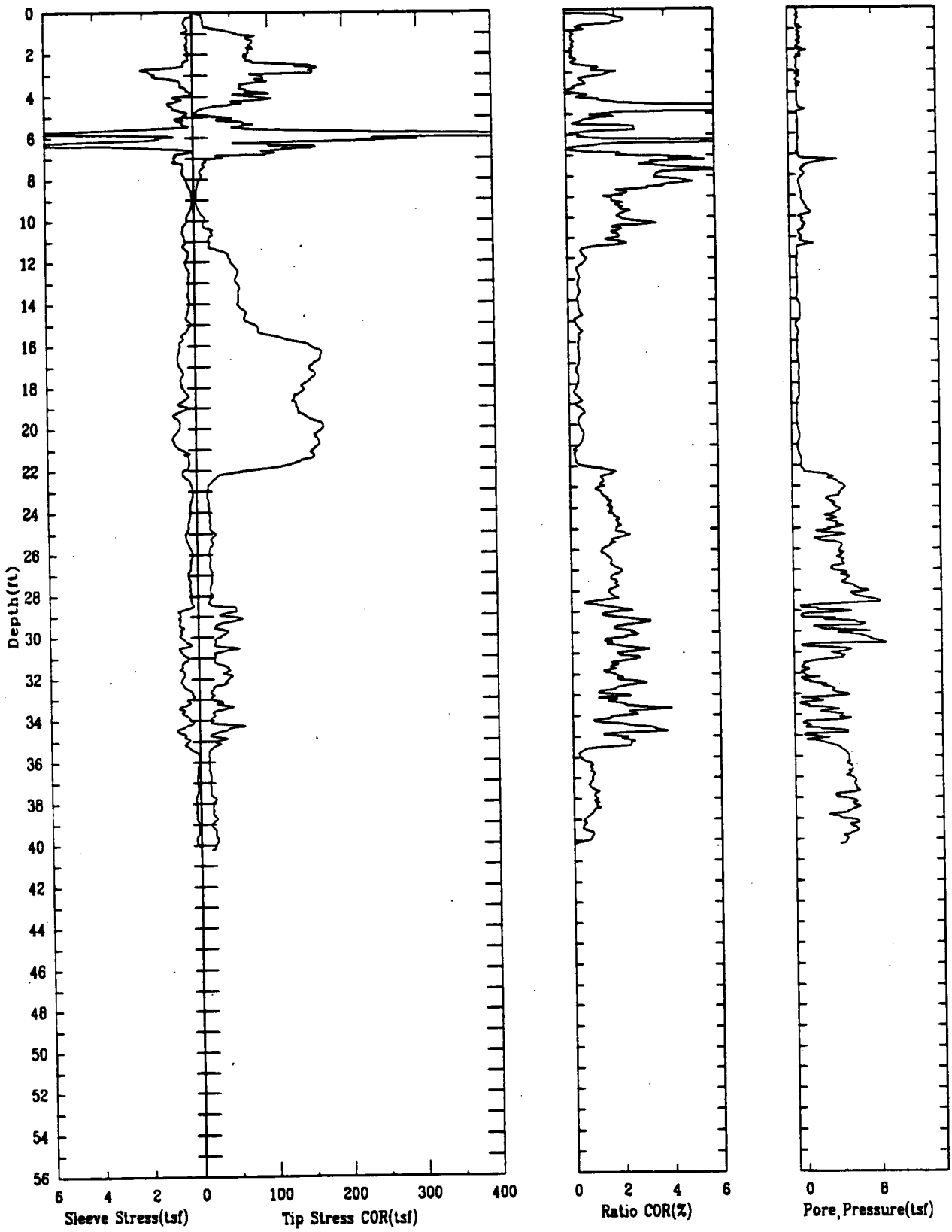

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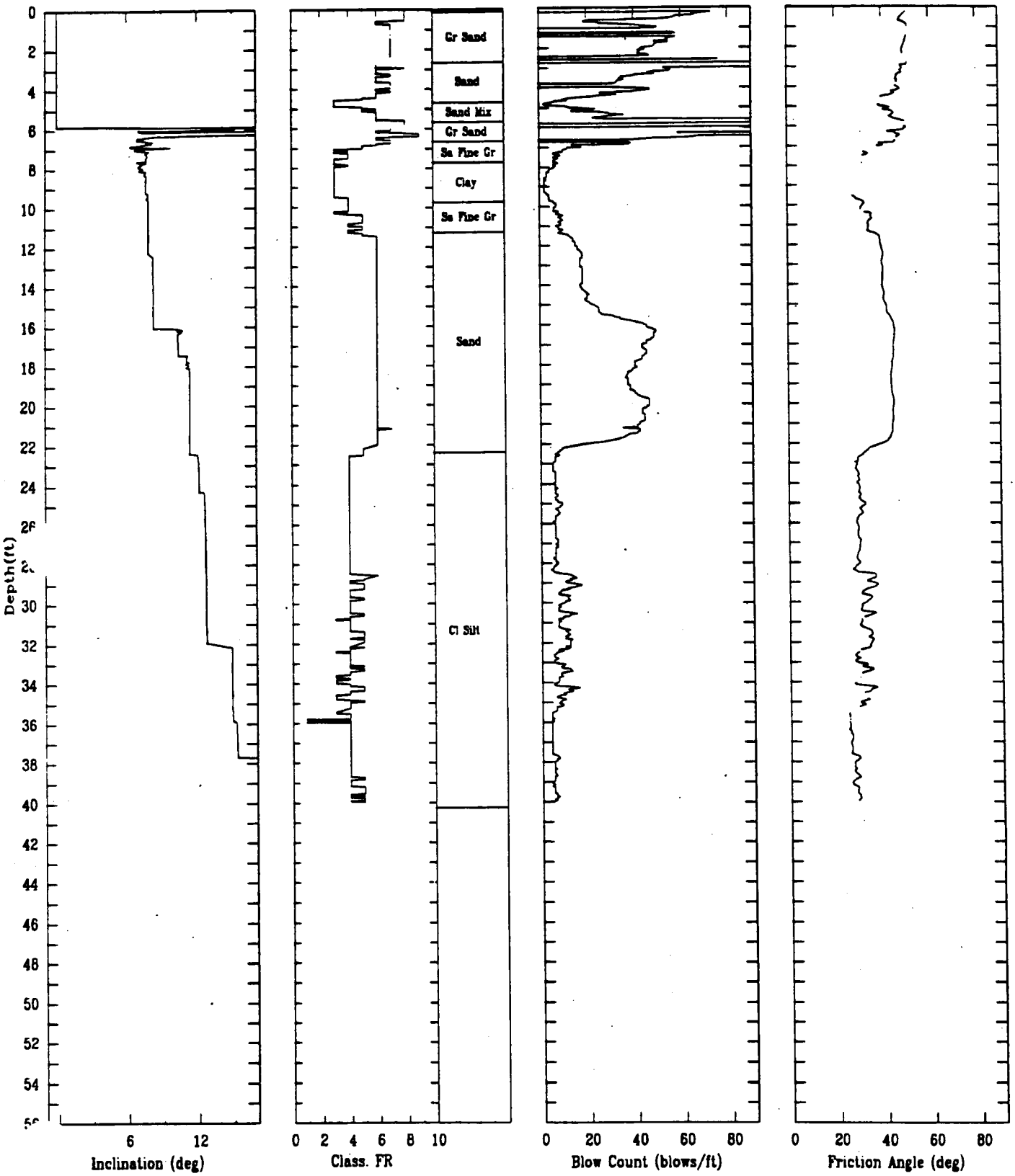

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APPLIED RESEARCH ASSOCIATES INC.

New England Division
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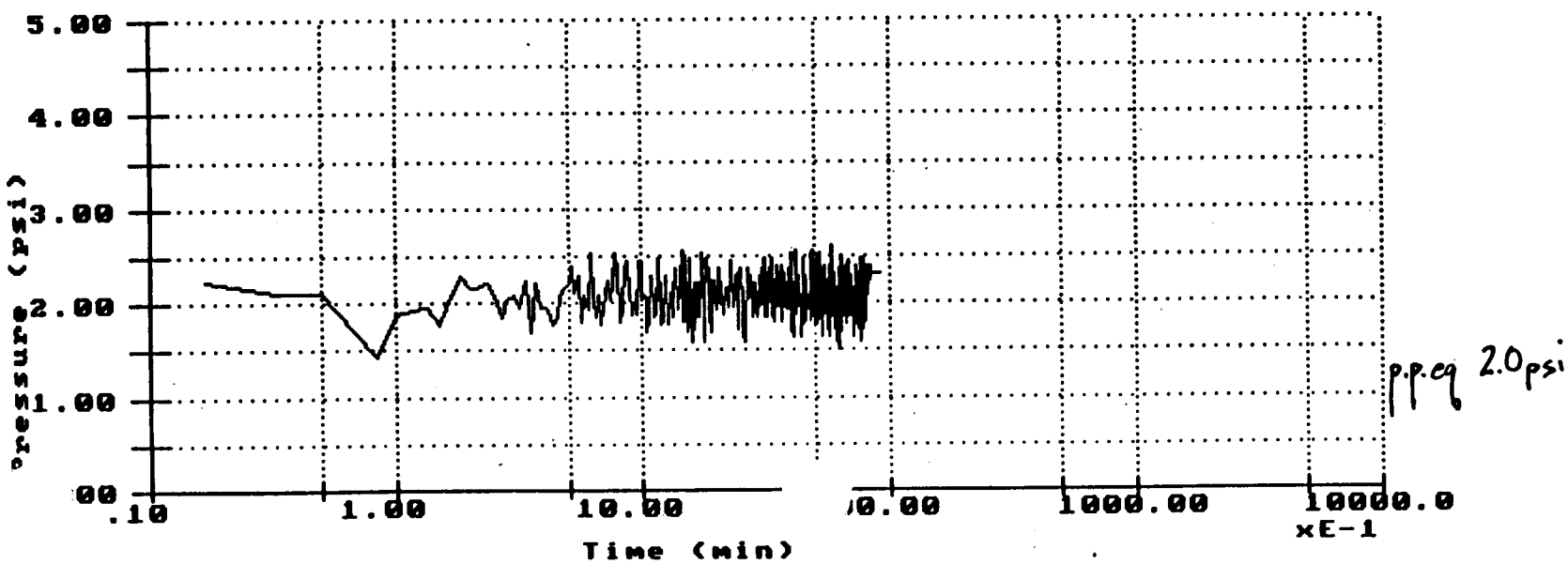

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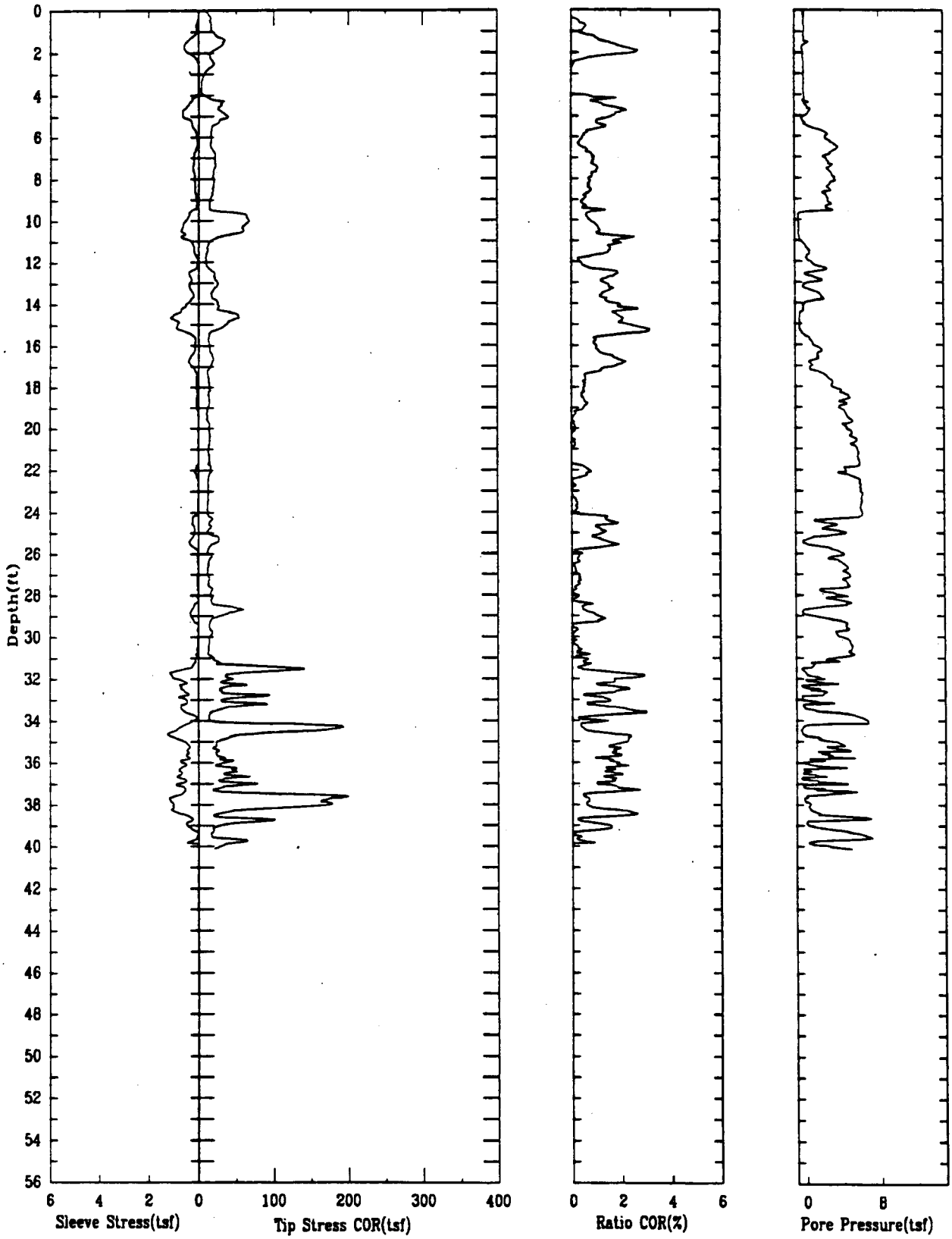

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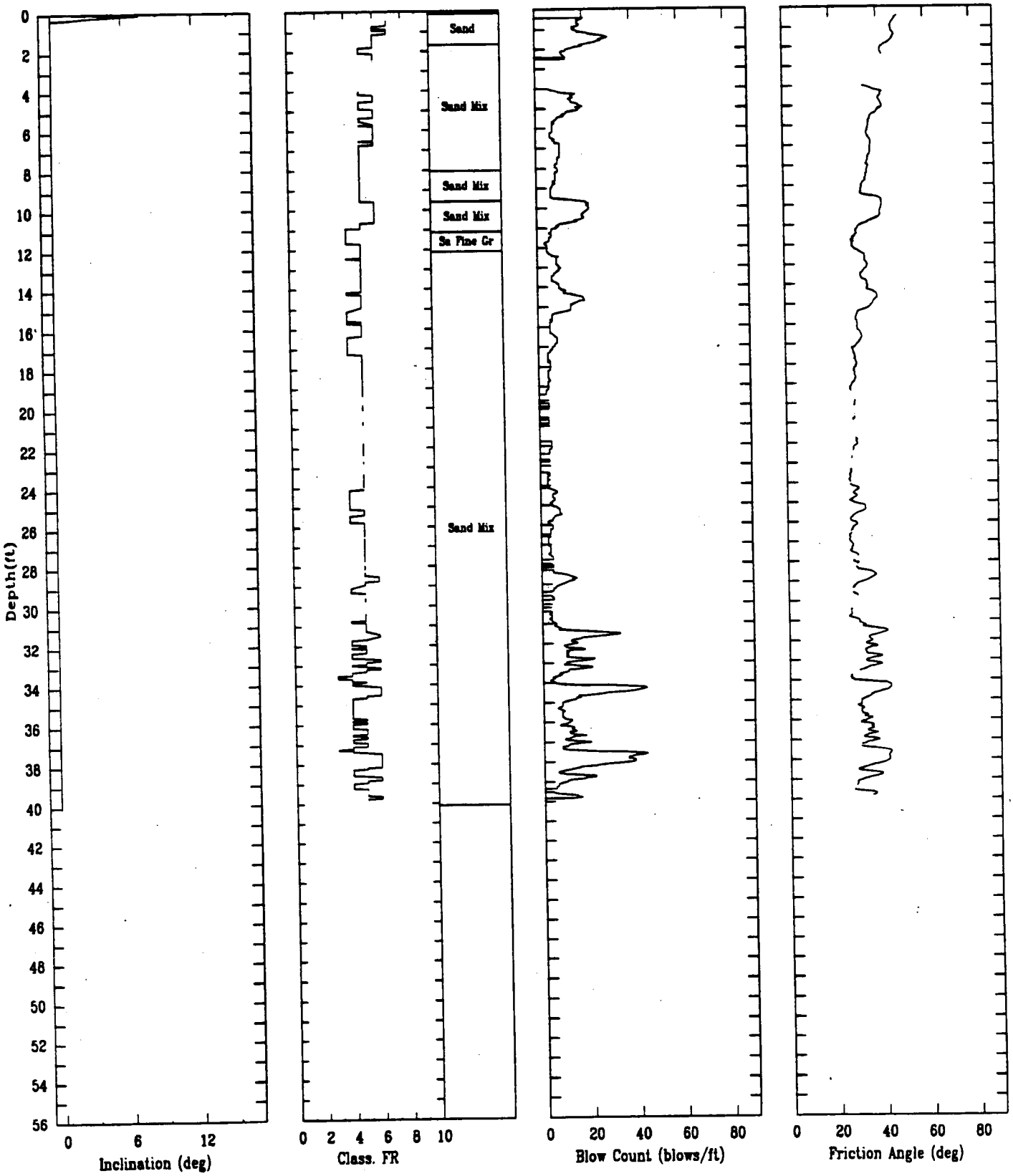

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APPLIED RESEARCH ASSOCIATES INC.

New England Division
Data Acquisition System
Version 6.00

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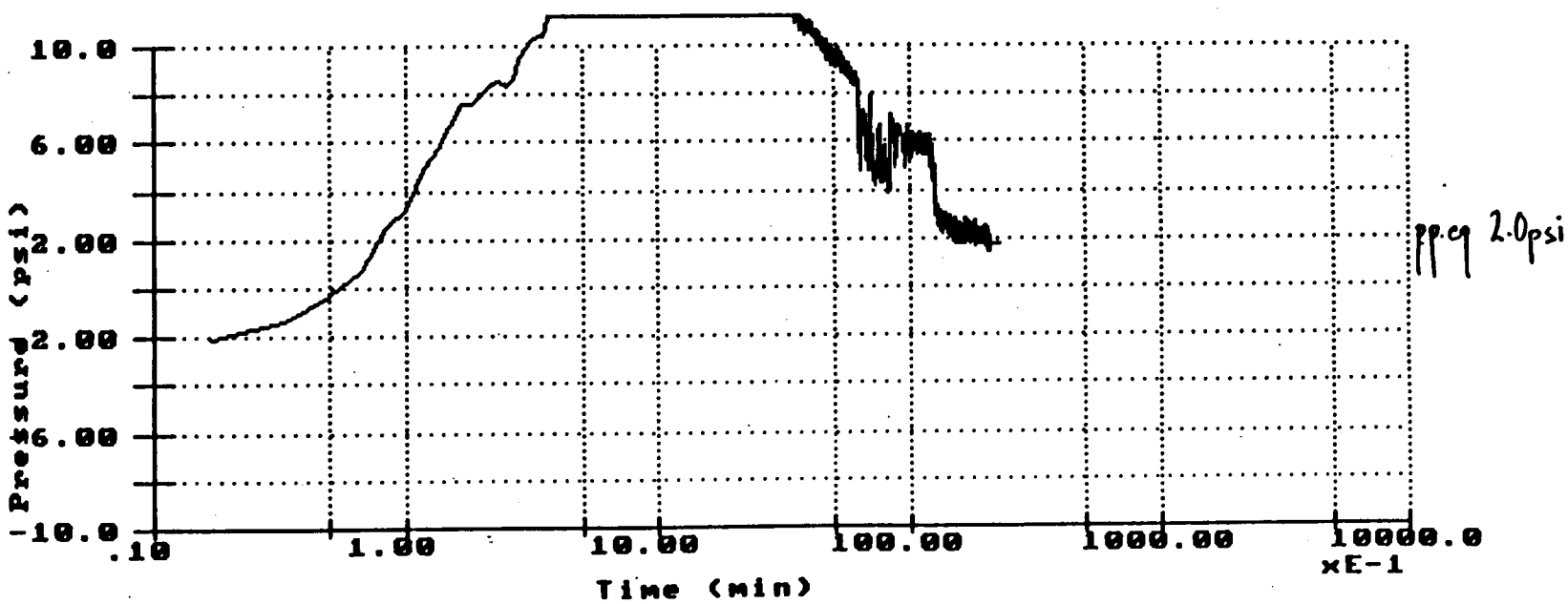

APPLIED RESEARCH ASSOCIATES INC.

New England Division
Data Acquisition System
Version 6.00

Pore Pressure Dissipation Test

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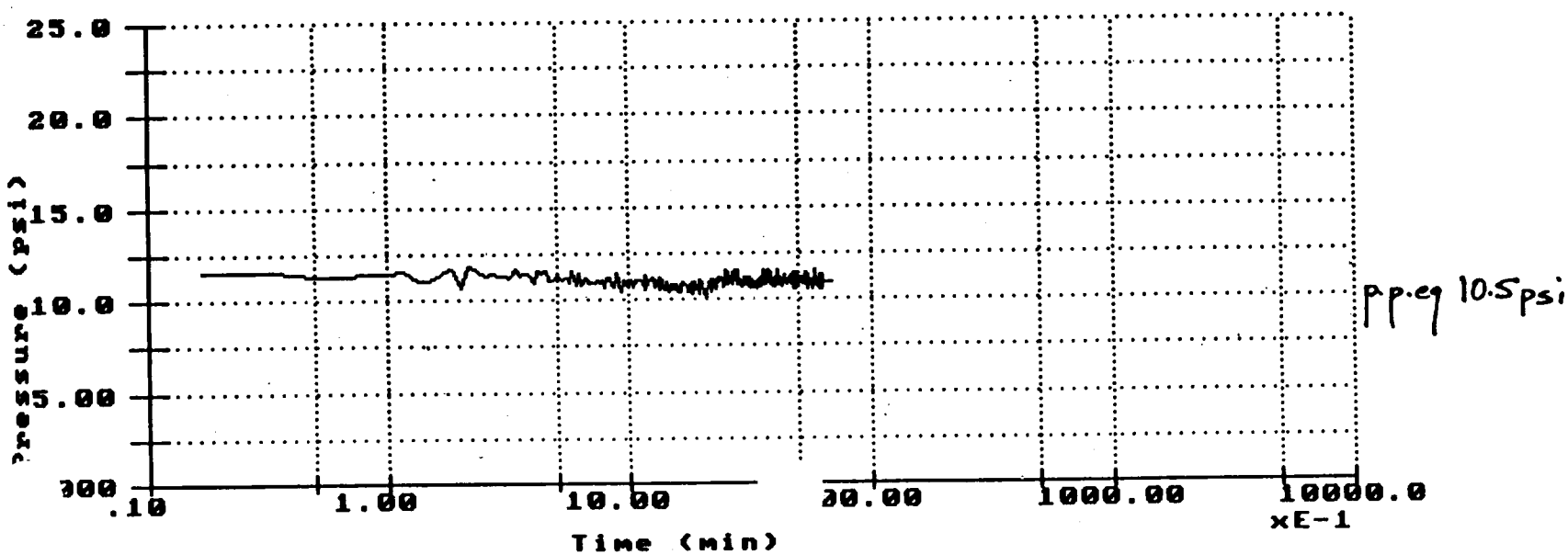

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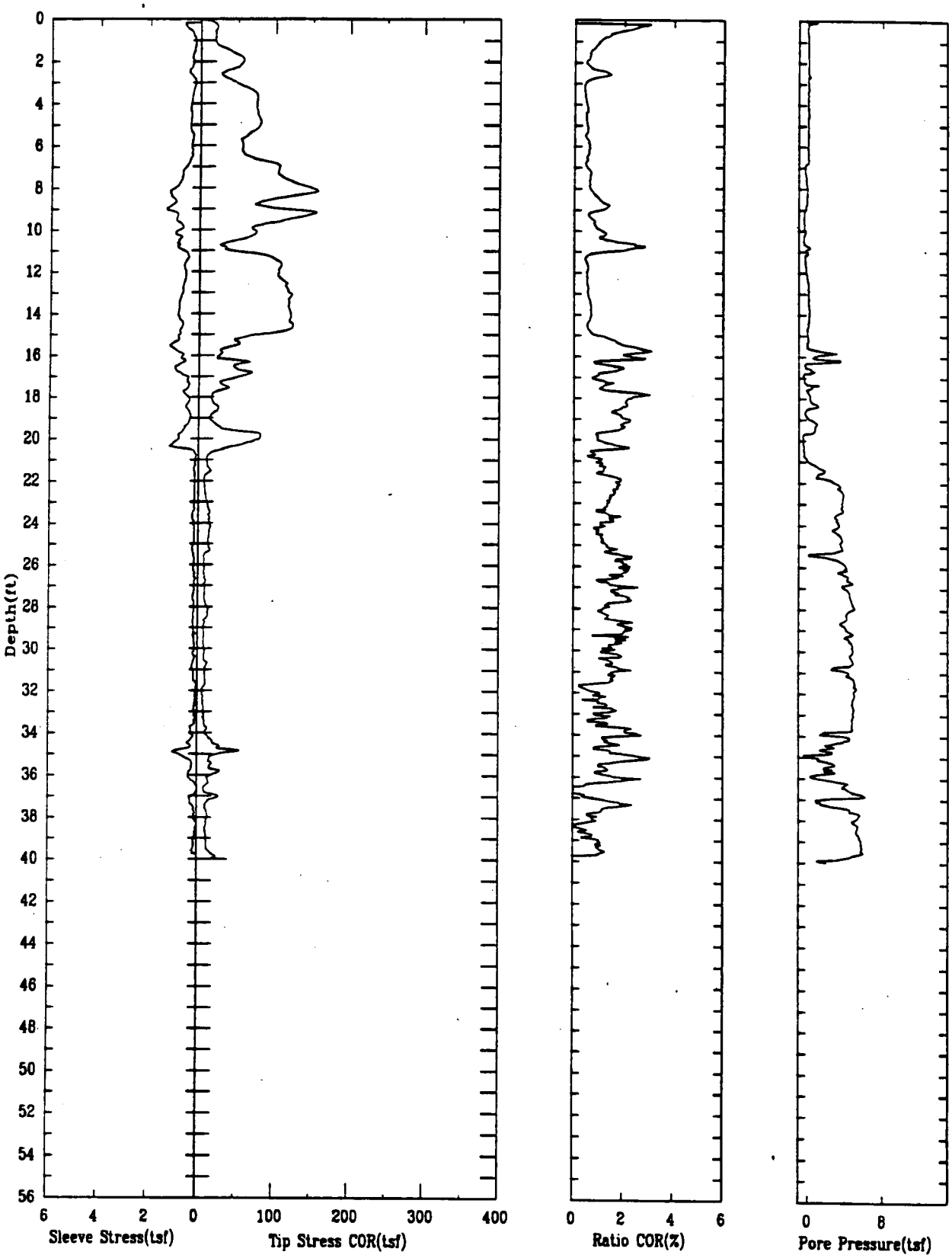
SW CORNER COUNTY PRISON GW



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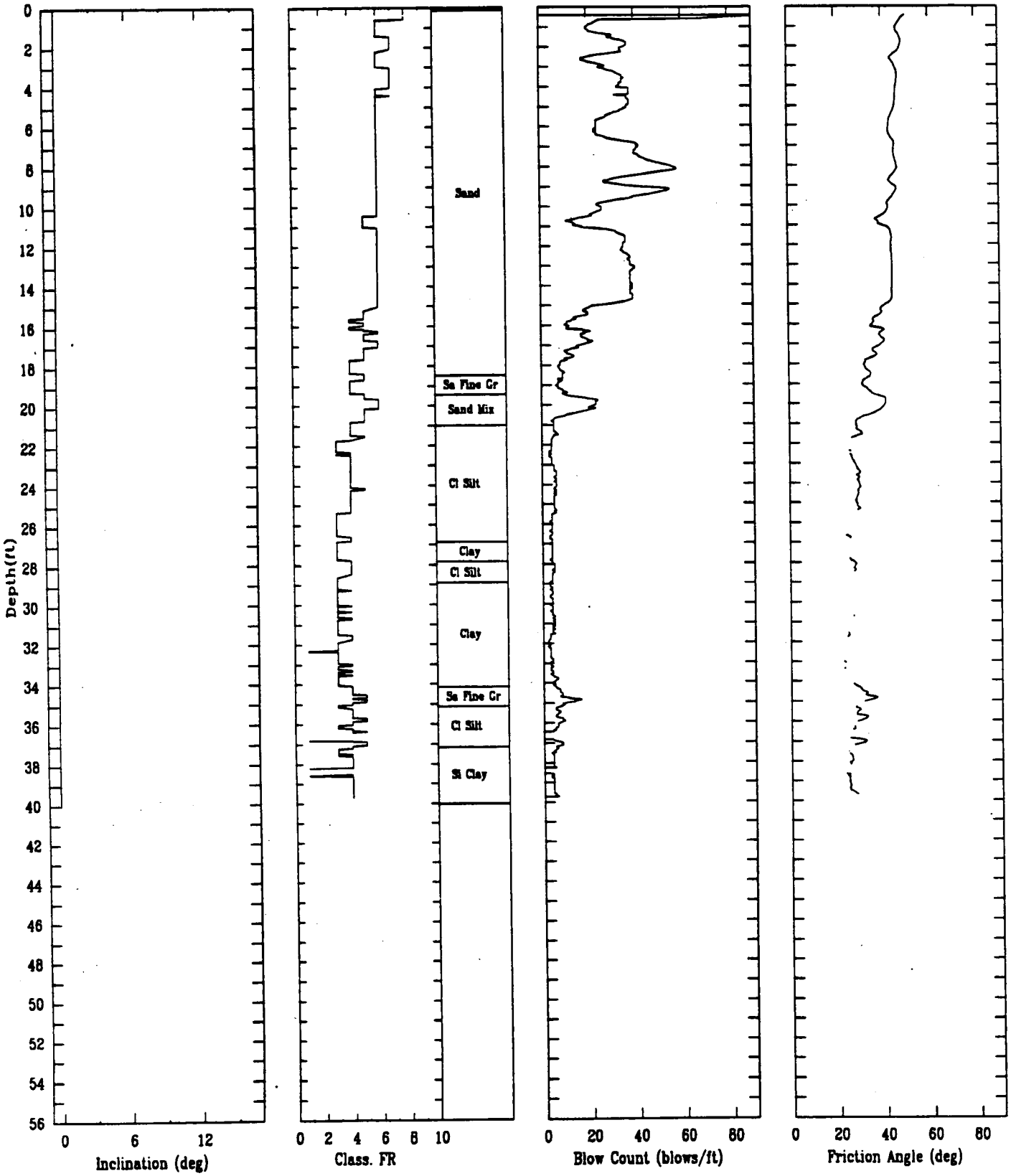

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New England Division
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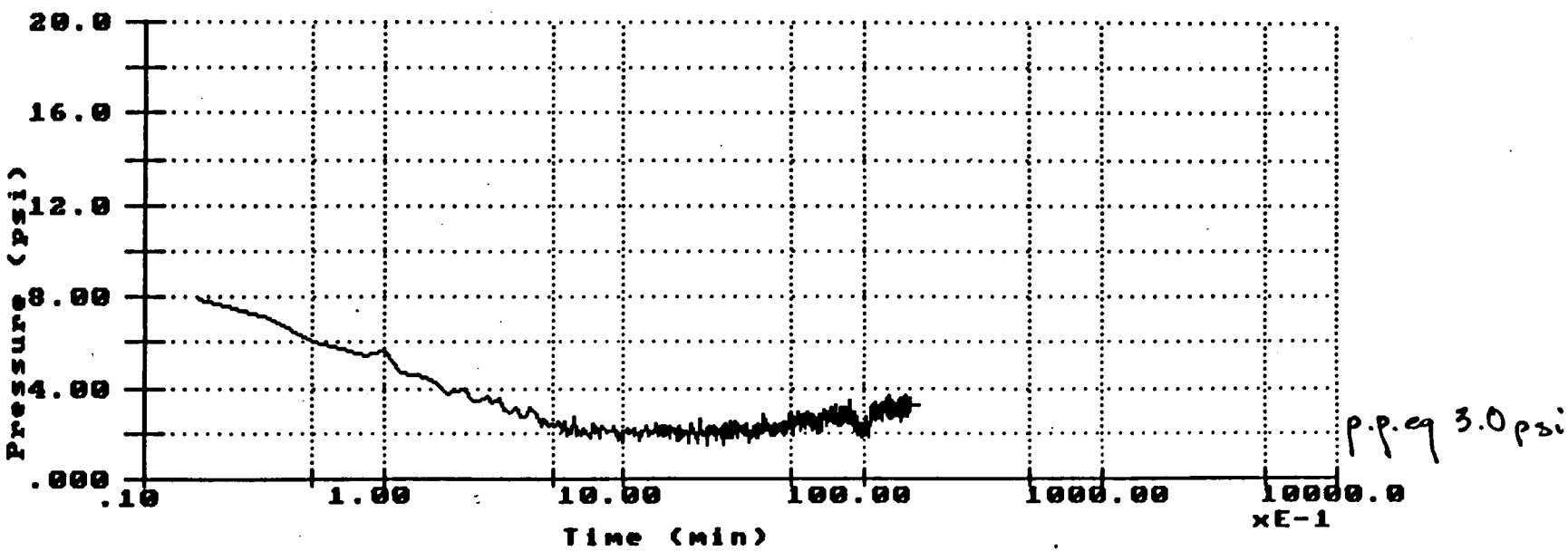

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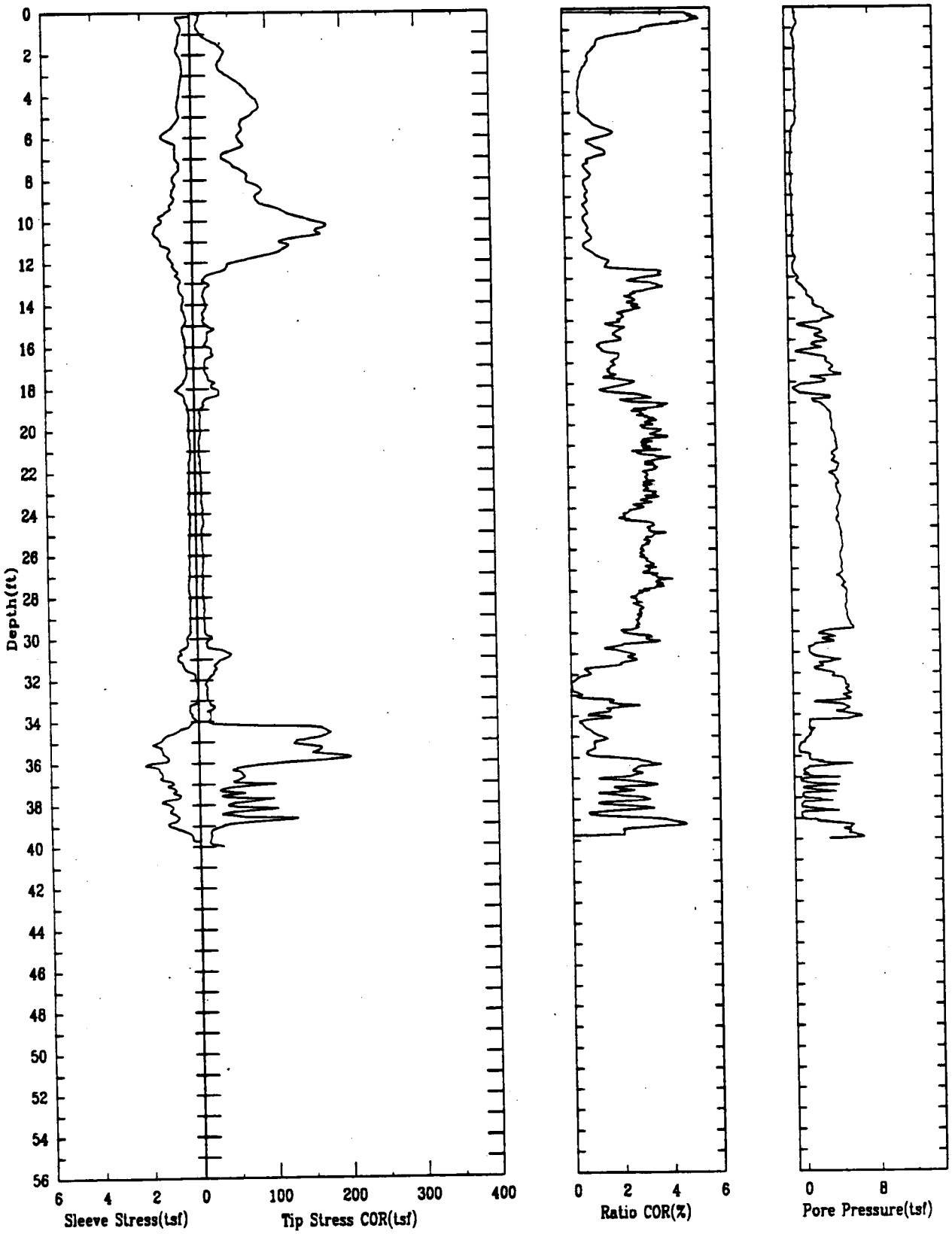

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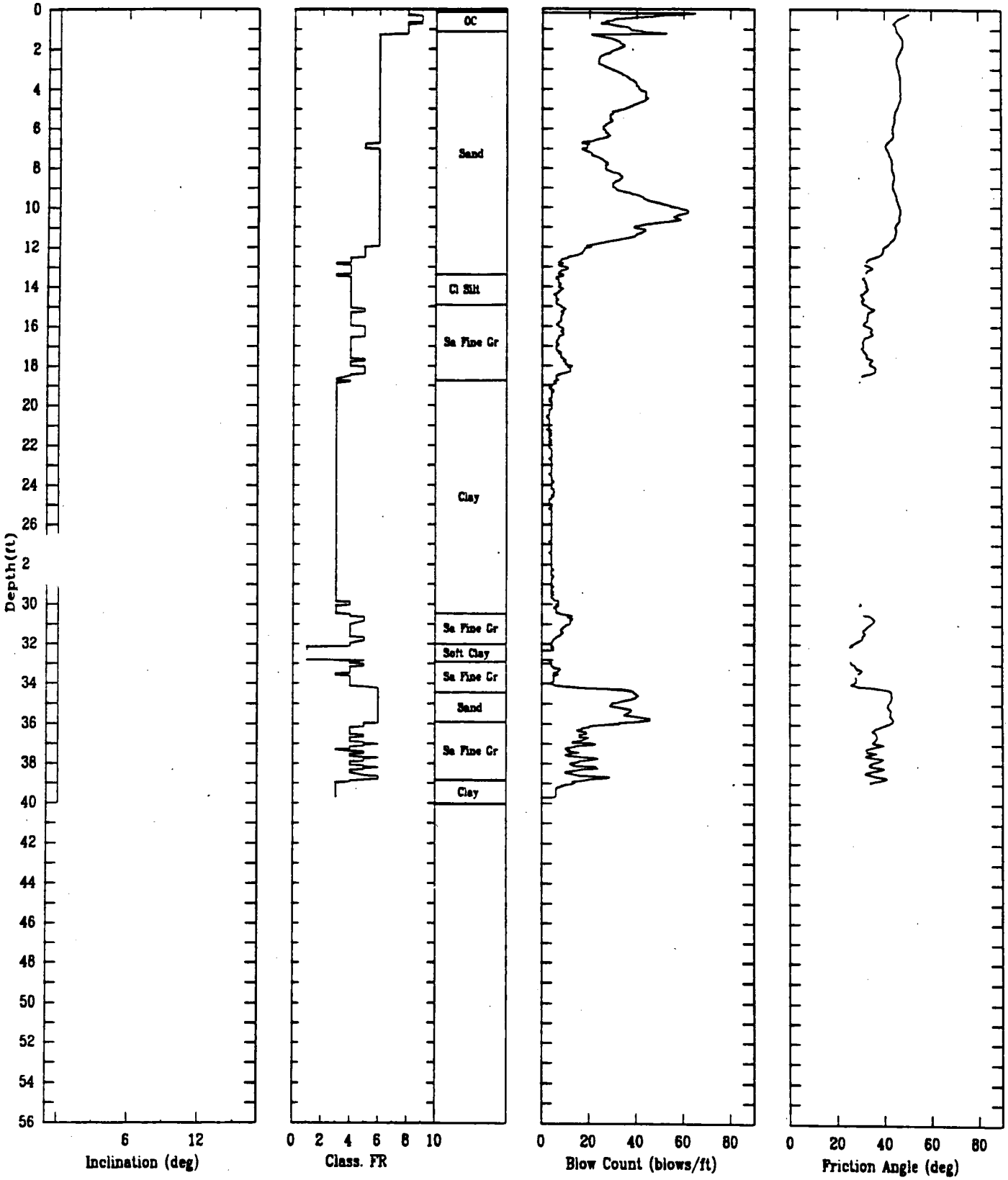

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APPLIED RESEARCH ASSOCIATES INC.

New England Division
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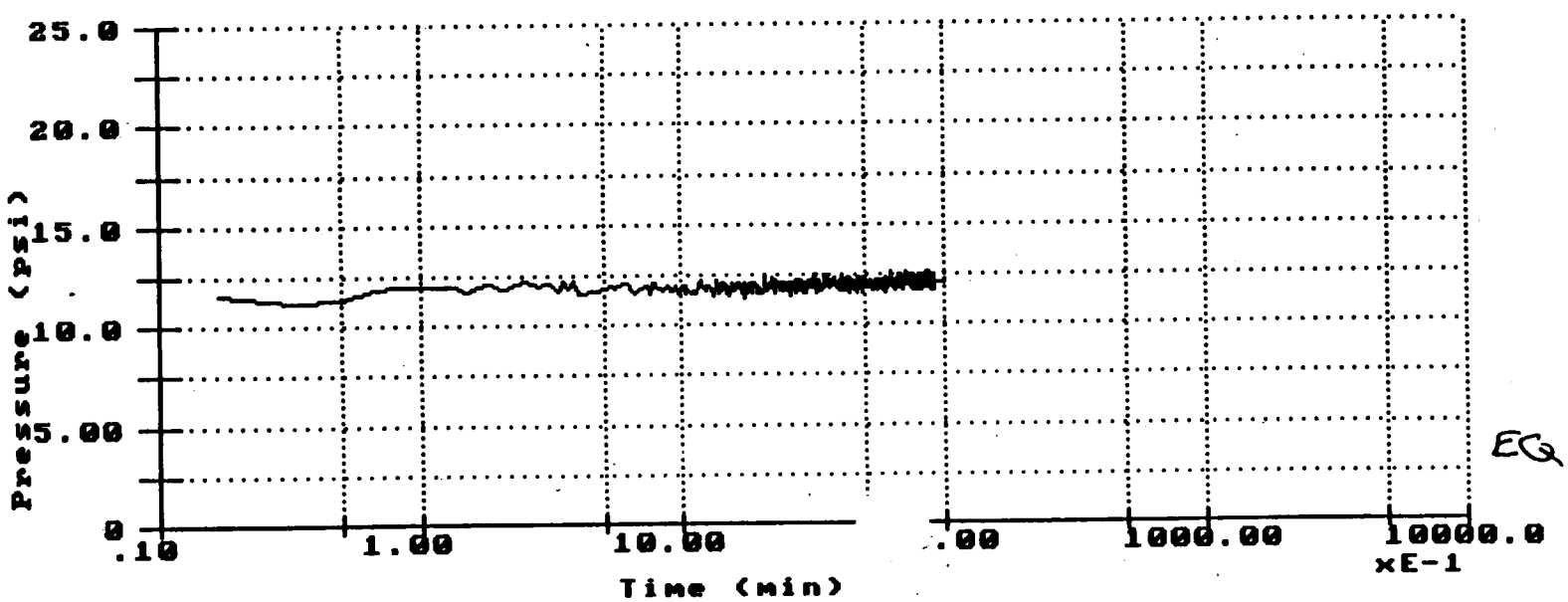

EQ PP. = 12.0 psi

Survey Results, Salt Lake lydroPunch 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	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

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**

Attachment B

DOE/AL/62350-134
REV. 1 c. 1

BASELINE RISK ASSESSMENT OF GROUND WATER CONTAMINATION AT THE URANIUM MILL TAILINGS SITE NEAR SALT LAKE CITY, UTAH

September 1995

Prepared for
U.S. Department of Energy
UMTRA Project Office
Albuquerque, New Mexico

Prepared by
Jacobs Engineering Group Inc.
Albuquerque, New Mexico

U. S. Dept. of Energy
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U.S. Government
Grand Junction Projects Office

14996

Health risks are evaluated for the age group most likely to experience health problems from the contamination. Noncarcinogenic risks are evaluated for children. Children (age group 1 to 10 years) are typically the most likely to be harmed from drinking contaminated ground water because children's bodies are small and they drink a lot of water. Infants (age group 0 to 1 year) generally drink less tap water than children but are nevertheless especially sensitive to contaminants like sulfate. In the case of cancer, which takes a long time to develop, risks are evaluated for adults (age group 11 years and up).

The seriousness of health effects varies for several reasons. The levels of contaminants in ground water vary from one well sampling round to the next. People vary in their body weight and consumption of water as well as in how their bodies react to chemical exposures. All these differences are considered in this risk assessment whenever possible. The risk assessment provides the reader with graphs to show different possible exposure levels along with the most current scientific information on the types of health effects that may result from the hypothetical exposure.

Results

There are no drinking water, livestock, or irrigation wells in the shallow aquifer at or near the Vitro site. Because no one uses the ground water for drinking or other purposes, it currently causes no health problems. This situation will continue if water use near the site does not change. It is unlikely that people will ever use the shallow aquifer ground water for drinking. Water from the shallow aquifer is naturally poor, and good water is available from the deep, confined aquifer and from the city.

Based on current concentrations of contaminants found in the most contaminated wells, there are possible health risks associated with drinking this ground water. Table CS-1 provides information on the nature of possible health problems that could be expected.

Note that only the people who drink all of their water from a well placed in the most contaminated portion of the aquifer (a fraction of the site) would be expected to experience the health problems described in Table CS-1. The table therefore provides the upper limit of possible risks; real risks would probably be lower.

The most important possible health hazard in this ground water is sulfate. Ingestion of sulfate in the amounts found in the ground water, particularly ingestion by infants, could cause severe diarrhea leading to dehydration in only a short time. However, sulfate in high amounts makes water taste and smell unpleasant, which discourages use.

Table CS-1 Human health effects from hypothetical future use as drinking water of contaminated ground water from the former Vitro site

Contaminant	Nature of health problems possible if people were drinking water from the shallow aquifer[a]	
	Short-term effects	Long-term effects
Fluoride	None	Mild dental damage (mottling)
Magnesium	Diarrhea; depression of nervous system and of skeletal muscles in people with kidney problems	Unknown
Manganese	None	Mild neurological symptoms include memory loss, irritability, and muscle rigidity
Molybdenum	None	Mild effects include copper deficiency anemia
Radium-226	None	None
Sodium and chloride	Unpleasant taste (salty)	Hypertension in sensitive people
Sulfate	Diarrhea and dehydration, particularly in infants	Unknown
Uranium	None	None

[a]These effects could vary from person to person depending on the amount of water a person drinks, body weight, dietary habits, and individual sensitivities such as the preexisting kidney or heart diseases, and other factors.

EPA - U.S. Environmental Protection Agency

The contaminated ground water also contains magnesium at levels sufficient to increase the severity of sulfate-caused diarrhea. In people with kidney disease and impaired magnesium excretion, these levels of magnesium could lead to muscle weakness, sleepiness, confusion, and other symptoms of the central nervous system depression.

Other milder health problems could result from the other contaminants if people were to drink water from the most contaminated portion of the aquifer for a long time. Fluoride levels at the site could cause dental damage in children. The amount of manganese could affect the nervous system causing mental disturbances, muscle rigidity, or tremors. The levels of molybdenum could result in copper deficiency, and the sodium chloride levels could lead to high blood pressure in people sensitive to salt. These health problems could be worse in people who have kidney problems.

ECOLOGICAL AND LIVESTOCK RISK ASSESSMENT

The ecological and livestock risk assessment presented in this document is a preliminary screening level assessment that relies on limited environmental sampling and literature information.

CITIZENS' SUMMARY

INTRODUCTION

The Uranium Mill Tailings Remedial Action (UMTRA) Project consists of two phases: the first is the Surface Project, and the second is the Ground Water Project. For the UMTRA Project site known as the Vitro site, near Salt Lake City, Utah, Surface Project cleanup occurred from 1985 to 1987. Tailings and radioactively contaminated soils and materials were taken about 85 miles (140 kilometers) west from the Vitro site to a disposal cell at Clive, Utah. The surface cleanup reduced radon and other radiation emissions and prevents further contamination of ground water.

The UMTRA Project's second phase, the Ground Water Project, evaluates the nature and extent of ground water contamination resulting from uranium processing and determines a strategy for ground water compliance with the Environmental Protection Agency (EPA) ground water standards established for the UMTRA Project. This ground water strategy must protect public health and the environment from radiological and nonradiological hazards. A risk assessment is one of the tools used to evaluate these hazards.

A risk assessment is the process of describing a source of contamination and showing how that contamination may reach people and the environment. The amount of contamination people or the environment may be exposed to is calculated and used to characterize the possible health or environmental effects that may result from this exposure.

This risk assessment report is the first site-specific document prepared for the UMTRA Ground Water Project at the Vitro site. The results of this report and further site characterization of the Vitro site will be used to determine what is necessary, if anything, to protect human health and the environment while complying with EPA standards.

RISK SUMMARY

Because no one is drinking the site-impacted water and no one is using it for irrigation or watering livestock, no human health risks are currently associated with the affected ground water. This favorable risk situation will continue if land and water use near the site do not change. Changes in land use may or may not create future risks. Therefore, any specific land uses determined for the site should be evaluated to identify potential health and environmental risks that might result from the contaminated ground water or surface water.

Because future land use at the site is not known, this risk assessment looks at the worst-case possibility. Calculations are performed on the assumption that a well placed in the area of affected ground water is used as a sole source of drinking water for people and livestock or to irrigate crops. Under this hypothetical scenario, those people and livestock could experience certain adverse health effects. Crops could also be adversely affected by the contaminated ground water. If that is so, the affected ground water from the shallow aquifer should not be used.

This risk assessment is conservative in the sense that it evaluates the residential scenario associated with the highest level of exposure, which could result from drinking water from the most contaminated wells on the site.

GROUND WATER QUALITY AND USES

Background ground water quality

Background ground water quality is the quality of water that would exist in the Vitro site area if uranium milling had never occurred. Two aquifers are present in the vicinity of the Vitro site: a shallow aquifer at 5 to 70 feet (1.5 to 20 meters) below land surface and a deeper aquifer at 70 to 500 feet or more (20 to 150 meters) below land surface. The deep aquifer is a source of municipal water in the Salt Lake City area.

In the shallow aquifer, the natural ground water is not fit for human consumption without substantial treatment. Arsenic, chloride, sodium, sulfate, and high levels of total dissolved solids from sources other than the milling operations (including some natural) exist in the aquifer. The ground water in the shallow aquifer does not move into the deep water-supplying aquifer because of upward pressure between the two aquifers.

Site-related ground water quality

Chloride, fluoride, magnesium, manganese, molybdenum, radium-226, sodium, sulfate, and uranium are the main contaminants in the shallow aquifer that are associated with former uranium processing activities. The contamination appears to extend some distance off the site to the northwest; however, its full extent has not been determined. The contamination may be entering surface water in the South Vitro ditch in the area of the south boundary of the site.

HUMAN HEALTH RISK ASSESSMENT

Methods

The risk assessment starts by identifying ground water contaminants resulting from uranium ore processing. This is done by comparing water quality data from wells drilled on the site to water quality data from background wells. Once contaminants are identified, the next step is to examine possible human health problems that could result from drinking the water containing these contaminants.

Both current and possible future human health risks are evaluated. To evaluate current risks, it is necessary to determine whether anyone is currently drinking the water. To evaluate future risks, it is assumed that people are getting all their drinking water from a well drilled into the most contaminated area beneath the site.

In the field of ecological and livestock risk assessment, many uncertainties result from limited scientific knowledge. Information is lacking on how some chemicals affect plants and animals. The impact of chemical mixtures on plants and animals is also poorly understood. Furthermore, due to limited environmental sampling at the former Vitro site, there is no information about the level of contamination in plants or animals there.

Therefore, the possible effects of the contaminants upon grazing livestock, wildlife, and agricultural crops are evaluated. This evaluation is done by comparison of the concentration of contaminants in the ground water, in surface water, and in sediment that has been affected by contaminated ground water to available guidelines from regulatory agencies and literature values. Surface water and sediment is evaluated from different areas of the South Vitro Ditch and Mill Creek. The shallow aquifer ground water is evaluated assuming plant roots take up the most contaminated ground water. This risk assessment also examines the use of this water as a sole source of drinking water for livestock, for crop irrigation, and for a ground water-fed pond stocked with fish.

Livestock results

There are currently no adverse effects to livestock and crops associated with the contaminated ground water in the shallow aquifer. Livestock are not currently grazed or watered on or around the former Vitro site, and no agricultural crops are currently irrigated with the affected ground water. In the future, if the ground water from the most contaminated portion of the aquifer under the site were the sole source of drinking water for cattle or sheep, sulfate levels would be high enough to cause diarrhea. This could preclude using this water for livestock watering.

Ecological results

If the affected ground water were used for irrigation, several constituents, such as fluoride, manganese, or molybdenum, could be present at concentrations exceeding levels protective of plants. The molybdenum concentration in the South Vitro Ditch also exceeds levels that are believed to be protective of plants. However, available data do not address the specific tolerances of plant species growing at the Vitro site.

Although silver, chloride, and iron are found in the South Vitro Ditch at concentration levels higher than those considered protective of aquatic organisms, it could not be determined with existing data whether aquatic organisms in South Vitro Ditch are sensitive to these constituent levels.

CONCLUSIONS

Ground water contamination below the Vitro site is limited to the shallow aquifer. Currently, there are no domestic wells in this aquifer on or near the site, and livestock do not graze there. Also, crops are not grown on the site. Therefore, no health risks are currently associated with site ground water.

This risk assessment has determined that certain health problems could occur in people and livestock if the contaminated ground water were used for drinking in the future. Therefore, neither humans or livestock should drink the untreated water. In addition, ground water could also be harmful to plants with roots in the shallow ground water and to plants irrigated with the water. Also, livestock grazing should not be permitted on those grasses growing on the site or that are irrigated with shallow ground water until the possible site-specific risks to livestock and plants are better evaluated.

The Vitro site evaluation is ongoing and will include further characterization of ground water quality, water levels, and movement. Issues related to surface water, sediment, and plants shall be addressed in future work plans. This risk assessment and future investigations will be used to determine how to deal with the contaminated ground water. If specific plans for land use at the site are ever developed, the risks should be reevaluated. Excavations into the contaminant plume, for instance, might expose contaminated ground water to surface sources, creating a new exposure risk and thus requiring reevaluation.

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LIST OF ACRONYMS

Acronym	Definition
AEC	U.S. Atomic Energy Commission
CVWRF	Central Valley Water Reclamation Facility
DDPA	monododecyl phosphoric acid
DHHS	Department of Health and Human Services
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ESADDI	estimated safe and adequate daily dietary intake
HEAST	Health Effects Assessment Summary Tables
IRIS	Integrated Risk Information System
LOAEL	lowest observed adverse effect level
MCL	maximum concentration limit
NOAEL	no observed adverse effect level
NRC	U.S. Nuclear Regulatory Commission
ppm	parts per million
RDA	recommended daily allowance
RfD	reference dose
SF	slope factor
TDS	total dissolved solids
UMTRA	Uranium Mill Tailings Remedial Action
UMTRCA	Uranium Mill Tailings Radiation Control Act

1.0 INTRODUCTION

The purpose of this baseline risk assessment is to determine whether ground water contamination at the Salt Lake City, Utah, uranium processing site (known as the Vitro site) could adversely affect human health or the environment. The Salt Lake City site is one of 24 abandoned uranium mill tailings sites undergoing remediation in accordance with the requirements of the *Uranium Mill Tailings Radiation Control Act* (UMTRCA) of 1978 (42 USC §7901 *et seq.)* under the oversight of the U.S. Department of Energy (DOE) Uranium Mill Tailings Remedial Action (UMTRA) Project. The remediation of surface contamination at the Salt Lake City uranium processing site was completed in 1987 with stabilization of the tailings and other contaminated materials and soils at Clive, Utah.

This risk assessment is a baseline assessment in the sense that it describes current ground water conditions at the site; ground water contamination was only partially characterized. This document evaluates the potential for public health and environmental risks that may need attention before the site is fully characterized. This risk assessment is based on available ground water data from wells at the processing site. Major exposure pathways have been identified and examined for this risk assessment.

This risk assessment follows the basic framework outlined by the U.S. Environmental Protection Agency (EPA) (EPA, 1989a) for evaluating hazardous waste sites to assess potential health and environmental impacts. The risk assessment framework consists of the following steps:

- Data evaluation.
  - Existing data from various site investigations are combined.
  - Sample results are compared to background and tailings source data.
  - Appropriate chemical data are selected for the risk assessment.
- Exposure assessment.
  - Exposure setting is characterized.
  - Exposure pathways are identified.
  - Exposure is quantified.
- Toxicity assessment.
  - Toxicity values are identified
  - Noncarcinogenic effects are evaluated.
  - Carcinogenic effects are evaluated for radionuclides and chemical carcinogens.
- Public health risk characterization.
  - Toxicity ranges are compared to predicted exposure ranges.
  - Risks are combined across exposure pathways and multiple contaminants.
  - Uncertainties are characterized.

- Environmental risk.

  - Potential biota exposure pathways are characterized.
  - Potential ecological receptors are identified.
  - Environmental risk is evaluated qualitatively.

This framework is incorporated in the methodology developed to evaluate current human health risk at UMTRA Project sites and to estimate risks from possible future use of contaminated ground water or surface water near the Vitro site (DOE, 1994a).

This risk assessment will support decisions made for the UMTRA Ground Water Project. The DOE was authorized to conduct ground water remediation under the 1988 UMTRCA Amendments Act (42 USC §7922 *et seq.*) and will determine site-specific ground water compliance strategies for each site. This baseline risk assessment provides information to assist in determining the site-specific ground water compliance strategy for the Vitro site.

2.0 SITE DESCRIPTION

The Salt Lake City site (the Vitro processing site) is in a large basin drained by the Jordan River. The 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.

2.1 SITE BACKGROUND

In 1941, a large smelting operation known as Calunite Smelter, Inc., was completed at 3300 South Street and 900 West Street in Salt Lake City. 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 with the U.S. Atomic Energy Commission (AEC). Because the plant operator was the Vitro Chemical Company, the site is often referred to as the Vitro processing site.

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.

In 1951, Vitro Chemical Company began processing uranium ores using the phosphate precipitation technique. Uranium ore was first roasted and then leached in a sulfuric acid solution. Metallic aluminum was added to the solution as a reducing agent and the pH was kept in the range of 1.0 to 1.8 to promote uranium precipitation (in a reduced trivalent form) as a phosphate. After the solids (tails) were separated from the uranium-bearing leachate, the uranium was precipitated from the acid solution by adding orthophosphate. The uranium phosphate precipitate was then digested in a 10- to 30-percent sodium or potassium hydroxide solution to remove excess phosphate. The mill could process 100 tons of ore per day in 1951 and by 1956 was processing 500 tons per day (Merritt, 1971).

In 1957, the plant was converted to a solvent extraction processing circuit; 600 tons of ore per day were processed with this method. After the ore was roasted and leached in a sulfuric acid solution adjusted to a pH of 1, a reducing agent (typically sodium hydrosulfide) was added to the slurry to reduce ferric iron and molybdenum. The solids were separated from the solution, then disposed of in tailings piles, and the solution was mixed with an organic solution. This organic solution was 10 percent or less monododecyl phosphoric acid (DDPA) dissolved in kerosene. While the kerosene solution and acid-aqueous solution were immiscible, intensive agitation allowed the uranium in the acid solution to complex with the DDPA in the kerosene solution, thus removing the uranium from the acid solution. The spent acid solution, called raffinate,

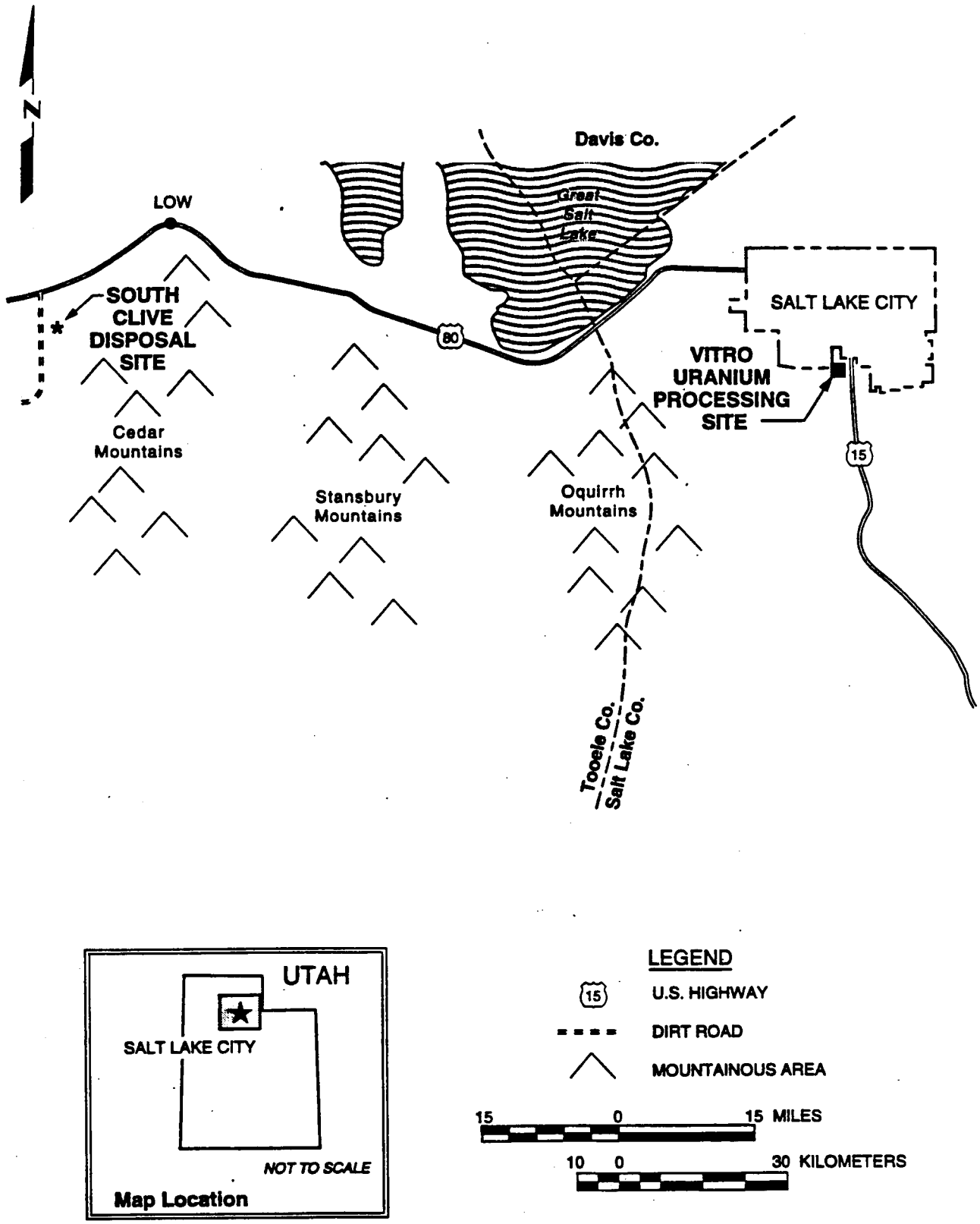


FIGURE 2.1
LOCATION OF THE SOUTH CLIVE DISPOSAL SITE AND THE VITRO URANIUM PROCESSING SITE SALT LAKE CITY, UTAH, SITE

MAC: SITE: SLC/BRA/CLIVE&VITRO SITELOC

was pumped to evaporation ponds. This raffinate may have contained up to 5 parts per million (ppm) DDPA (Merritt, 1971).

The uranium was extracted from the kerosene solution by mixing the organic liquid with aqueous 10 normal hydrochloric acid. The uranium complexed with chloride in the aqueous solution, which was then separated from the immiscible kerosene. The hydrochloric acid solution was evaporated, and the distilled acid was recovered for reuse. After uranium-bearing solids left by evaporation of the acid were diluted with water, ammonia was added to precipitate ammonium diuranate, which was heated to drive off excess ammonia. This process resulted in a final product of uranium oxide (U_3O_8).

The DDPA-kerosene solution was recycled. However, buildup of thorium, titanium, and scandium in the solvent required periodic treatment to remove these elements from the kerosene solution. This was done by stripping with 10 percent hydrofluoric acid solution, which resulted in precipitation of thorium, titanium, and scandium as fluorides. These precipitates were shipped elsewhere for refining (Merritt, 1971).

Remedial action at the Salt Lake City uranium processing site occurred from January 1985 to March 1987. A total of 2,798,000 cubic yards (yd^3) (2,139,000 cubic meters [m^3]) of tailings were 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, 1995b). Clean fill was placed in all excavated areas and the ground was recontoured and revegetated.

2.2 CLIMATE

The Salt Lake City site is in the intermountain plateau climatic zone that extends between the Cascade and Sierra Nevada ranges and the Rocky Mountains. This area is classified as a middle-latitude, dry climate or steppe, characterized by a hot, dry summer, cool spring and fall, and moderately cold winter. Normal daily highs range from about 37 degrees Fahrenheit (°F) (3 degrees Celsius [°C]) in January to 93 °F (34 °C) in July, while normal daily lows range from about 19 °F (-7 °C) in January to 61 °F (16 °C) in July (DOE, 1984a).

The prevailing winds are from the southeast and south-southeast. Average annual precipitation from 1948 to 1983 was 15.8 inches.

2.3 HYDROGEOLOGY

The lithology underlying the Salt Lake City site consists of a thick sequence of Quaternary lacustrine-fluvial deposits with minor alluvial overburden. Unconsolidated lacustrine deposits below the site are approximately 700 feet (ft)

(210 meters [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). After site surface remediation, the upper 4 to 13 ft (1.2 to 3.9 m) of soil was replaced with clean sandy gravel fill material.

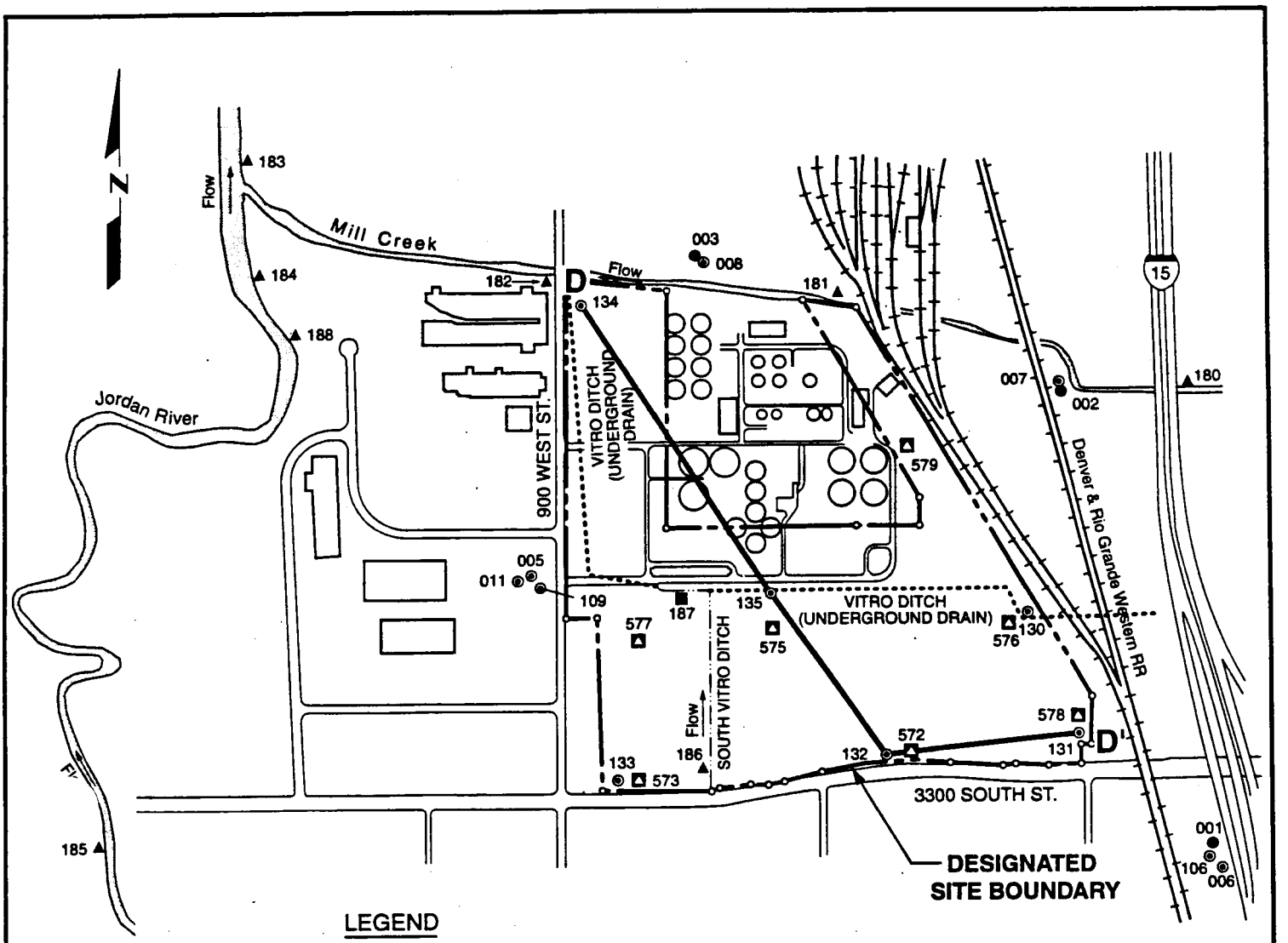
Borehole samples from previous investigations (Figure 2.2) indicate the shallow materials consist of unconsolidated silt, clayey-silt, silty-clay, and lenticular sands deposited in a fluvial-lacustrine environment. These sediments are complexly interbedded, and correlation between individual boreholes is sometimes difficult. Figure 2.3 shows a geologic cross section of the site. Borehole data suggest siltier and more clayey sediments are to be found in the southern and eastern portions of the site (monitor wells 130 to 133) and sandier sediments occur in the northern and western portions of the site (monitor wells 134 and 135). Monitor well locations are shown in Figure 2.2.

The ground water regime in the vicinity of the Salt Lake City 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. Wells 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. 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.

2.3.1 Shallow unconfined aquifer

In the vicinity of the former tailings pile, the upper, unconfined aquifer is approximately 45 ft (14 m) thick. Ground water yields from the interbedded strata of this aquifer system depend on the lithology of the screening location. Results from DOE on-site aquifer pumping tests conducted in July 1992 indicate ground water yields can range from much less than 1 gallon (4 liters) per minute from the silts and clays, to long-term sustained yields of more than 4 gallons (16 liters) per minute from the fine-grained sands and silty sands.

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). However, a highway drain below the Denver & Rio Grande Western Railroad overpass at 3300 South Street locally influences ground water flow in the unconfined aquifer. Ground water entering the drain is pumped out of a sump into a culvert that discharges into the head of South Vitro Ditch. Ground water levels in the area indicate a local ground water divide in the southeast corner of the site draws ground water from that area toward the drain (Figure 2.4).



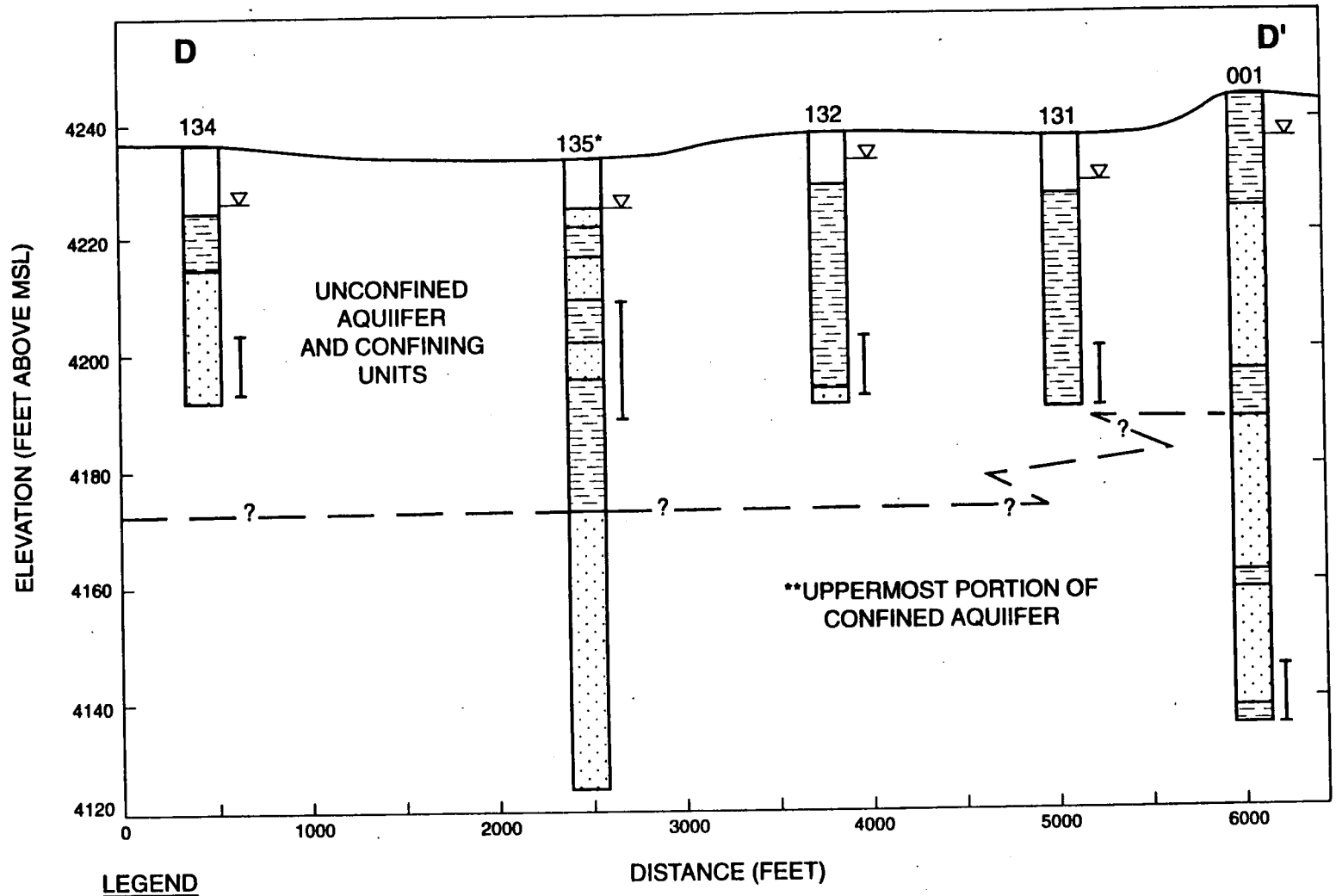
LEGEND

133 ◉	NUMBER AND LOCATION OF WELL SCREENED IN THE SHALLOW UNCONFINED AQUIFER
003 ●	NUMBER AND LOCATION OF WELL SCREENED IN THE DEEP CONFINED AQUIFER
186 ▲	SURFACE WATER AND SEDIMENT SAMPLING LOCATION AND NUMBER
187 ■	SEDIMENT SAMPLING LOCATION AND NUMBER
579 ◻	BOREHOLE LOCATION AND NUMBER
□	BUILDING
═══	PAVED ROAD
(15)	INTERSTATE HIGHWAY
	SEWAGE TREATMENT PLANT
··—··—	DRAINAGE DITCH
-------	DITCH DRAIN LINE
D — D'	CROSS SECTION (SEE FIGURE 2.3)

500 0 500 1000 FEET

150 0 150 300 METERS

FIGURE 2.2
MONITOR WELL, SURFACE WATER, SEDIMENT, AND BOREHOLE SAMPLING LOCATIONS, SALT LAKE CITY, UTAH, SITE



LEGEND

134 WELL DESCRIPTION

FILL

WATER BEARING UNITS (SAND AND SILTY SAND)

CONFINING UNITS (CLAY AND SILTY CLAY)

SCREEN INTERVAL

GROUND WATER ELEVATION (10/27/93)

NOTES: 1. ELEVATIONS AND DISTANCES GIVEN IN FEET. TO CONVERT FROM FEET TO METERS, MULTIPLY FEET BY 0.3048.

2. SEE FIGURE 2.2 FOR LINE OF SECTION.

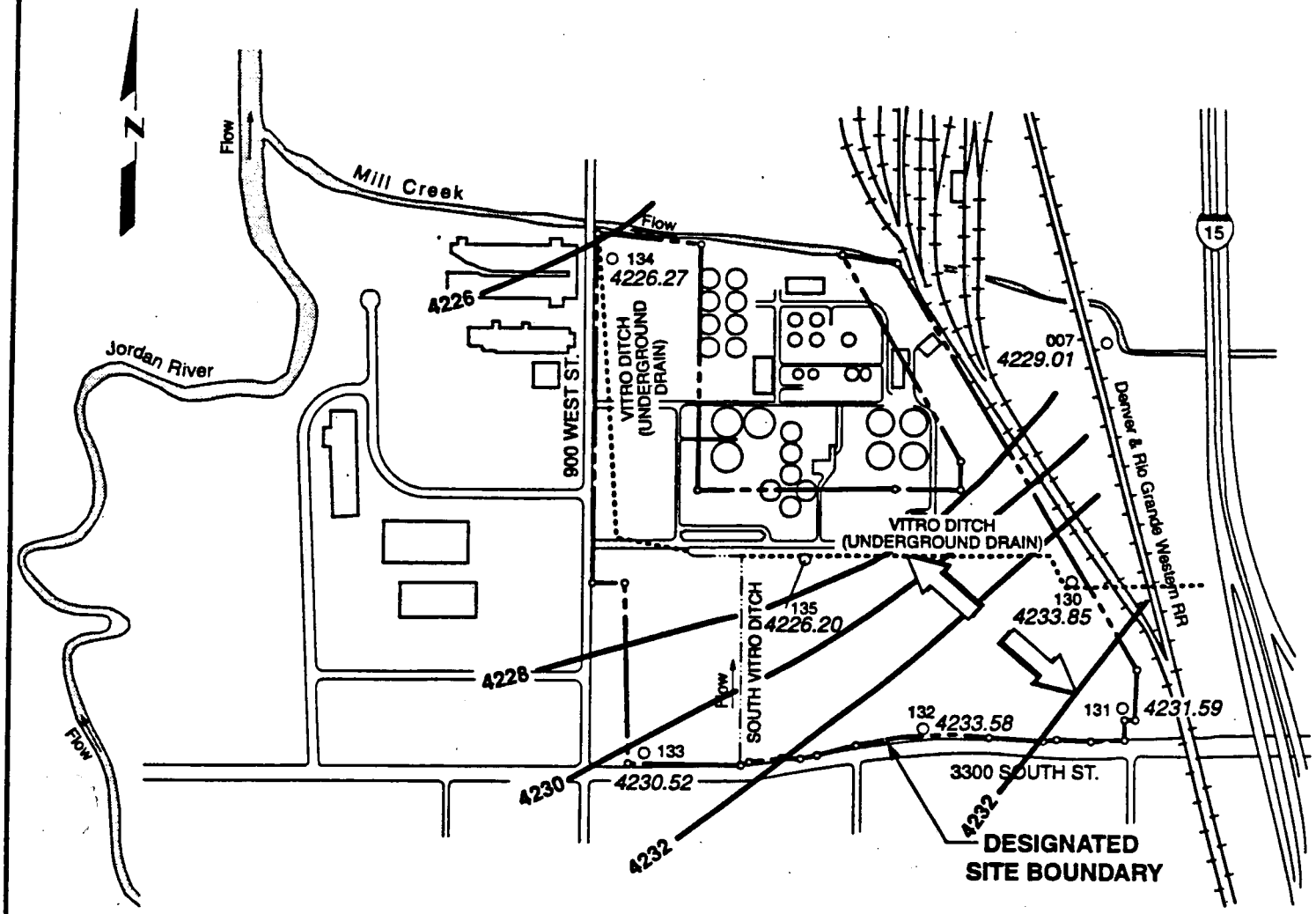
*GEOLOGIC INFORMATION FROM ADJACENT BOREHOLE G135.

**PRODUCTIVE PORTION OF THE CONFINED AQUIFER BEGINS BELOW 200 FEET.

FIGURE 2.3

HYDROSTRATIGRAPHIC UNITS IN MONITOR WELLS, CROSS SECTION D-D'
SALT LAKE CITY, UTAH, SITE

MAC: SITE/SLC/BRA/GEOX-SEC(D-D')



LEGEND

133 ○	WELL NUMBER AND LOCATION
4233.58	WATER TABLE ELEVATION (FT ABOVE MSL)
—4232	WATER TABLE ELEVATION CONTOUR (FT ABOVE MSL)
□	BUILDING
⇦	DIRECTION OF GROUND WATER FLOW
▬	PAVED ROAD
(15)	INTERSTATE HIGHWAY
○○ ○○	SEWAGE TREATMENT PLANT
—·—·—	DRAINAGE DITCH
-------	DITCH DRAIN LINE

500 0 500 1000 FEET

150 0 150 300 METERS

NOTE: WATER LEVELS MEASURED 10/27/93

FIGURE 2.4
WATER TABLE SURFACE OF THE UNCONFINED AQUIFER
SALT LAKE CITY, UTAH, SITE

MAC: SITE/SLC/BRA/BASE-UNCONAQUIF

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

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. The ground water flows primarily from southeast to northwest. Figure 2.4 shows a water table map of the shallow unconfined aquifer.

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 velocity for ground water flow in the shallow unconfined aquifer ranges from approximately 3 to 80 ft (1 to 30 m) per year.

2.3.2 Confined aquifer

The confined aquifer begins 70 ft (20 m) below the ground surface. Ground water is in this aquifer under substantial artesian pressure. 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 source of recharge to the confined aquifer is 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. A potentiometric contour map of the deeper confined aquifer was not constructed because there were too few data to contour.

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. The potential for contamination of the confined aquifer exists, however, if hydraulic head in the confined aquifer declines so that the direction of flow between the two aquifers reverses. Localized water could percolate from the shallow-unconfined aquifer into the confined aquifer in the area of the cone of depression caused by large-scale pumping from wells developed in the confined aquifer. Because of the aquifer heterogenicity, the actual effects of large-scale pumping are difficult to predict with available data.

2.4 SURFACE WATER

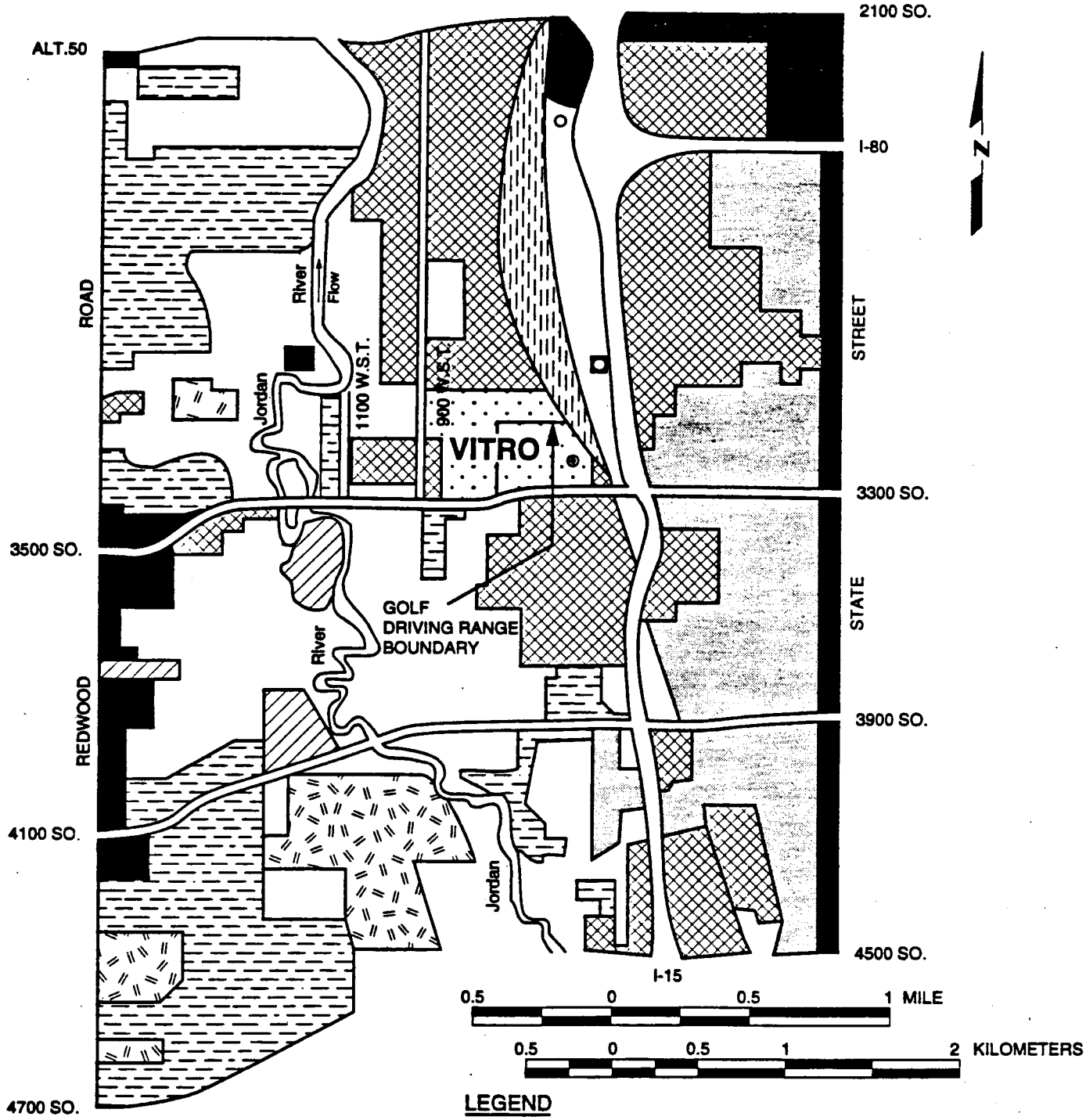
Four surface water bodies are near or at the Salt Lake City site. The Jordan River is about 1500 ft (460 m) west of the site and flows north to the Great Salt Lake. Mill Creek, a perennial stream, flows along the north edge of the site. This creek empties directly into the Jordan River. Two flowing drainages are on the Salt Lake City site (Figure 2.2). Vitro Ditch drains a marshy area on the Denver & Rio Grande Western Railroad property immediately east of the site. Prior to surface remediation, Vitro Ditch was an open Ditch crossing the site from east to west and continuing west to the Jordan River. After remediation, the Ditch was replaced by a drain pipe beneath the site and the discharge point was changed to Mill Creek. Thus, at present, the drainage enters the drain on the east edge of the site, runs from east to west across the site, and discharges to the north end of South Vitro Ditch. South Vitro Ditch is an open drainage Ditch that runs from south to north across the site, where it intersects with Vitro Ditch. About 50 ft (20 m) downstream of that point, the combined flow enters another drain pipe which ultimately discharges to Mill Creek near the far northwest corner of the site. This point of discharge is immediately downstream from the Central Valley Water Reclamation Facility (CVWRF) point of discharge for treated effluent. The CVWRF contributes about 200 million gallons (gal) (800 million liters [L]) per day of treated water to Mill Creek.

Ground water elevations in monitor wells located along the south boundary of the site are at or above the level of the South Vitro Ditch bed; therefore, ground water may recharge the ditch near its south (upstream) end. South Vitro Ditch receives drainage from the storm sewers that drain 3300 South Street. The sewer system includes a sump pump located at the bottom of a railway underpass on 3300 South Street. Water levels in the sewer at the bottom of the underpass are about 24 ft (7 m) below water levels on site, and thus there is the potential for contaminated ground water to discharge to the sewer system, and hence to South Vitro Ditch.

2.5 LAND USE

The 128-ac (52-ha) former processing site is in a primarily 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 industrial use.

The entire site is owned by the CVWRF, except for a 25 x 25-ft (8 x 8-m) strip of land surrounding the municipal water well, and an easement, which is 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 remaining land is currently vacant but will probably be developed as an industrial, commercial, or recreational area. Figure 2.5 shows land use within a radius of about 0.5 mi (0.8 km) from the site.



LEGEND

- RETAIL
- MANUFACTURING AND INDUSTRY
- RESIDENTIAL
- MIXED (RETAIL, MANUFACTURING, RESIDENTIAL)
- TRAILER COURT
- PUBLIC
- RAILROAD
- VACANT AND AGRICULTURE
- FORMER VITRO URANIUM PROCESSING SITE
- LOCATION OF INACTIVE SOUTH SALT LAKE CITY WATER WELL SCREENED IN THE DEEP CONFINED AQUIFER
- LOCATION OF ACTIVE SOUTH SALT LAKE CITY WATER WELL SCREENED IN THE DEEP CONFINED AQUIFER

FIGURE 2.5
LAND USE AND LOCATION OF WATER WELLS
SALT LAKE CITY, UTAH, SITE

MAC: SITE/SLC/BRA/LANDUSE

The CVWRF sewage treatment plant (on adjacent property north of the central portion of the site) and the channel of Mill Creek are north of the driving range. Warehouses and Denver & Rio Grande Western Railroad property are still farther north.

The railroad also occupies the land on the east side of the site. This property extends as far as Interstate 15. A cement 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 Salt Lake City site. Livestock is kept by some of these residents. Cattle and horses graze on the nearby fields.

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

2.6 WATER USE

A ground water-well records search and field reconnaissance were conducted in April 1994, at and near the former uranium processing site. Detailed examination of the state engineer's data base and intensive field investigation downgradient from the site did not reveal any users of the shallow-unconfined aquifer ground water within a 1-mi (1.6) radius of the site (TAC, 1994). The shallow unconfined aquifer seldom is used in the area for domestic (potable) purposes because it yields water slowly and the water is of poor quality (USGS, 1984; DNR, 1971). Shallow wells installed for use as a potable water supply must meet potable water quality standards issued by the state of Utah and enforced by the Salt Lake City county (SLCC, 1981; Minor, 1995). However, the standards and regulations applied to individual wells or a certain type of use are not clear.

Residences and small businesses in the site vicinity use the municipal water supply system. Some residents living about 0.25 mi (400 m) west of and downgradient from the site (on South 1100 West Street) use domestic wells completed in the deep-confined aquifer (from 100 to 300 ft (30 to 90 m) below the land surface). None of these wells is currently used for drinking water. One well was used to irrigate a garden but appears to be sanded up and now produces only a trickle of water.

City (South Salt Lake) water lines serve the area of the former mill site and the area east of the site. The city obtains water from five operating water wells completed in the confined (artesian aquifer). Location of two of these wells is shown in Figure 2.5. The municipal water wells range from 800 to 1000 ft (240 to 300 m) deep, but they generally are perforated from 400 to 800 ft (120 to 240 m).

Water from the wells is pumped to an underground reservoir (at 1300 East Street) where it is gravity-fed into the water lines. The state of Utah samples and tests the water once a month. Other than transient coliform contamination, the water has always met drinking water standards. Therefore, no water treatment is necessary except chlorination. Areas west of the site are served by the water lines of the Water Conservancy District, which uses Salt Lake City or county water wells.

In 1985, the CVWRF sold the water rights to four on-site wells to the city of South Salt Lake. These wells had been owned by the Vitro Uranium Company. One of these wells, a 10-inch cased well, is in the southeast corner of the site. The city may attempt to develop this well as a source for the municipal water supply system. The city has water rights for 2.67 cubic feet (ft^3) (0.08 cubic meters [m^3]) per second. The remaining three wells have been abandoned.

Because the state of Utah is concerned about the potential movement of contamination into the confined aquifer beneath the site, pumping from the on-site city well, should it occur, will be limited so as to prevent gradient reversal. Before full-scale production pumping begins, a geophysical survey must be completed to ensure well integrity. Water quality in the well will be evaluated every six months. During the first 6 months of pumping, the flow will be limited to 1 ft^3 (0.03 m^3) per second and drawdown shall not exceed 60 ft (18 m) below ground surface. The water will be retested after 6 months of pumping. If the surrounding wells and the ground water chemistry show no signs of contamination, pumping will continue for another 6 months. After that, the state of Utah may approve an increase in production rate. It may restrict pumping if the well shows negative impacts from drawdown and/or if the water chemistry changes.

The city of South Salt Lake supplies irrigation water for about 25 ac (10 ha) of grass at the driving range at the former mill site. However, the treated water obtained from CVWRF will be used to irrigate the driving range in the future. Approximately 1 acre-foot is used for irrigation during the summer.

3.0 EXTENT OF CONTAMINATION

Ground water quality data from the unconfined aquifer were collected from 1982 through 1988 from a total of 37 monitor wells and from August 1990 through February 1994 from 11 monitor wells (DOE, 1995a). One additional monitor well (106) was sampled for organic contaminants in 1990. Because trace element data collected prior to 1990 are particularly unreliable, pre-1990 data were used only to document trends in major-element chemistry.

Between August 1990 and February 1994, the DOE collected ground water samples from11 monitor wells (DOE, 1995a). The data were used to establish background and contaminated ground water chemistry in the unconfined aquifer. This time period allowed for incorporation of at least 3 years of data from each well while using the most recent information available for the aquifer. Figure 2.2 shows the locations of these monitor wells. Table 3.1 provides well completion data for these wells. Filtered ground water samples were analyzed for inorganic constituents. One round of unfiltered water samples was collected from well 131 in 1992 and analyzed for inorganic constituents. Comparing those data to filtered samples data indicates some constituents were present at levels greater than the highest levels reported for filtered water samples within the contamination zone. These constituents are aluminum (28 milligrams per liter [mg/L]), iron (41 mg/L), chromium (0.029 mg/L), copper (0.137 mg/L), and lead (0.086 mg/L). There are not enough unfiltered samples to verify these data. However, this well was newly completed at the time of sampling and produced a large amount of bentonite drilling mud. Therefore, the unfiltered data may not represent the true influence of very fine solid particles (colloids) on water chemistry within the contaminant plume. Thus, there are not enough unfiltered samples to assess the influence of colloids on ground water chemistry. Collection of additional unfiltered samples will be addressed in future field plans.

In 1990, a screening for organic contaminants was conducted. Monitor wells 008, 011, and 106 were sampled and analyzed for all organic hazardous constituents listed in Appendix IX to 40 CFR Part 264 (1994) of the Resource Conservation and Recovery Act. None of these hazardous organics were detected in the screening (DOE, 1995a).

The DOE sampled four monitor wells within the confined aquifer from 1990 through 1993 (Figure 2.2). Well information is summarized in Table 3.1, and water quality data are summarized in Table 3.2. Water quality in the confined aquifer varies in the region. Water with low total dissolved solids (TDS) (less than 250 mg/L) occurs near the point of recharge (about 9 mi [14.15 km] southeast of the site) and increases to as much as 20,000 mg/L toward the Great Salt Lake (Hely et al., 1971). In the site area, TDS in the confined aquifer range from 100 to 500 mg/L, with areas of high TDS west and north of the site (Hely et al., 1971).

One round of surface water and sediment samples was taken in December 1993. The surface water data were used to make a preliminary evaluation of surface water contamination. These data are for unfiltered surface water samples collected at the locations shown in Figure 2.2.

Table 3.1 Monitor wells used to determine water quality in the unconfined and confined aquifers

Well	Location	Screened interval (depth below surface) (ft)	(m)	Year sampled	Number of sampling rounds
Unconfined aquifer					
006	Off-site upgradient	26-28	7.9-8.5	83,94	3
007	Off-site crossgradient	26-28	7.9-8.5	83-94	11
008	Off-site downgradient	26-28	7.9-8.5	86-93	9
011[a]	Off-site downgradient	24-26	7.3-79	83-92	9
106[a]	Off-site upgradient	18-20	5.5-6.1	83-90	4
109[a]	Off-site downgradient	16-18	4.9-5.4	83-92	9
130	On-site crossgradient	31.8-41.8	9.7-12.7	92-94	4
131	On-site downgradient	34.7-44.7	10.6-13.6	92-94	4
132	On-site crossgradient	36.3-46.3	12.4-14.1	92-94	4
133	On-site crossgradient	35.0-45.0	10.7-13.7	92-94	4
134	On-site crossgradient	32.2-42.2	9.8-12.9	92-94	4
135	On-site crossgradient	25.5-45.5	7.8-13.9	92-94	4
Confined aquifer					
001	Off-site south	100-110	30.5-33.5	86-92	6
002	Off-site northeast	119-129	36.3-39.3	86-93	7
003	Off-site north	110-120	33.5-36.6	86-93	7
005	Off-site west	115.5-125.5	35.2-38.3	83-90	3

[a]Decommissioned well.

Table 3.2 Water quality of the confined aquifer, Salt Lake City, Utah, site

Parameter	Monitor well			
	001	002	003	004
Alkalinity[a]	262	282	242	200
Aluminum	<0.1	<0.1	<0.1	<0.1
Ammonium	4.3	6.7	4.6	10.7
Antimony	<0.003	<0.003	<0.003	<0.003
Arsenic	<0.01	<0.01	<0.01	<0.01
Barium	0.1	0.1	0.2	0.4
Beryllium	<0.01	<0.01	<0.01	<0.01
Cadmium	<0.001	<0.001	<0.001	<0.001
Calcium	63	40	55	122
Chloride	18	8	19	207
Chromium	<0.01	<0.01	<0.01	<0.01
Cobalt	<0.05	<0.05	<0.05	<0.05
Copper	<0.02	<0.02	<0.02	<0.02
Fluoride	0.2	0.3	0.2	0.2
Iron	0.08	0.58	0.17	0.74
Lead	<0.01	<0.01	<0.01	<0.01
Magnesium	23	20	21	60
Manganese	0.07	0.11	0.06	0.58
Mercury	<0.0002	<0.0002	<0.0002	<0.0002
Molybdenum	<0.01	<0.01	<0.01	<0.01
Nickel	<0.04	<0.04	<0.04	<0.04
Nitrate[b]	<1.0	<1.0	<1.0	<1.0
pH	7.9	7.6	7.8	7.4
Potassium	7	11	5	17
Radium-226 (pCi/L)	0.1	0.1	0.0	0.4
Radium-228 (pCi/L)	1.4	0.5	0.0	1.5
Selenium	<0.005	<0.005	<0.005	<0.005
Silver	<0.01	<0.01	<0.01	<0.01
Sodium	20	35	20	36
Strontium	0.7	0.4	0.7	1.2
Sulfate	33	<0.1	29	230
Sulfide	0.3	<0.1	<0.1	<0.1
Thallium	<0.01	<0.1	<0.01	<0.01

Table 3.2 Water quality of the confined aquifer, Salt Lake City, Utah, site (Concluded)

Parameter	Monitor well			
	001	002	003	004
Thorium-230 (pCi/L)	0.0	0.0	0.0	0.0
Tin	<0.005	<0.005	<0.005	<0.005
TDS	NA	308	251	NA
Uranium	0.0003	0.0003	<0.0003	<0.0003
Vanadium	0.01	0.01	0.01	<0.01
Zinc	<0.005	<0.005	<0.005	<0.005

[a]Alkalinity as mg/L $CaCO_3$.
[b]Nitrate expressed as NO_3.

Notes:
1. Filtered samples collected 8 August 1990, at the site periphery.
2. Results of the most recent complete sampling round.
3. All data in milligrams per liter unless noted as picocuries per liter (pCi/L).

NA – not available.

3.1 BACKGROUND WATER QUALITY SUMMARY

Background water quality is defined as the water quality if uranium milling activities had not occurred. There are two hydrologic systems at the site: a deep, confined aquifer and a shallow unconfined aquifer. The unconfined aquifer clearly has received contaminants from the former tailings piles and ponds. In contrast, in the confined aquifer, which was sampled near the property boundaries to the southeast, northeast, north, and west (Figure 2.2), radioactive constituents or metals that could be associated with tailings have not been found at levels above background determined for the unconfined aquifer (Table 3.2).

None of the DOE monitor wells in the confined aquifer are designated as background because the local ground water flow direction is not known in the confined aquifer (Section 2.3). The TDS in the confined aquifer at the site range from 251 to 1400 mg/L (Table 3.2). The more saline water is found in monitor well 005, on the west side of the site. This well water has the highest sulfate and chloride levels of the four confined aquifer monitor wells. Historical data also show higher sulfate, chloride, and TDS levels in the area west of the site within the confined aquifer. The concentrations of uranium, molybdenum, and other metals are low in monitor well 005 and the other confined aquifer wells, with a range about equal to the unconfined aquifer background well (007). Thus, the lack of uranium and molybdenum above background suggests that the higher salinity in the confined aquifer west of the site is due to natural variability.

A former Vitro water production well, now owned by the city of South Salt Lake and being considered for use as a municipal water supply, produces water from the confined aquifer beneath the site. This flowing well is 710 ft (216 m) deep and is in the southeast portion of the site (Figure 2.2). Table 3.3 summarizes water quality data from samples taken February 1985 and July 1989 during testing of the well. The data were obtained from the Utah Division of Drinking Water. The city well samples a much larger and deeper portion of the confined aquifer and may represent an average of the natural variation in water quality of the confined aquifer. Thus, the water chemistry falls within the range of DOE monitor wells sampled in the confined aquifer. Uranium was not analyzed for; however, gross alpha measurements indicate uranium concentrations are less than 2 picocuries per liter (pCi/L) equivalent to less than 0.003 mg/L natural uranium. Thus, the ability of the upward gradient to prevent downward contamination migration is supported by the lack of site-related contamination in this well.

In the unconfined aquifer, DOE monitor well 007 is off and crossgradient of the site. Monitor well 007 has been sampled repeatedly since 1990.

Table 3.3 Ground water quality data, city of South Salt Lake proposed municipal water supply well, Salt Lake City, Utah, site

Parameter	Concentration (mg/L)	
	August 1989	February 1985
Aluminum	NA	NA
Ammonium	<0.3	NA
Antimony	NA	NA
Arsenic	<0.001[a]	<0.001
Barium	0.03[a]	0.03
Beryllium	NA	NA
Boron	0.03	0.06
Cadmium	<0.001[a]	<0.001
Calcium	51	66
Chloride	12	10
Chromium	<0.001[a]	0.002
Cobalt	NA	NA
Copper	<0.01[a]	<0.01
Cyanide	NA	NA
Fluoride	0.32	0.36
Iron	<0.03[a]	0.15[a]
Lead	<0.001	<0.001
Magnesium	20	20
Manganese	70	80
Mercury	<0.02[a]	<0.02[a]
Molybdenum	NA	NA
Nickel	<0.03[a]	<0.01
Nitrate as NO_3	<0.09	<0.04
Potassium	2	2
Selenium	<0.001[a]	<0.001
Silver	<0.001[a]	<0.001
Sodium	22	23
Strontium	NA	NA
Sulfate	80	108
Sulfide	NA	NA
Thallium	NA	NA
Tin	NA	NA

Table 3.3 Ground water quality data, city of South Salt Lake proposed municipal water supply well, Salt Lake City, Utah, site (Concluded)

Parameter	Concentration (mg/L)	
	August 1989	February 1985
Uranium	NA	NA
Vanadium	NA	NA
Zinc	<0.01[a]	<0.001
Radionuclide	**(pCi/L)**	**(pCi/L)**
Lead-210	NA	NA
Polonium-230	NA	NA
Radium-226	NA	NA
Thorium-230	NA	NA
Gross alpha	<2	<2
Gross beta	<3	<3

[a]Unfiltered water samples. All other data are for filtered samples.

NA - not available.

Regionally, TDS values in the unconfined aquifer average about 1250 mg/L. In the site vicinity, shallow ground water TDS values range from 1000 to 2000 mg/L (Seiler and Waddell, 1983). TDS values in ground water from monitor well 007 range from 500 to 600 mg/L, which is actually less saline than normal for the shallow aquifer.

The relatively low salinity of ground water in well 007 may be caused by areal variations in salinity or by vertical salinity gradient in the shallow unconfined aquifer. In the areas near monitor well 007, ground water salinity increases dramatically in the upper 20 ft (6 m) of the aquifer. In the well cluster associated with monitor well 007 (wells 002, 007, 107, and 157, all sampled in 1983) salinities vary from 290 mg/L within the confined aquifer at 120 ft (37 m) below land surface to 4600 mg/L near the top of the unconfined aquifer at 8 ft (2.4 m) below land surface.

As discussed in Section 2.3.1, the unconfined aquifer probably is recharged both by vertical leakage of ground water from the confined aquifers and by surface recharge from rainfall and irrigation. The increased salinity near the top of the unconfined aquifer probably represents dissolved solids concentrated by evapotranspiration. Therefore, the relatively low salinity of well 007 (compared to regional ground water) may be because it is completed in the deeper, lower-salinity portion of the unconfined aquifer.

Ground water in monitor well 007 is a sodium-bicarbonate-type water; it is in equilibrium with calcium carbonate, magnesium carbonate, and barium sulfate (barite). The pH is slightly basic (near 8) and the Eh is slightly oxidizing (100 millivolts).

Table 3.4 provides a statistical summary of water quality data for monitor well 007 (background).

Most constituents commonly associated with ground water contamination from uranium mill tailings are below detection in well 007. However, two constituents commonly associated with uranium mill tailings, arsenic and ammonium, are present at levels above detection in the background ground water in this well. Arsenic is known to occur naturally in the shallow aquifer throughout the region (USGS, 1984). Regionally, arsenic averages about 0.05 mg/L. Several possible sources are the past use of arsenic-bearing pesticides, flue dust from copper smelters, and Quaternary sediments derived from arsenic-bearing sulfide deposits in the mountains east and southwest of the site. In well 007, arsenic averaged about 0.05 mg/L and ammonium averaged 7.7 mg/L since 1990. The combination of arsenic and ammonium suggests that the source of these two contaminants may have been agricultural, related to the past use of pesticides and fertilizers.

Table 3.4 Comparison of background and on-site ground water quality data in the unconfined aquifer at the Salt Lake City, Utah, site, August 1990 - February 1994, filtered water samples

Parameter[b]	Detection frequency[c]	Concentration[a]		
		Minimum	Median[d]	Maximum
Inorganic constituent				
Aluminum				
Background	1/6	<0.05	e	0.10
Plume	1/24	<0.05	e	0.40
Ammonium[f]				
Background	5/5	6.1	7.7	11.8
Plume (well 008)	5/5	10.9	12.6	20.9
Antimony				
Background	1/6	<0.003	e	0.025
Plume	11/24	<0.003	e	0.027
Arsenic				
Background	7/7	0.027	0.050	0.061
Plume	14/27	<0.025	0.006	0.133
Barium[f]				
Background	6/6	0.10	0.11	0.12
Plume (well 134)	3/3	0.44	0.47	0.61
Beryllium				
Background	0/5	<0.001	e	<0.01
Plume	0/20	<0.001	e	<0.01
Cadmium				
Background	0/7	<0.001	e	<0.001
Plume	1/27	<0.001	e	0.001
Calcium[f]				
Background	7/7	11	12	13
Plume (well 008)	6/6	29	217	426
Chloride[f]				
Background	7/7	56	62	74
Plume (well 135)	4/4	2540	2680	2830
Chromium				
Background	0/5	<0.003	e	<0.05
Plume	0/20	<0.003	e	<0.02
Cobalt				
Background	0/5	<0.003	e	<0.05
Plume	0/20	<0.003	e	<0.10

Table 3.4 Comparison of background and on-site ground water quality data in the unconfined aquifer at the Salt Lake City, Utah, site, August 1990 - February 1994, filtered water samples (Continued)

Parameter[b]	Detection frequency[c]	Concentration[a]		
		Minimum	Median[d]	Maximum
Copper				
Background	1/5	0.003	e	<0.02
Plume	2/20	<0.002	e	0.01
Cyanide				
Background	0/4	<0.01	e	<0.01
Plume	0/14	<0.01	e	<0.01
Fluoride[f]				
Background	6/6	0.7	0.7	0.8
Plume (well 109)	5/5	2.0	2.4	2.7
Iron[f]				
Background	7/7	0.04	0.12	0.25
Plume (well 109)	5/5	1.50	5.24	6.48
Lead				
Background	0/6	<0.001	e	<0.010
Plume	2/23	<0.003	e	0.008
Magnesium[f]				
Background	7/7	32	33	35
Plume (well 135)	4/4	757	808	900
Manganese[f]				
Background	7/7	0.03	0.04	0.04
Plume (well 109)	5/5	0.11	0.48	0.63
Mercury				
Background	0/4	<0.0001	e	<0.0002
Plume	1/20	<0.0001	e	0.0002
Molybdenum[f]				
Background	1/7	<0.004	e	0.01
Plume (well 131)	2/3	<0.01	0.88	0.94
Nickel				
Background	1/5	0.007	e	<0.04
Plume	0/20	<0.006	e	<0.08
Nitrate				
Background	5/6	<1.0	1.7	5.5
Plume	10/23	<0.2	e	4.6
Potassium[f]				
Background	7/7	26	29	32
Plume (well 135)	4/4	176	214	228
Selenium				
Background	0/7	<0.001	e	<0.005
Plume	3/27	<0.001	e	0.030

Table 3.4 Comparison of background and on-site ground water quality data in the unconfined aquifer at the Salt Lake City, Utah, site, August 1990 - February 1994, filtered water samples (Continued)

Parameter[b]	Detection frequency[c]	Concentration[a] Minimum	Median[d]	Maximum
Silver[f]				
Background	0/5	<0.002	e	<0.010
Plume	6/20	<0.010	e	0.041
Sodium[f]				
Background	7/7	129	135	150
Plume (well 135)	4/4	2490	2875	3160
Strontium[f]				
Background	6/6	0.20	0.20	0.55
Plume (well 135)	3/3	4.16	4.24	4.39
Sulfate[f]				
Background	2/7	<0.1	e	3.6
Plume (well 135)	4/4	4970	5310	5560
Sulfide				
Background	3/5	<0.1	0.7	2.3
Plume	4/20	<0.1	e	2.1
Thallium				
Background	0/5	<0.005	e	<0.067
Plume	0/20	<0.005	e	<0.340
Tin				
Background	1/5	<0.005	e	0.006
Plume	0/20	<0.005	e	<0.100
Uranium[f]				
Background	1/7	<0.0001	e	0.009
Plume (well 109)	5/5	0.160	0.233	0.266
Vanadium[f]				
Background	0/6	<0.005	e	<0.010
Plume (well 135)	2/3	<0.010	0.021	0.071
Zinc				
Background	3/6	<0.005	e	0.018
Plume	11/24	<0.005	e	0.187
Radionuclide				
Lead-210[g]				
Background	1/1	NA	0.5	NA
Plume	4/4	0.0	0.55	1.1
Polonium-210[g]				
Background	0/1	NA	0.0	NA
Plume	4/4	0.0	0.05	0.2

Table 3.4 Comparison of background and on-site ground water quality data in the unconfined aquifer at the Salt Lake City, Utah, site, August 1990 - February 1994, filtered water samples (Concluded)

Parameter[b]	Detection frequency[c]	Concentration[a]		
		Minimum	Median[d]	Maximum
Radium-226[f]				
Background	5/5	0.0	0.1	0.5
Plume	20/20	0.1	0.4	1.3
Radium-228				
Background	4/5	0.0	0.9	8.9
Plume	18/18	0.0	1.45	5.2
Thorium-230				
Background	5/5	0.0	0.2	0.9
Plume	20/20	0.0	0.3	0.8

[a]Inorganic constituent concentrations are reported in milligrams per liter. Radionuclide concentrations are reported in picocuries per liter.
[b]Background well is 007. Plume concentrations are from DOE wells 008, 011, 109, 131, 134, and 135, unless otherwise noted.
[c]Number of samples with detectable concentration/total number of samples.
[d]50th percentile of the data. Computation of the median requires that more than 50 percent of the data are above detection.
[e]Median cannot be determined.
[f]Constituents are elevated in plume wells compared to background at the 0.05 level of significance. For these constituents, concentrations observed in highest plume wells are presented.
[g]Unfiltered samples.

3.2 MAGNITUDE OF SITE-RELATED CONTAMINATION

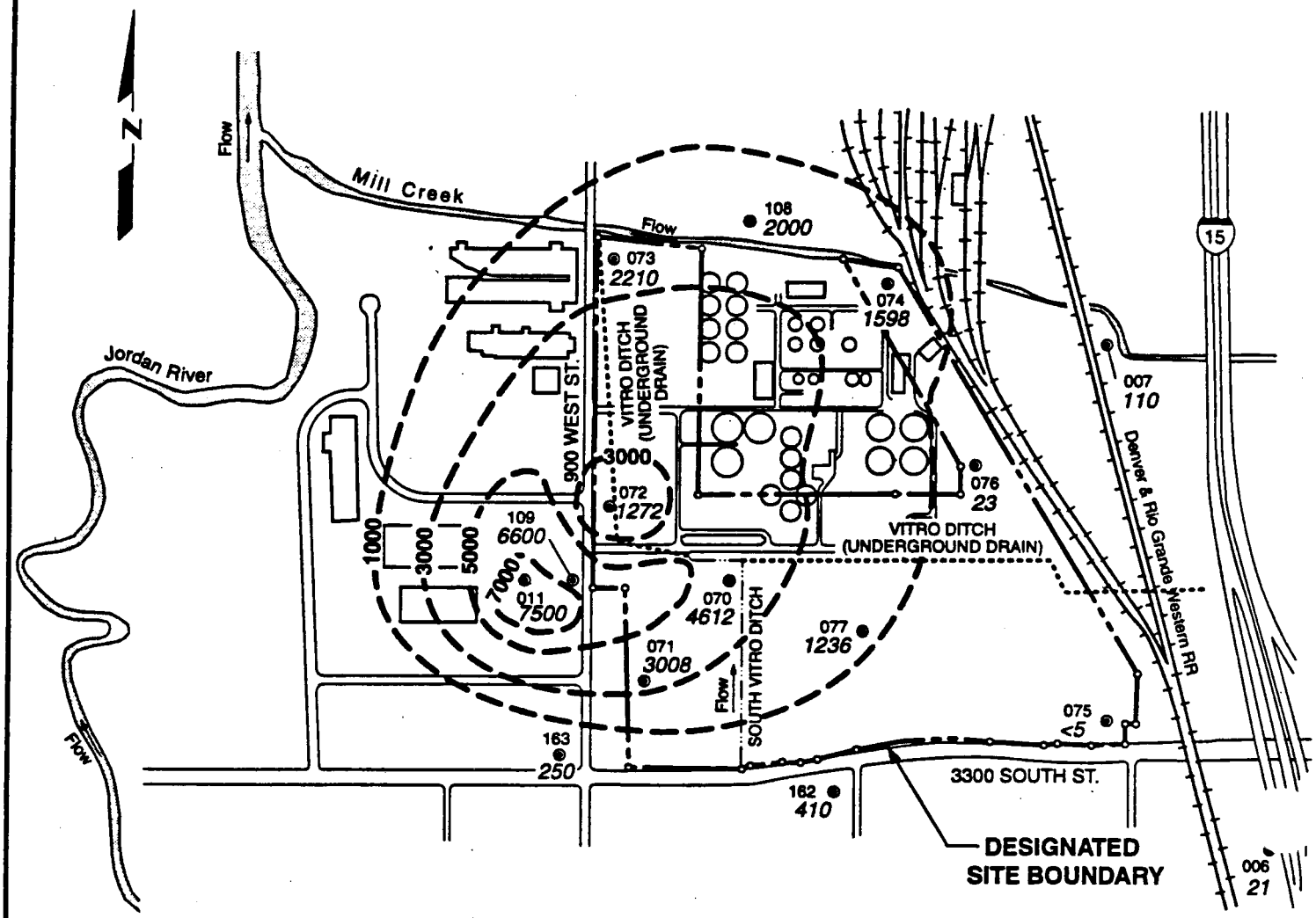
The original tailings solutions within tailings piles and evaporation ponds were acid solutions (pH less than 4) composed predominantly of aluminum sulfate and sodium chloride (Markos and Bush, 1982). Previous geochemical studies demonstrated that as the solutions migrated into the unconfined aquifer, 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 [cm]) zone includes gypsum, iron oxides, and basic iron and aluminum sulfates (Markos and Bush, 1982).

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. It is recognized primarily by high concentrations of TDS and major ions including sulfate, chloride, calcium, magnesium, and sodium. Locally, the alkalinity is very high (about 1100 mg/L as calcium carbonate in well 135), reflecting the neutralization of the acid tailings solutions by carbonates. Compared to background waters, several trace elements are found to be present at elevated concentrations, including manganese, molybdenum, uranium, vanadium, strontium, and silver.

Ground water contamination varies both over time and area across the site. In 1983, the highest concentration of sulfate was found in the western portion of the site (Figure 3.1). At present, the highest concentrations of sulfate (Figure 3.2) and chloride occur in the central portion of the site, near monitor well 135, the area that was once the site of evaporation ponds; to the west (in monitor wells 011 and 109) sulfate and chloride concentrations have decreased over time. However, in monitor wells 011 and 109, uranium and molybdenum concentrations have remained constant or have increased during the same period, indicating a lower-salinity contamination is replacing a higher-salinity contamination along the western portion of the site.

Comparing sulfate and chloride concentrations (1983 data) from well clusters in the contaminated area to the sulfate and chloride concentrations in the background well cluster demonstrates that contamination extends to at least 30 ft (9 m) below land surface within the unconfined aquifer. The vertical extent of contamination can be demonstrated by salinity that does not decrease with increasing depth. Data from two onsite wells screened between 54 and 68 ft (16.5 to 20.1 m) below land surface did not indicate contamination in 1983. Therefore, available data indicate that contamination probably is limited to depths of less than 50 feet.

Chemical data from monitor wells on the south and east boundaries of the site (wells 130, 132, and 133) indicate contamination has not affected these crossgradient site boundaries. However, in the southeast corner of the site, monitor well 131 shows an increase in sulfate, sodium, chloride, uranium and



LEGEND

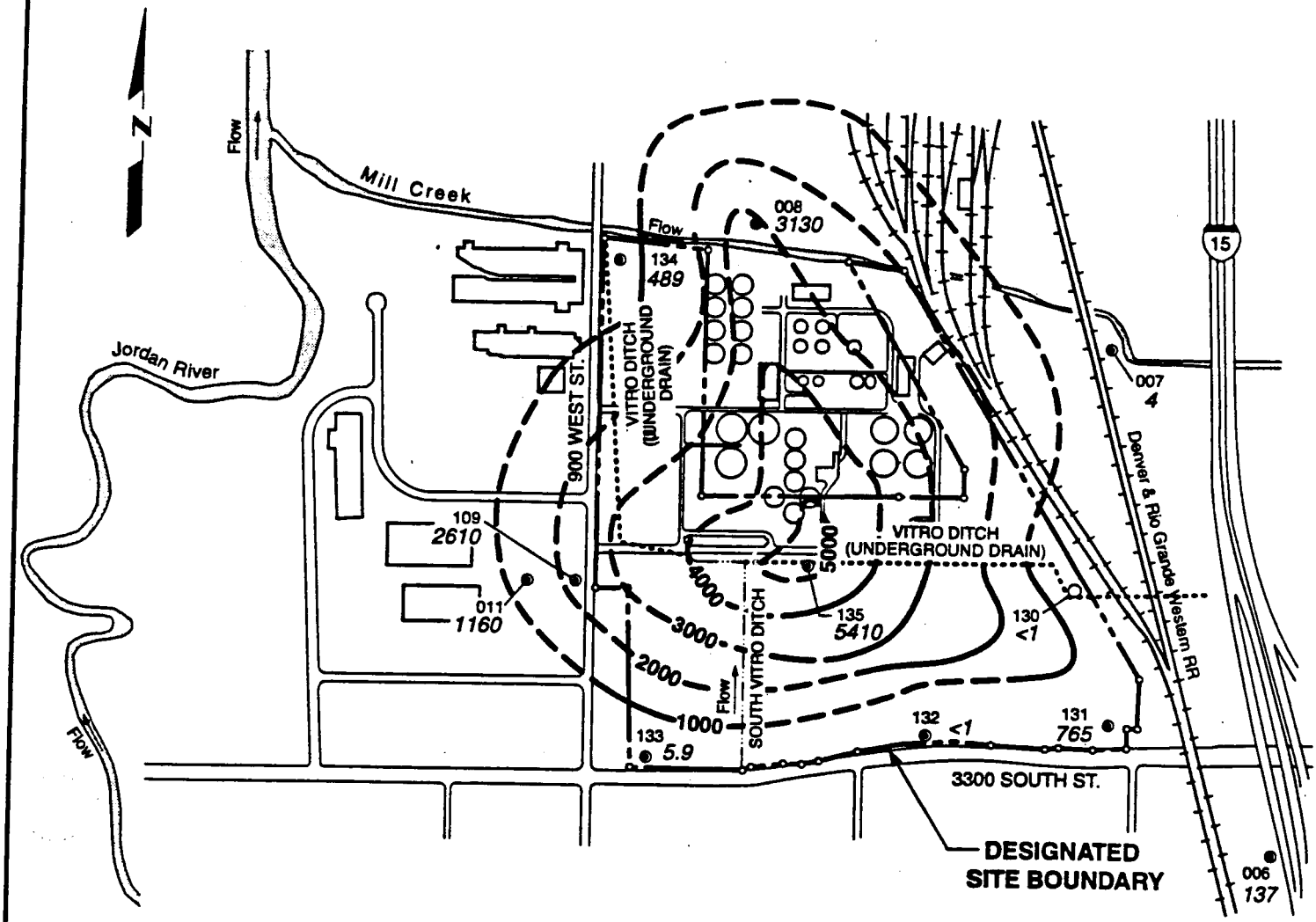
007 ●	NUMBER AND LOCATION OF WELL SCREENED IN THE SHALLOW UNCONFINED AQUIFER
110	SULFATE CONCENTRATION (mg/L)
1000 —	SULFATE ISOPLETH (DASHED WHERE INFERRED, mg/L)
□	BUILDING
▬	PAVED ROAD
(15)	INTERSTATE HIGHWAY
	SEWAGE TREATMENT PLANT
—·—·—	DRAINAGE DITCH
-------	DITCH DRAIN LINE

500 0 500 1000 FEET

150 0 150 300 METERS

FIGURE 3.1
APPROXIMATE EXTENT OF SULFATE CONTAMINATION (1982-1983 DATA)
SALT LAKE CITY, UTAH, SITE

MAC: SITE/SLC/BRA/BASE-SUL('82-'83)



LEGEND

007 ●	NUMBER AND LOCATION OF WELL SCREENED IN THE SHALLOW UNCONFINED AQUIFER
4	SULFATE CONCENTRATION (mg/L)
1000 —	SULFATE ISOPLETH (DASHED WHERE INFERRED, mg/L)
□	BUILDING
▬	PAVED ROAD
(15)	INTERSTATE HIGHWAY
	SEWAGE TREATMENT PLANT
···—··—	DRAINAGE DITCH
·····	DITCH DRAIN LINE

500 0 500 1000 FEET

150 0 150 300 METERS

FIGURE 3.2
APPROXIMATE EXTENT OF SULFATE CONTAMINATION (1992-1993 DATA)
SALT LAKE CITY, UTAH, SITE

MAC: SITE/SLC/BRA/BASE-SUL('92-'93)

molybdenum. This well is near the old mill site, adjacent to the underpass of State Route 171 beneath the Denver & Rio Grande Western Railroad. As discussed in Section 2.3.1, the underpass excavation created a lateral gradient reversal in the area (DOE, 1984b) and it appears that contaminated water is moving to the southeast, toward the underpass.

The extent of the contamination is unknown downgradient of the site, to the west and north. Contaminants have migrated beyond the existing monitor wells in these areas (wells 109, 011, 008, and 134). Extrapolating the existing chemical gradients could estimate the downgradient extent of the plume. However, there are too few existing wells for such an extrapolation to be meaningful.

3.3 STATISTICAL ANALYSIS OF GROUND WATER QUALITY

After determining the extent of contamination using a limited set of constituents indicative of contamination (chloride, sulfate, uranium, and molybdenum), water quality data collected between 1990 and 1993 were used to statistically identify the full suite of constituents elevated above background in contaminated portions of the unconfined aquifer (DOE, 1995a). Qualitative evaluation of water quality data from each plume monitor well showed similar constituent concentrations. Therefore, in the statistical evaluation, the 1990-1993 data from background well 007 were compared to the pooled 1990-1994 data for contaminated ground water from wells 008, 011, 109, 131, 134, and 135. For each constituent, a Mann-Whitney test was conducted at the 0.05 level of significance. A significant Mann-Whitney test result indicates the concentrations in the pooled data from all plume wells are, on average, higher than those in background.

Vanadium was screened out because most (70 percent or more) of the analyses were below detection and because all detected values were either within the range of laboratory error (that is, at the detection limit for the analysis) or associated with a systematic laboratory error in one round of sampling. Vanadium was detected in ground water in 14 instances; 10 of these detections occurred during a single sampling round and were near the limit of detection. Most of those 10 detections were not replicated by previous sampling rounds, and none was replicated by a subsequent sampling round. The remaining four vanadium detections during other sampling rounds were at the limit of detection for the analysis (0.01 mg/L). Thus, these data probably reflect a systematic error in the laboratory analyses and do not represent toxicity concerns. In the future, ground water should be monitored for vanadium to verify it remains below background.

Table 3.4 summarizes the water quality data in the unconfined aquifer between 1990 and 1994. The following constituents were elevated statistically above background: ammonium, barium, calcium, chloride, fluoride, iron, magnesium, manganese, molybdenum, potassium, radium 226, silver, sodium, strontium, sulfate, and uranium. For these constituents, the concentrations observed in the

most contaminated ground water wells are presented. However, these results are for filtered samples, and all the constituents may be reduced as a result of the filtration.

3.4 CONTAMINANTS OF POTENTIAL CONCERN

The results of analyses presented in Section 3.3 were used to compile a list of contaminants of potential concern for the assessment of risks to human health and the environment at the Salt Lake City site. The constituents listed in the first column of Table 3.5 are elevated above background levels at the 0.05 level of significance.

These constituents were screened for their potential to affect human health. The screening was based on the range of observed concentrations in filtered ground water samples between August 1990 and February 1994.

Some constituents were screened out because they are essential nutrients present at levels within nutritional ranges, even when added to expected dietary ranges (DOE, 1994b; DOE, 1995a). These constituents are calcium, iron, and potassium (Table 3.5, column 2).

The final screening of the remaining contaminants was based on their relatively low toxicity and/or relatively high dietary intake by comparison to the values measured, so that levels at which they are observed at the site would not be associated with adverse health effects even when added to expected dietary intake (DOE, 1994; DOE, 1995a). Although silver levels in the plume (maximum observed concentration of 0.041 mg/L) are above background, silver has been eliminated from the list of contaminants of potential concern because it would not be expected to result in adverse health effects in potentially exposed humans. Silver levels in contaminated ground water are well below the EPA health advisory levels of 0.2 mg/L for a 10-kilogram [kg] child following 10-day exposure duration and the level of 0.1 mg/L for a 70-kg adult following lifetime exposure (EPA, 1993). Based on the screening, contaminants of potential concern to human health are chloride, fluoride, magnesium, molybdenum, sodium, sulfate, uranium, and radium-226 (Table 3.5, column 3).

Uranium and radium-226 are the only radionuclides statistically above background levels in the unconfined aquifer (with a level of significance of less than 0.05). Because radionuclide toxicity, manifested as carcinogenicity, is a function of the total exposure dose from ionizing radiation, all of the longer-lived progeny of the uranium decay series are evaluated in Section 6.0.

These constituents form the basis of the human health risk assessment for ground water at the Vitro site. Because ecological impacts differ from effects on human health, the complete list of contaminants (Table 3.5, column 1) is considered for ecological risk assessment in Section 7.0.

Table 3.5 Contaminants of potential concern, Salt Lake City, Utah, site

Contaminant levels exceed background	Contaminant levels in nutritional range	Contaminant of low toxicity compared to values measured and/or high dietary range	Contaminant of potential concern[a]
Ammonium	Calcium	Ammonium	Chloride
Barium	Iron	Barium	Fluoride
Calcium	Potassium	Silver[b]	Magnesium
Chloride		Strontium	Manganese
Fluoride			Molybdenum
Iron			Sodium
Magnesium			Sulfate
Manganese			Uranium
Molybdenum			Radium-226
Potassium			
Silver			
Sodium			
Strontium			
Sulfate			
Uranium			
Radium-226			

[a] The screening process began with the first column. Constituents in the second and third columns were subtracted from the list of constituents in the first column. The remaining constituents form the list shown in the last column.

[b] Although silver levels in the plume (maximum observed concentration of 0.041 mg/L) are above background, silver has been eliminated from the list of contaminants of potential concern because it would not be expected to result in adverse health effects in potentially exposed humans. Silver levels in contaminated ground water are well below the EPA health advisory levels of 0.2 mg/L for a 10-kilogram child following 10-day exposure duration and the level of 0.1 mg/L for a 70-kg adult following lifetime exposure (EPA, 1993).

3.5 CONTAMINANT FATE AND TRANSPORT

Contaminant mobility, uptake, and toxicity depend on the species of ions that exist in the aqueous environment. The type of ion species and complexes depend on the availability of various anions and cations for the formation of complex ions, and on pH and Eh conditions. Species of the contaminants of concern have been computed using the geochemical speciation code PHREEQE (Parkhurst et al., 1980). Table 3.6 summarizes the predominant species and their molar percentages. Modeling indicates the distribution of species and the valence state of metals do not notably change over the range of oxidation-reduction potentials reported from ground water at the site (100 to -100 millivolts) (DOE, 1995a).

Magnesium

Modeling indicates magnesium concentrations are controlled by equilibrium with magnesite (magnesium carbonate) in both contaminated and background waters, as a function of alkalinity and the partial pressures of carbon dioxide. In soils, soil bacteria usually hold carbon dioxide partial pressures at near-constant values. In 1983, partial pressures of carbon dioxide were high (at or greater than 1 atmospheric pressure) in response to neutralization of the tailings solutions by carbonates. With time, the partial pressure of carbon dioxide in contaminated ground water has decreased to near background levels (0.016 atmospheres). The decrease was probably accompanied by the precipitation of magnesite, which resulted in decreased alkalinity and decreased magnesium concentrations. Because most carbon dioxide degassing has already occurred, further decreases in magnesium and alkalinity will be due to dilution.

Chloride

Chloride concentrations are about 45 times those of background. Chloride forms insoluble salts at high salinities (above 180,000 mg/L chloride concentrations). Therefore, observed concentrations are too low to be affected by precipitation. In contrast, chloride concentrations are too great to be affected by adsorption. Therefore, decreases in chloride concentrations within the contaminated ground water will be due to dilution.

Fluoride

Fluoride concentrations in contaminated ground water are about 3 times those of background. Fluoride forms fluorite (calcium fluoride), a relatively insoluble mineral. However, both contaminated and background water are below fluorite saturation by a factor of 10. Thus, fluoride will decrease from slightly higher than background (2.4 mg/L) to background levels (0.8 mg/L) in response to dilution.

Table 3.6 Predominant ionic species of the constituents of potential concern

Constituent	Common name	Dominant species	Valence	Molar percent
Ammonium		Not determined		
Chloride	Chloride	Cl^-	Cl(-I)	100
Fluoride	Fluoride	F^-	F(-I)	69
	Magnesium fluoride	MgF^+	F(-I)	30
Magnesium	Magnesium	Mg^{2+}	Mg(II)	63
	Magnesium sulfate	$MgSO_{4\,aq}$	Mg(II)	32
	Magnesium bicarbonate	$MgHCO_3$	Mg(II)	5
Manganese	Manganese	Mn^{2+}	Mn(II)	63
	Manganese sulfate	$MnSO_{4\,aq}$	Mn(II)	26
Molybdenum	Molybdate	MoO_4^{2-}	Mo(VI)	100
Sodium	Sodium	Na^+	Na(I)	95
	Sodium sulfate	$NaSO_4^-$	Na(I)	4
Sulfate	Sulfate	SO_4^{2-}	S(VI)	66
	Magnesium sulfate	$MgSO_{4\,aq}$	S(VI)	22
	Sodium sulfate	$NaSO_4^-$	S(VI)	9
Uranium	Uranyl tricarbonate	$UO_2(CO_3)_3^{4-}$	U(VI)	97
Radium-226		Not determined		

Manganese

Manganese concentrations are up to about 16 times those of background. Like iron, manganese is most soluble under acidic or reducing conditions although manganese can persist at greater concentrations than iron in oxidizing, near-neutral pH ground water. None of the ground water at the site is saturated with manganese oxides or manganese carbonate (rhodochrosite). Therefore, the major decrease in concentration will be due to dilution, perhaps accompanied by coprecipitation with iron oxides and sorption.

Molybdenum

Molybdenum concentrations range up to about 94 times that of background. Molybdenum occurs in the contaminated ground water as molybdate (MoO_4^{2-}), a negatively charged ion. As with most negatively charged ions, molybdenum sorption is most effective under acidic conditions (pH in the 3 to 4 range). Thus sorption of molybdenum in the contaminated ground water will be less important than dilution as a mechanism for decreasing concentrations.

Sodium

Sodium concentrations in contaminated ground water are up to about 20 times those of background. Sodium forms very soluble bicarbonate, chloride and sulfate salts; therefore, those salts will not precipitate. A likely mechanism for its removal is cation exchange for magnesium and calcium within clay minerals, but not enough information is available to evaluate this mechanism at the site. Dilution will probably play the greatest role in decreasing its concentrations.

Sulfate

Sulfate concentrations vary across the site, from 249 to 5560 mg/L in contaminated water (Figure 3.2). Most of the contaminated water is undersaturated with respect to gypsum, the phase most likely to control the sulfate concentration in this ground water. Therefore, the observed real decreases in sulfate, which are matched by decreases in chloride, are due to dilution of the tailings solutions by natural waters. This dilution may have occurred in the well bore or during the initial migration of the tailings solutions into the aquifer, either by mixing with diluted surface water before infiltration (as would be the case along the former Vitro Ditch) or by mixing with dilute ground water during infiltration. Further decreases in sulfate concentrations will occur by dilution and dispersion as the contaminated ground water migrates.

Uranium

Uranium concentrations in contaminated ground water are about 30 times as great as those in background. Uranium occurs in the hexavalent (+6) state in the site ground water as a uranyl carbonate complex ($UO_2(CO_3)_3^{4-}$). Because

this complex is mobile in neutral-to-alkaline ground water, dilution will be the primary control on uranium concentrations.

Radium-226

Radium-226 concentrations in the contaminated ground water range from 0.1 to 1.3 pCi/L, with the maximum value about 3 times the maximum observed background value of 0.5 pCi/L. In ground water, radium coprecipitates with sulfates, such as gypsum. However, because most water at the site is now below gypsum saturation, further gypsum precipitation will not occur. Therefore, dilution will have the greatest effect on decreasing radium concentrations in the contaminated ground water.

3.6 SURFACE WATER AND SEDIMENT SAMPLING

Both South Vitro Ditch and Vitro Ditch were identified as having radium-226 or thorium-230 contaminated sediments prior to surface remediation. These contaminated sediments were removed during surface remediation (DOE, 1995b) and thus, contaminated sediments are no longer a potential source for surface water contamination. However, there is a current potential for contaminated ground water to enter the ditches and for those contaminants to accumulate in sediments. Also, there is the potential for contaminated ground water to discharge to Mill Creek along the north edge of the site or to enter Mill Creek from Vitro Ditch. This contaminated surface water could then enter the Jordan River. For these reasons, samples of surface water and sediment were collected and analyzed for site-related contamination in 1993.

Jordan River

Surface water and sediment samples were collected at four locations in December 1993 (locations 183, 184, 188, and 185) (Figure 2.2 and Table 3.7). Results of these screening analyses of surface water samples indicate no evidence for site-related contamination of the Jordan River downstream of the site. Concentrations of constituents downstream of the site are generally less than or the same as those observed upstream of the site. The decrease in concentrations of several site-related contaminants downstream of the site, such as uranium and sulfate, is due to dilution by better quality water from Mill Creek.

Sediment samples were collected from the same locations in the Jordan River. The upriver location in the Jordan River showed the highest values for virtually all constituents sampled in December 1993, suggesting that there is no site-related contamination in the river sediments (Table 3.8).

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

	Mill Creek			Jordan River			
	Upstream		Downstream	Upstream			Downstream
Contaminant	180	181	182	184	188	185	183
Calcium	104	113	85	141	139	135	86
Chloride	66	67	197	288	296	278	200
Magnesium	36	39	35	64	63	60	35
Molybdenum	<0.01	<0.01	<0.01	0.01	0.01	0.01	<0.01
Selenium	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Silver	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium	35	39	152	191	186	181	150
Strontium	1.01	1.08	0.78	1.28	1.29	1.25	0.79
Sulfate	173	173	141	340	349	339	147
Uranium	0.002	0.002	0.004	0.015	0.015	0.015	0.005

Notes:

1. Unfiltered water samples collected December 6, 1993.
2. All parameters reported in milligrams per liter.
3. Sampling locations 180, 181, 184, 185, and 188 are upstream of the site. Sampling locations 182 and 183 are downstream.

Table 3.8 Summary of Mill Creek and Jordan River sediment chemistry data, December 1993, Salt Lake City, Utah, site

	Mill Creek			Jordan River			
	Upstream		Downstream	Upstream			Downstream
Parameter	180	181	182	184	188	185	183
Calcium	76,100	64,500	8,810	17,600	55,500	72,000	18,400
Chloride	110	807	165	57	220	304	117
Magnesium	11,000	10,900	18,200	4,140	11,500	12,500	3,670
Molybdenum	<4.6	<4.2	<4.1	<2.8	<4.8	<6.4	<2.7
Selenium	<2.3	<2.1	<2.1	<1.4	<2.4	<3.2	<1.3
Silver	<4.6	<4.2	<4.2	<2.8	<4.8	<6.4	<2.7
Sodium	908	857	1,240	575	1,600	1,620	519
Strontium	190	153	82.6	47.5	197	272	60.1
Sulfate	60	184	67	<14	116	91	150
Uranium	1.3	1.4	1.2	0.65	2.1	2.5	0.74

Notes:

1. Concentrations in milligrams per kilogram.
2. < indicates less than the given method detection limit.

Mill Creek

Surface water and sediment samples were collected at three locations in December 1993 (180, 181, and 182) (Figure 2.2). A sample from Mill Creek taken downstream of its confluence with South Vitro Ditch (sampling location 182) indicates water quality in Mill Creek changes below the confluence. Some of those changes, however, such as increases in sodium and chloride and decreases in calcium, sulfate, and strontium, probably are attributable to the treated effluent discharged by the CVWRF. Future sampling of the CVWRF effluent will be considered to address this contamination. There is the potential for uranium in contaminated ground water to enter the sewage treatment system via check valves in large clarifier tanks. Thus, the slight increase in uranium (from 0.002 to 0.004 mg/L) downstream of the South Vitro Ditch may be from the treated effluent, from contaminated ground water entering Mill Creek from South Vitro Ditch, or from direct discharge of contaminated ground water to Mill Creek. However, Mill Creek samples have uranium concentrations less than those in the Jordan River upstream of the site (up to 0.015 mg/L).

The screening analysis of sediment samples collected in December 1993 from Mill Creek indicates that constituent concentrations do not increase at the downstream location (sample site 182), suggesting that there is no site-related contamination of the creek sediments (Table 3.9). However, a more thorough sampling of site-related contaminant trace metals would be required to rule out the possibility of site-related impacts on sediments in Mill Creek.

Table 3.9 Summary of Vitro Ditch and South Vitro Ditch sediment chemistry data, December 1993, Salt Lake City, Utah, site

Parameter	South end 186	North end 187
Calcium	69,800	81,700
Chloride	41	130
Magnesium	3,710	16,500
Molybdenum	6	236
Selenium	<1.4	<1.4
Silver	<2.7	<6.4
Sodium	718	1,600
Strontium	79	43
Sulfate	77	99
Uranium	3.9	4.8

Notes:

1. Concentrations in milligrams per kilogram.
2. < indicates less than the given method detection limit.

Vitro Ditch and South Vitro Ditch

Because current surface water quality data are not available for Vitro Ditch and South Vitro Ditch, the present impact of the processing site on the water quality in South Vitro Ditch cannot be demonstrated or ruled out.

No background data are available for sediments in South Vitro Ditch. However, for the purposes of a screening analysis, constituents have been compared to average concentrations of elements in soils. These comparisons indicate that sediments in South Vitro Ditch collected in December 1993 had a high concentration of molybdenum (236 mg/kg) at the north end (sample site 187 in Figure 2.2). The molybdenum level at location 187 was much higher than the average for soils in the western United States (6 mg/kg) (Jarrell et al., 1980) and the suggested maximum acceptable concentrations of 37 mg/kg for soils at UMTRA Project sites (JEG, 1986). Lower concentrations of molybdenum (6.6 mg/kg) occur at the south end of South Vitro Ditch (sample site 186).

Summary

A screening analysis of surface water and sediment indicates that there are no impacts of site-related contamination to the Jordan River. Surface water in Mill Creek may be receiving a small amount of uranium from the site. Measured concentrations of uranium increased from 0.002 to 0.004 mg/L downstream of the site. Sediments in Mill Creek do not appear to be impacted; however, this conclusion is based on limited information. Because there are no current surface water data for Vitro Ditch and South Vitro Ditch, site-related impacts of potential ground water discharge cannot be evaluated. However, elevated concentrations of molybdenum in sediments from South Vitro Ditch suggest that surface water is being impacted by ground water discharge from the site.

4.0 EXPOSURE ASSESSMENT

Exposure can occur only if there are both a source of contamination and a mechanism of transport to a receptor population or individual. This section discusses the environmental interactions of affected media, exposure pathways, and potential receptors scenarios (Figure 4.1). This section also quantifies the possible exposures that could be incurred by future residents and others who could use contaminated ground water at the Vitro site. Livestock and other environmental receptors exposures and resulting toxicities are evaluated in Section 7.0.

4.1 POTENTIALLY EXPOSED POPULATION

As discussed in Sections 2.4 and 3.2, contaminants related to former mill operations are limited in extent to ground water in the shallow unconfined aquifer. Ground water contaminated by uranium processing at the Salt Lake City site is not currently used by area residents. As shown in Figure 2.5, ground water is not withdrawn from the unconfined aquifer within a 2-mi (3-km) radius of the site. Water from the shallow unconfined aquifer is of poor quality (USGS, 1984; DNRS, 1971). Therefore, area residents use water supplied by a municipal water system, which obtains water from the deeper confined aquifer. One proposed municipal well completed in the deep, confined aquifer is on the former Vitro site. This risk assessment finds no contamination in the municipal well water collected during testing of the well (Section 3.0).

Although plans for future land use do not specify residential developments at the site, such land uses cannot be precluded. Therefore it is assumed that in the future, a domestic well could be installed in the most contaminated portion of the aquifer at the site, creating the potential for exposure through drinking, bathing, livestock watering, or irrigation. However, the likelihood of residential development and the use of poor quality ground water from the unconfined aquifer at the site in the future is considered low.

Although plans for future land use do not specify residential developments at the site, such land uses cannot be precluded. Therefore, such development is considered for this risk assessment.

The future residential scenario evaluates domestic ground water use consistent with current water uses by the population in the region.

The potentially exposed population includes residents of the following age groups: infants (birth to 1 year old); children (1 to 10 years old), and adults (11 to 65 years old). These age groups were selected for the following reasons.

- Survey data for population variables such as age, weight, and daily water intake are available for these age groups.

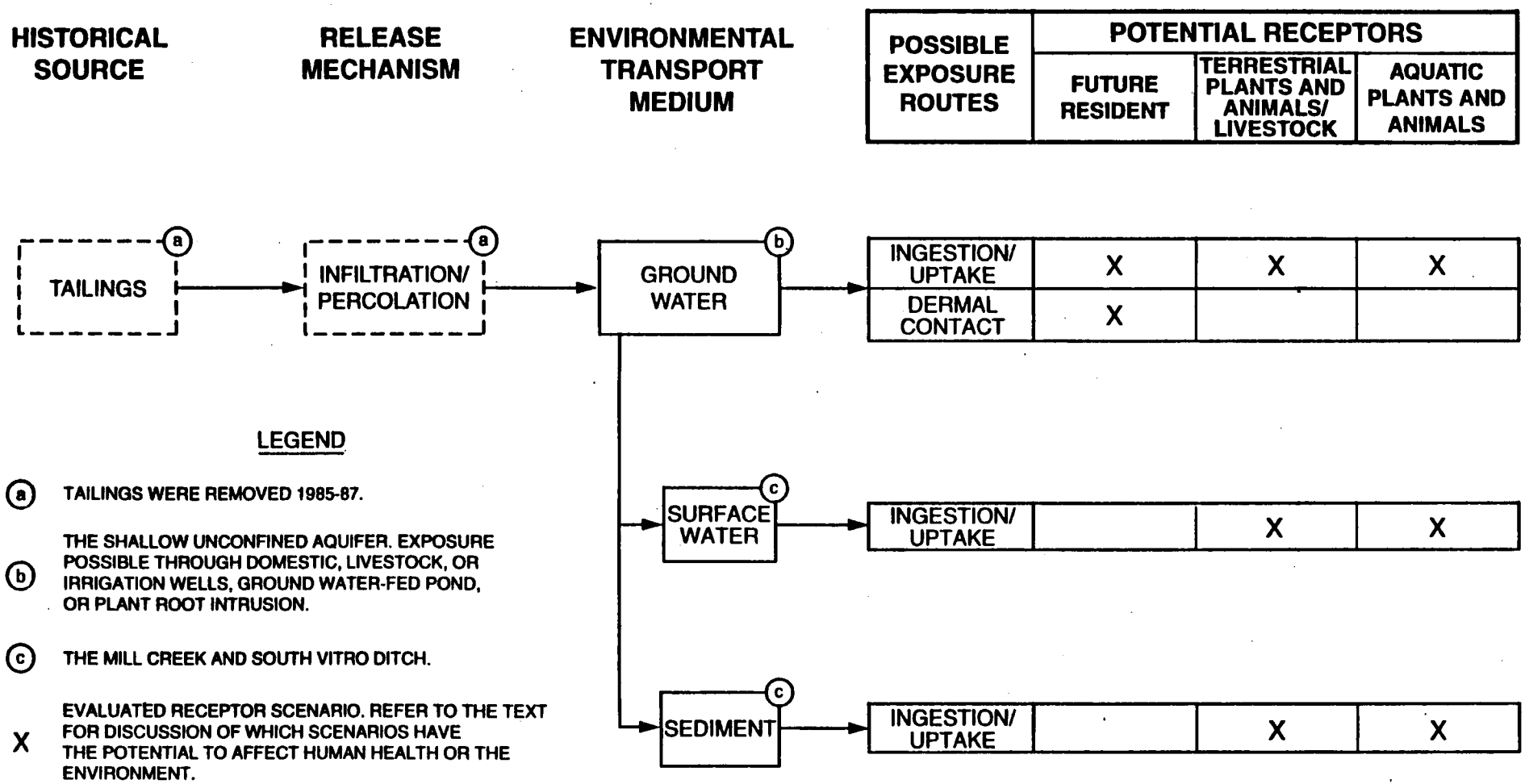


FIGURE 4.1
CONCEPTUAL MODEL
SALT LAKE C[illegible]Y, UTAH, SITE

MAC: SITE/SL[illegible]HA/CONCEPTMODEL2

- Toxicological variables are similar within these age groups, including responsiveness of sensitive subgroups (infants, children, and adults) to the contaminants of potential concern, toxicant intake-to-body-weight ratios, and toxicokinetics (a study of the time course of absorption, distribution, metabolism, and excretion of a contaminant in an individual's body).

Some individuals and/or subpopulations could be more vulnerable to possible exposures than the general population. These sensitive subpopulations could include infants, children, the elderly, or people with preexisting illness such as diabetes or kidney insufficiency with the absence of diabetes.

4.2 EXPOSURE PATHWAYS

An exposure pathway describes the course a contaminant takes from the source to the exposed individual or population. For an exposure pathway to be complete, there must be a source of contamination, a point of contact with a population or individual, and a route of exposure (e.g., water ingestion). Because the tailings piles and soils contaminated from uranium milling operations at the site were removed and relocated to a disposal cell, soil or air exposure pathways (such as incidental soil ingestion, dermal contact with soil, or inhalation of particulates) are not considered.

This assessment evaluates ground water exposure pathways. Figures 4.1 and 4.2 provide a conceptual model of the possible future ground water exposure pathways that are believed to lead to the greatest exposure possible at the former Vitro site. Pathways that are not considered in this model, but that could possibly be completed, include exposure to soil contaminated via irrigation (for example, inhalation of fugitive dust and incidental soil ingestion). Preliminary calculations demonstrate that the sum of these pathways typically contributes much less to the total exposure dose than exposure from drinking water ingestion and would not be associated with health problems (DOE, 1995a). Under some future land uses or construction activities, these pathways could constitute a notable exposure. Upon determination of a specific land use or construction activity, these pathways may therefore require additional evaluation.

Although it is unlikely that the ground water in the unconfined aquifer at the site will be used in the future for drinking purposes because of its naturally poor quality, slow yield to wells and the availability of good quality water from the municipal water supply system, this risk assessment evaluates a hypothetical future use of the ground water from the shallow unconfined aquifer.

Ground water in the region is used primarily for household purposes such as drinking, cooking, and bathing. Other uses typical of the region that could lead to human exposure are irrigation and livestock watering.

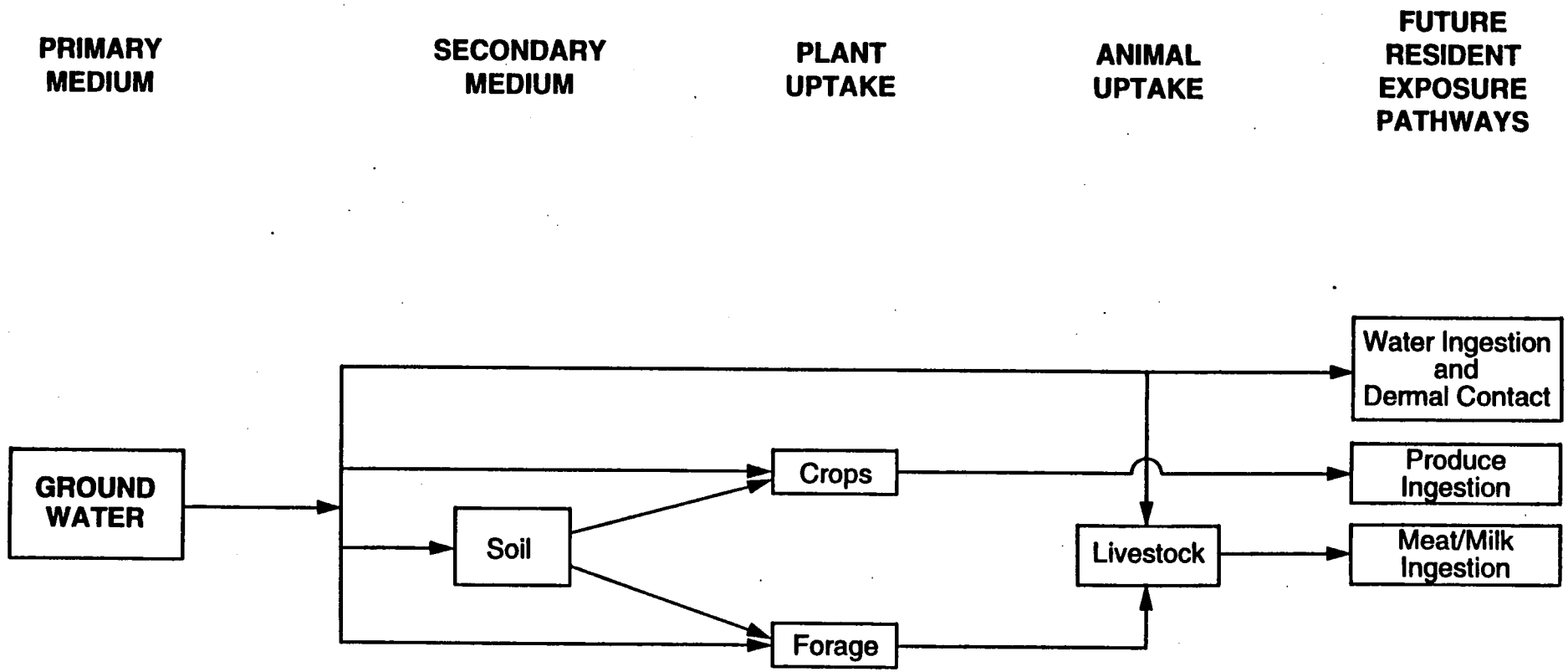


FIGURE 4.2
HUMAN EXPOSURE PATHWAY INTERACTIONS
SALT LAKE C'''. UTAH, SITE

4.2.1 Drinking water ingestion

Drinking water ingestion generally is the dominant exposure route for ground water contaminated with metals and other nonvolatile compounds (DOE, 1994b). In this evaluation, drinking water consumption includes water ingested by drinking and consuming food prepared with water (e.g., reconstituted juices, soup, rice, and beans). Because drinking water ingestion is the dominant pathway, it is evaluated probabilistically in Section 4.4.

4.2.2 Dermal absorption

Dermal absorption is the process by which chemicals coming into contact with the skin become absorbed into the blood vessels near the surface of the skin. Although some compounds are absorbed easily in this manner, metals are poorly absorbed through intact skin (EPA, 1992).

To determine whether dermal absorption route is likely to be an important route of exposure, a screening level calculation was performed to learn the relative contribution of dermal absorption to exposure dose from the drinking water ingestion route for the contaminants of potential concern (DOE, 1995a). Because chemical-specific absorption factors are not available for these contaminants, they are assumed to absorb across intact skin at the same rate as water (EPA, 1992). This assumption probably overestimates the potential exposure contribution from dermal absorption.

Although the dermal dose is an absorbed dose and only a percentage of the ingested dose will be absorbed, the very low (0.2 percent) relative contribution of dermal absorption is assumed to be insignificant compared to drinking water ingestion exposure route (DOE, 1995a). Because the assumptions used to estimate the dermal absorption dose are believed to overestimate exposure (metals are assumed to be absorbed like water), and because the dose is less than a 1 percent incremental contribution to the exposure from drinking water ingestion and would not be associated with health problems, this pathway is not further evaluated in this risk assessment.

4.2.3 Ingestion of ground water-irrigated produce

Contaminants in ground water could be taken up by plants either through roots in soil saturated with contaminated ground water or from irrigation water obtained by a well in the contaminated ground water. These plants could be eaten by humans or could enter the food chain and subsequently be consumed in the form of meat or milk. The amount this exposure route contributes could be substantial if the contaminants concentrate in plants. However, there are currently not enough data to evaluate this potential contribution based on literature values. The UMTRA Ground Water Project is currently studying contaminant uptake by irrigated vegetables and grasses. When these data become available, this pathway can be evaluated for this site; any results will be included in the site environmental assessment or environmental impact

statement. If applicable, these data will also be considered in the development of a ground water compliance strategy for the site.

An evaluation of potential damage to plants from contaminated ground water is presented in Section 7.0.

4.2.4 Ingestion of meat or milk from livestock drinking ground water

These pathways were eliminated from further consideration because the sulfate concentrations are so high that livestock could not chronically drink the water. If the livestock cannot consume the water, contaminants cannot bioaccumulate or transfer to meat tissue or milk. Evaluation of the toxicity of contaminants of potential concern to livestock is presented in Section 7.0.

4.3 EXPOSURE CONCENTRATIONS

For a contaminant in ground water, exposure concentration is the concentration contacted by an individual over the period of exposure being considered. In this evaluation, the contaminant concentrations (and therefore exposures) are assumed to be in a steady state, even though actual exposure concentrations are expected to fluctuate but eventually decrease with time because the site has been remediated. Nonetheless, they are reasonable estimates for chronic exposure soon after surface remediation. Chronic exposure for noncarcinogens is considered any period longer than 7 years. For carcinogens, a lifetime exposure over 30 years is considered.

Exposure concentrations are evaluated as a probability of occurrence based on ground water data collected from monitor well 135. This well is closest to the former tailings location and raffinate ponds and has consistently shown the highest contamination levels in the past 3 years of monitoring. Three exceptions to this rule occurred.

- Fluoride, manganese, and uranium levels were higher in well 109 than in well 135; samples from well 109 were analyzed for fluoride, manganese, and uranium toxicities.

- Molybdenum concentrations were consistently higher in well 131 than in well 135; therefore, molybdenum toxicity was analyzed based on levels observed in well 131.

- The maximum observed concentration measured in ground water from combined downgradient wells 008, 011, 109, 131, and 135 was used for radium-226 and other longer-lived progeny of the uranium decay series. Carcinogenic effects associated with exposure to radium-226, lead-210, polonium-210, and thorium-230 are evaluated in Section 6.0.

The probability distribution selected for a contaminant had approximately the same mean, median, standard deviation, and shape as were observed in the

actual water quality data (DOE, 1995a). The upper tails of the distributions were truncated at the 99th percentile. This truncation is conservative, since for every contaminant, the highest concentration in the distribution was higher than the maximum observed concentration in the data base. The software package @RISK (Palisade Corporation, 1992) was used to generate the probability curves for the contaminants of potential concern. The results are shown in Figures 4.3 through 4.10.

4.4 ESTIMATION OF INTAKE

Individuals within this hypothetical population are expected to vary in their water consumption habits, stable body weight, and length of time they reside in the potential contamination zone. Consequently, health risks associated with ground water consumption will also vary in this population. To adequately describe the range of potential risks to a future population, naturally occurring variabilities in daily water intake, body weight, and residency time were incorporated in this assessment through probability distributions selected from published public health and census documents for the United States. All distributions were truncated at the upper and lower 0.01 percentile (DOE, 1995a). Values disallowed through this truncation have a probability of less than 1 in 10,000 of occurring within this hypothetical population.

The potential toxicity of noncarcinogenic contaminants in drinking water depends primarily on long-term or chronic (i.e., at least 7 years) average daily consumption of the contaminant per kilogram of body weight (measured in milligrams per kilogram per day [mg/kg-day]). For these noncarcinogenic contaminants, chronic daily intake is calculated as follows:

$$\text{(1) Intake (mg/kg-day)} = \frac{\text{Concentration (mg/L) x ingestion rate (L/day) x EF (days/year) x ED (yrs)}}{\text{Body weight (kg) x averaging time (365 days/year x ED [yrs])}}$$

Radionuclide carcinogenicity increases with total intake over time, compared to the average daily intake for noncarcinogens. Also, the body weight factor is relatively insignificant in determining risk from exposure. Intake of a radioactive carcinogenic substance (measured in picocuries) is therefore quantified as total exposure to radioactivity throughout the residency period of an individual:

$$\text{(2) Intake (pCi/lifetime)} = \underset{\text{(pCi/L)}}{\text{Concentration}} \times \underset{\text{(L/day)}}{\text{Ingestion rate}} \times \underset{\text{(years)}}{\text{Exposure duration}} \times \underset{\text{(days/year)}}{\text{Exposure frequency}}$$

Average daily intake (L/day)

Lognormal probability distributions were used to describe variations in average daily tap water intake among members of the hypothetical population (Roseberry and Burmaster, 1992). These distributions were developed from data collected during the 1977-1978 National Food Consumption Survey conducted by the U.S. Department of Agriculture. During the survey, total tap water consumption

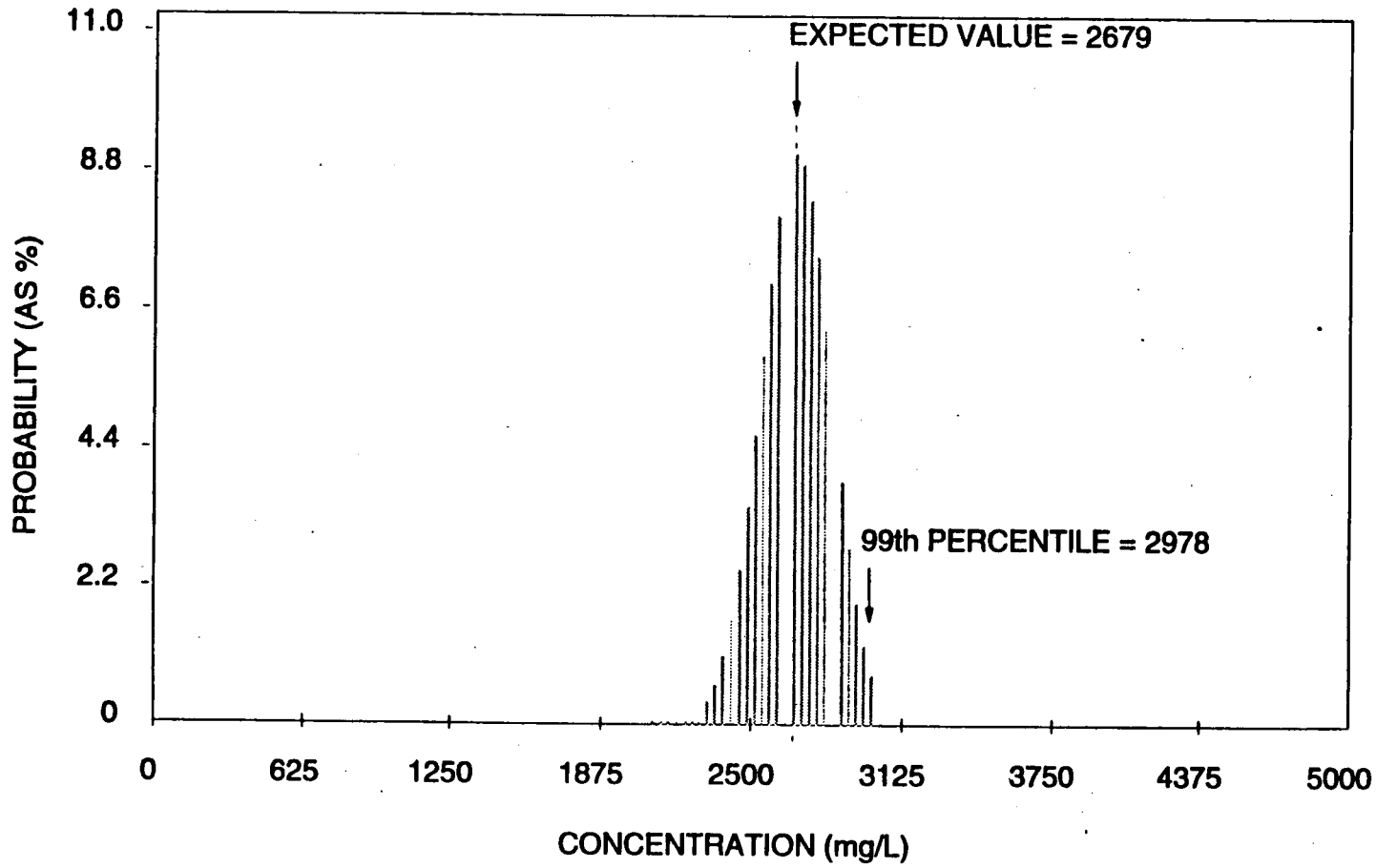


FIGURE 4.3
PROBABILITY DISTRIBUTION OF CHLORIDE CONCENTRATIONS
SALT LAKE , UTAH, SITE

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CHLODONC.DRW

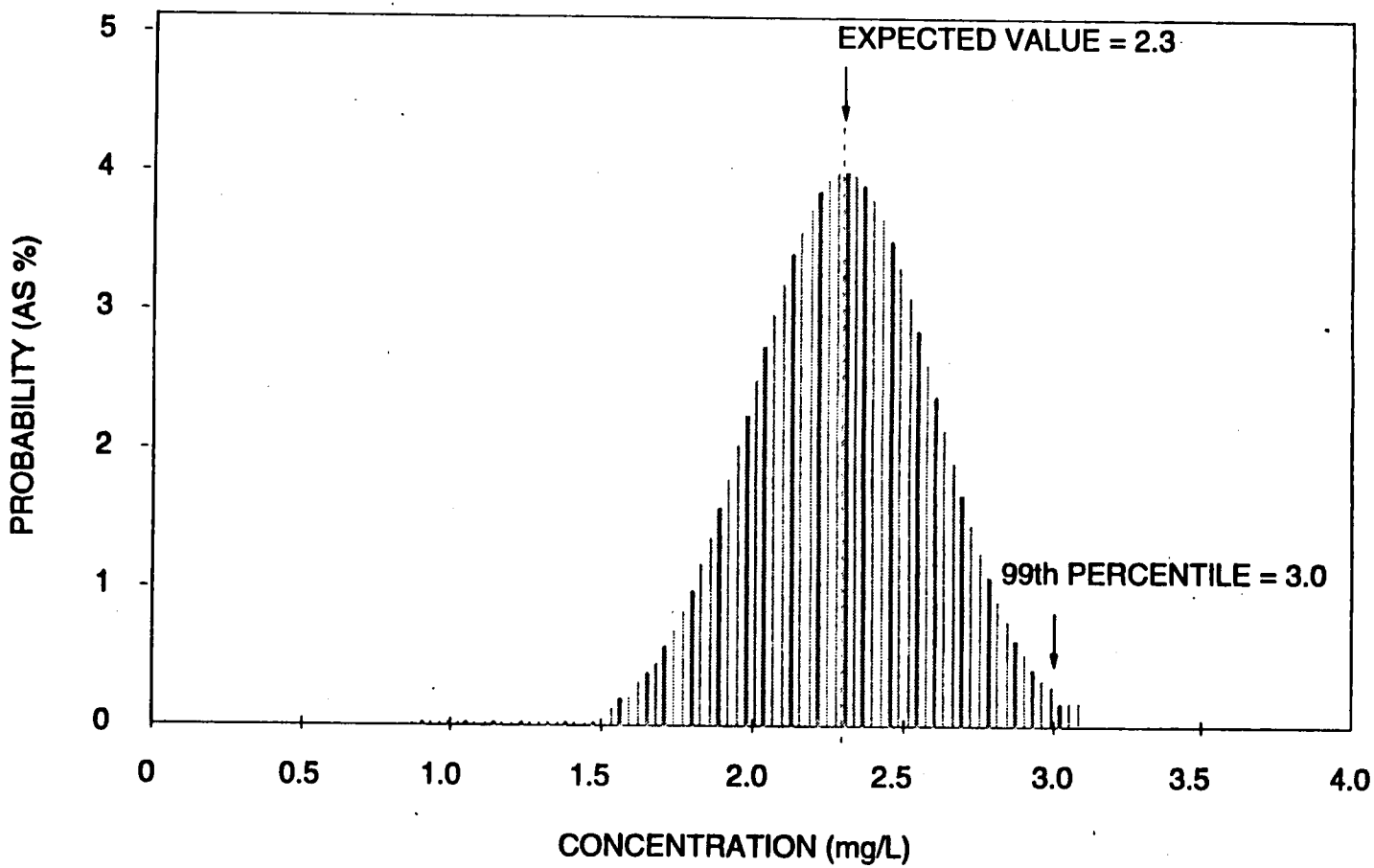

FIGURE 4.4
PROBABILITY DISTRIBUTION OF FLUORIDE CONCENTRATIONS
SALT LAKE CITY, UTAH, SITE

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FLUOCONC.DRW

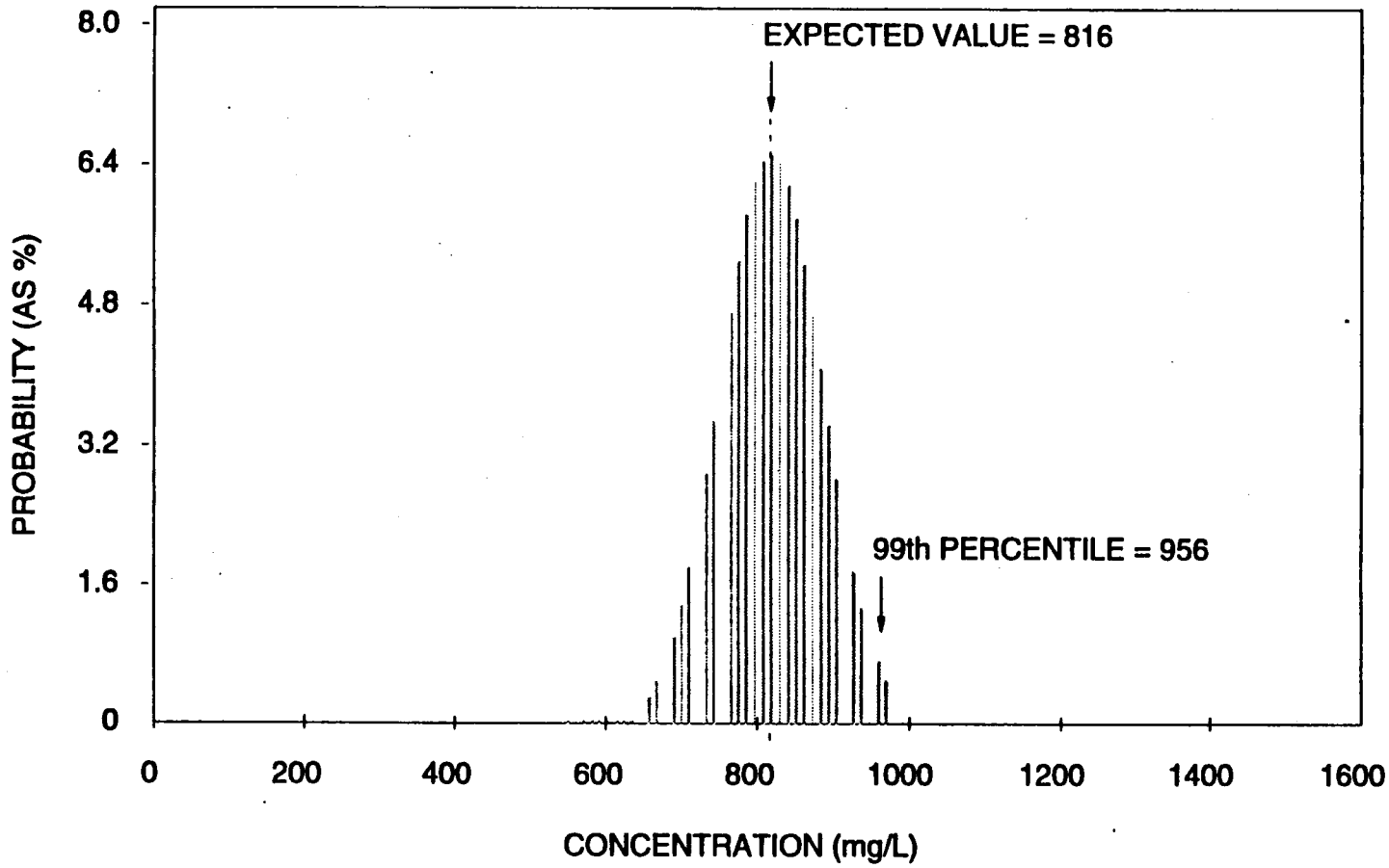

FIGURE 4.5
PROBABILITY DISTRIBUTION OF MAGNESIUM CONCENTRATIONS
SALT LAKE C[illegible] UTAH, SITE

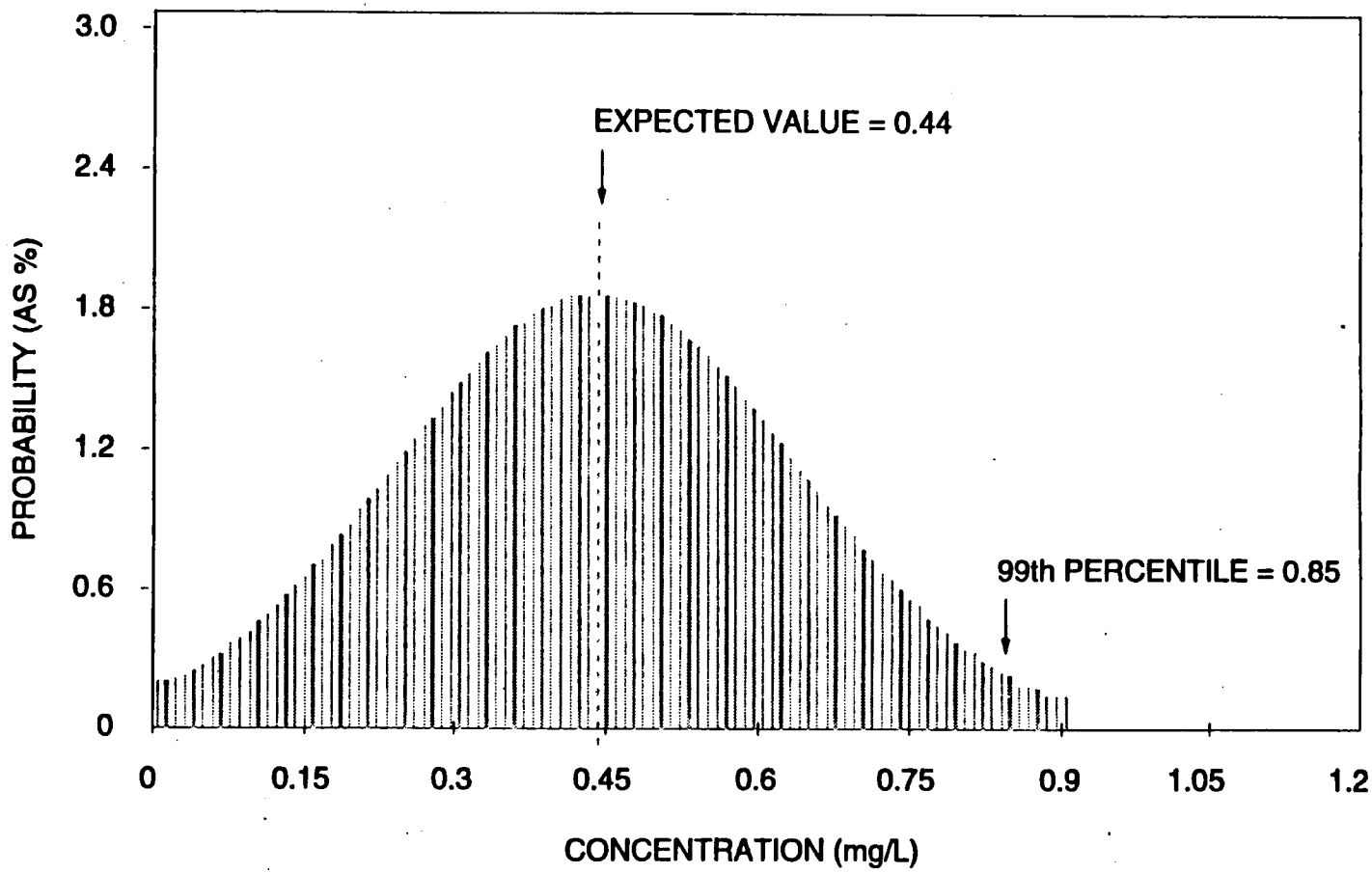

FIGURE 4.6
PROBABILITY DISTRIBUTION OF MANGANESE CONCENTRATIONS
SALT LAKE CITY, UTAH, SITE

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MNGACONC DRW

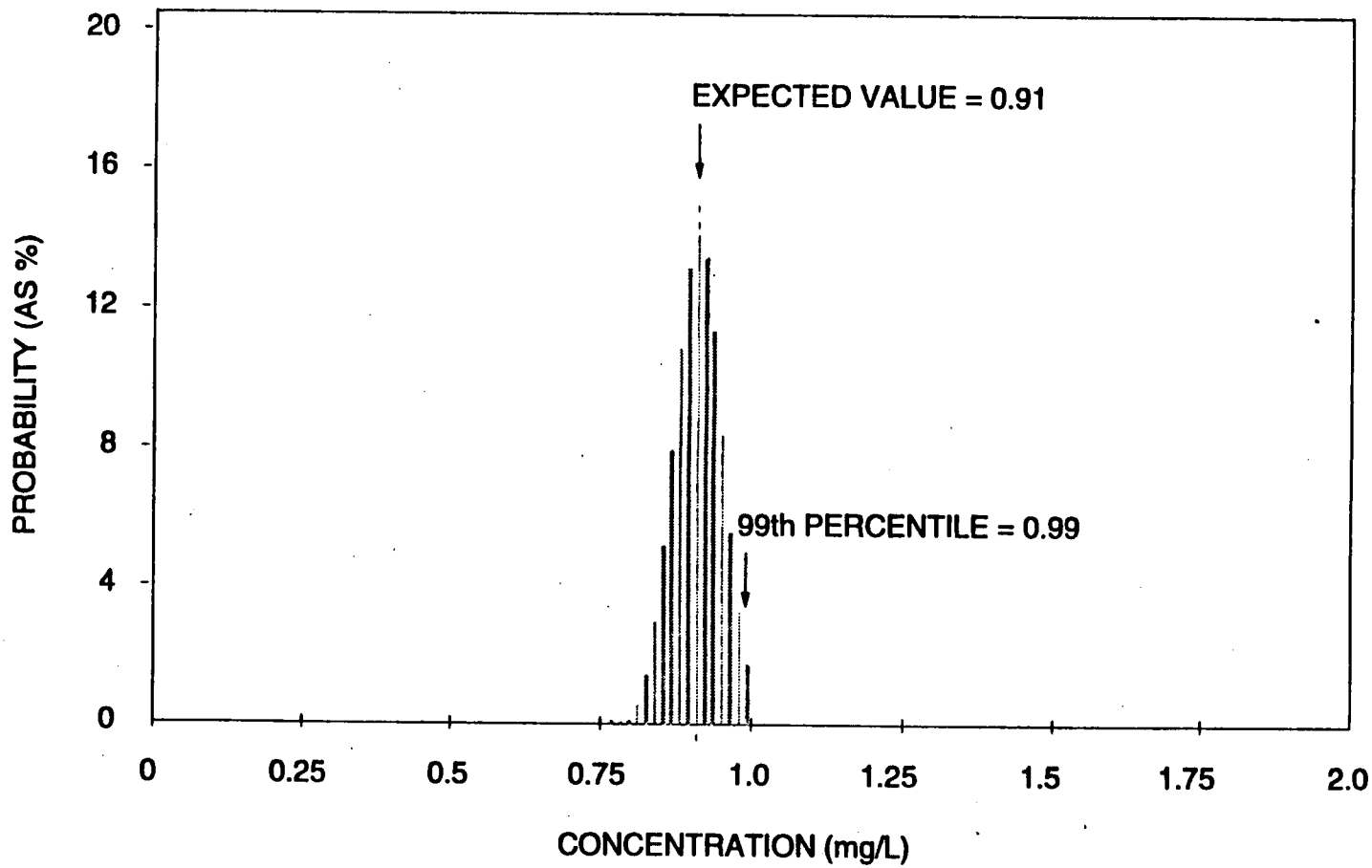

FIGURE 4.7
PROBABILITY DISTRIBUTION OF MOLYBDENUM CONCENTRATIONS
SALT LAKE CITY, UTAH, SITE

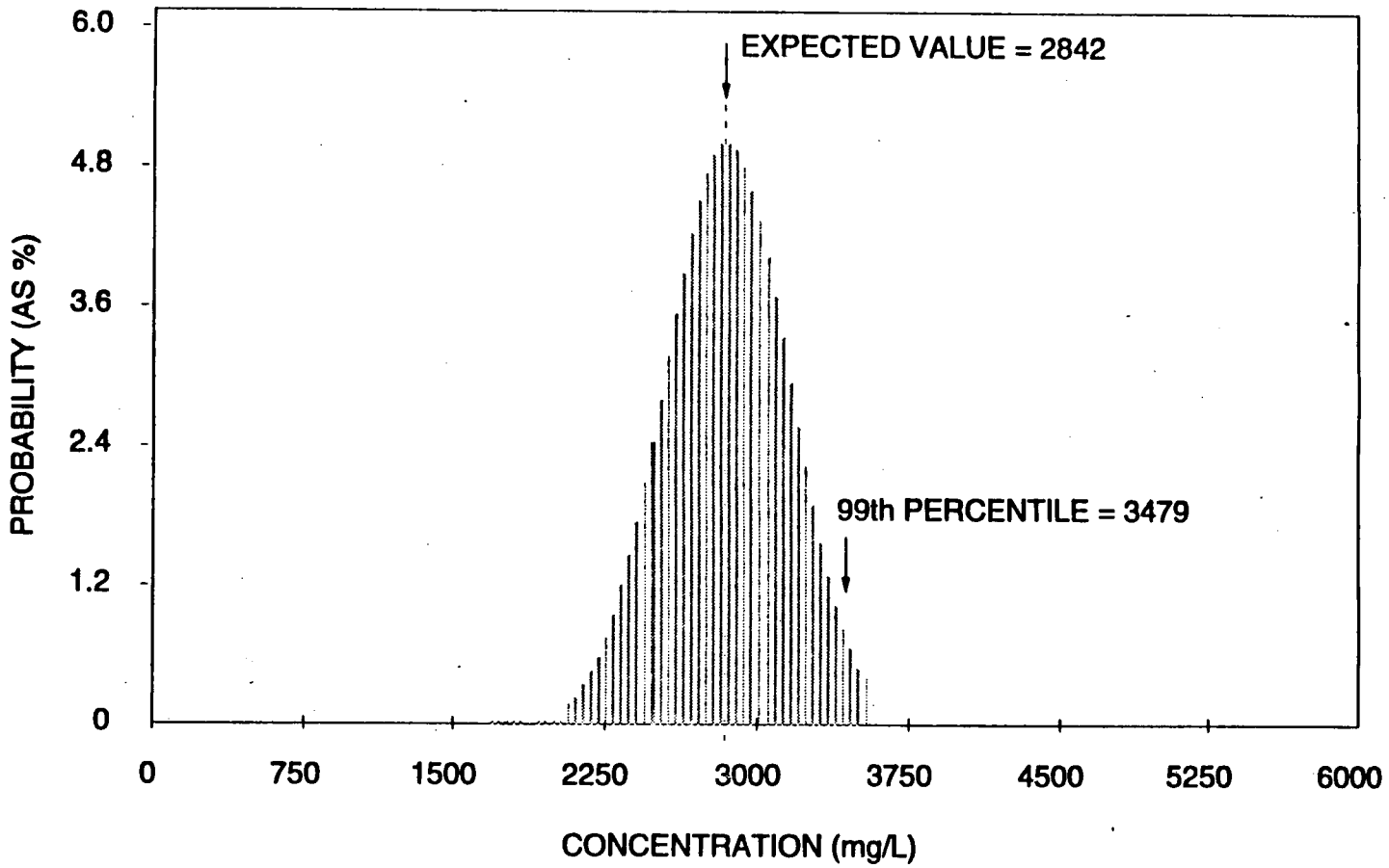

FIGURE 4.8
PROBABILITY DISTRIBUTION OF SODIUM CONCENTRATIONS
SALT LAKE CITY, UTAH, SITE

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SODICONC.DRW

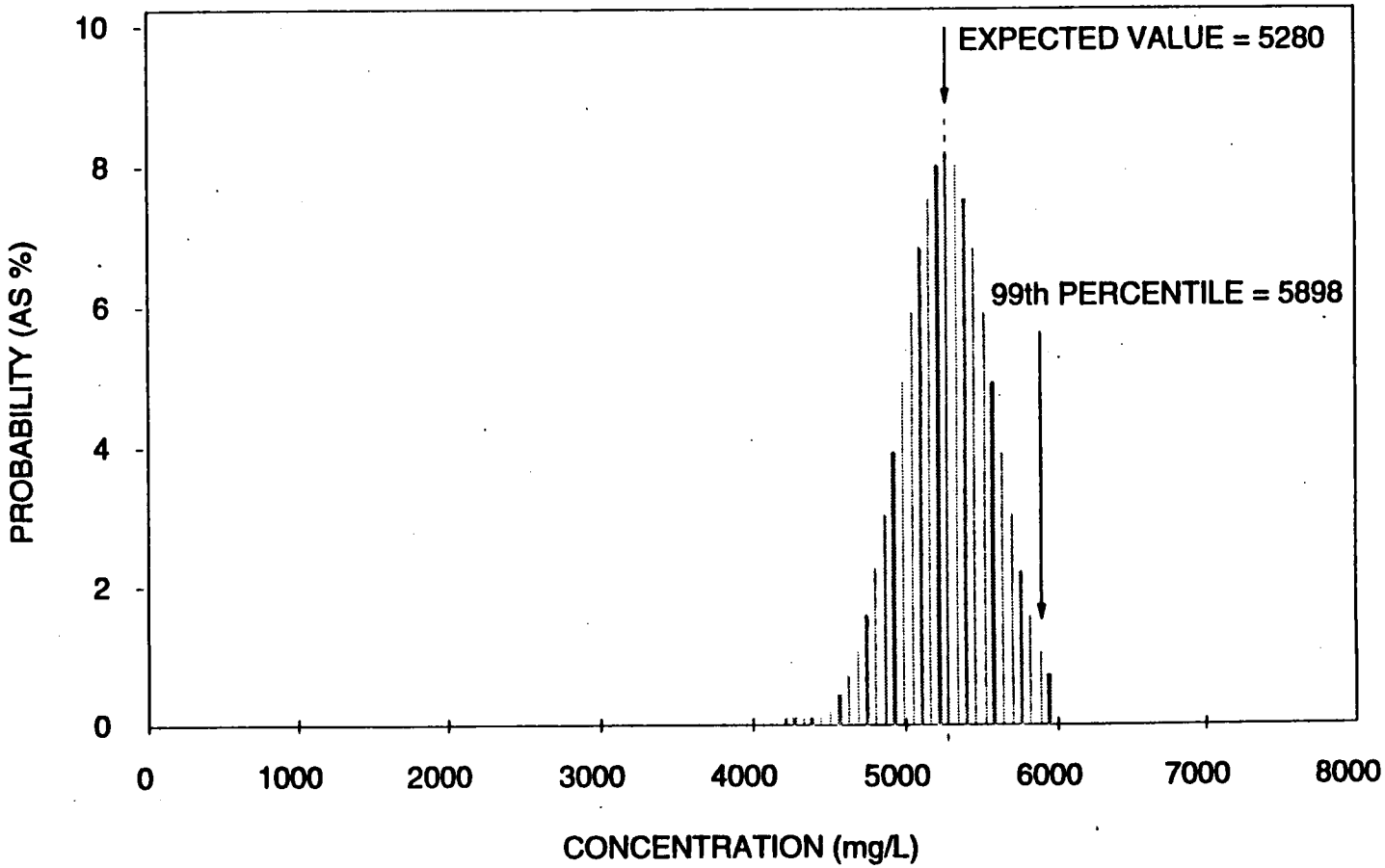


FIGURE 4.9
PROBABILITY DISTRIBUTION OF SULFATE CONCENTRATIONS
SALT LAKE CITY, UTAH, SITE

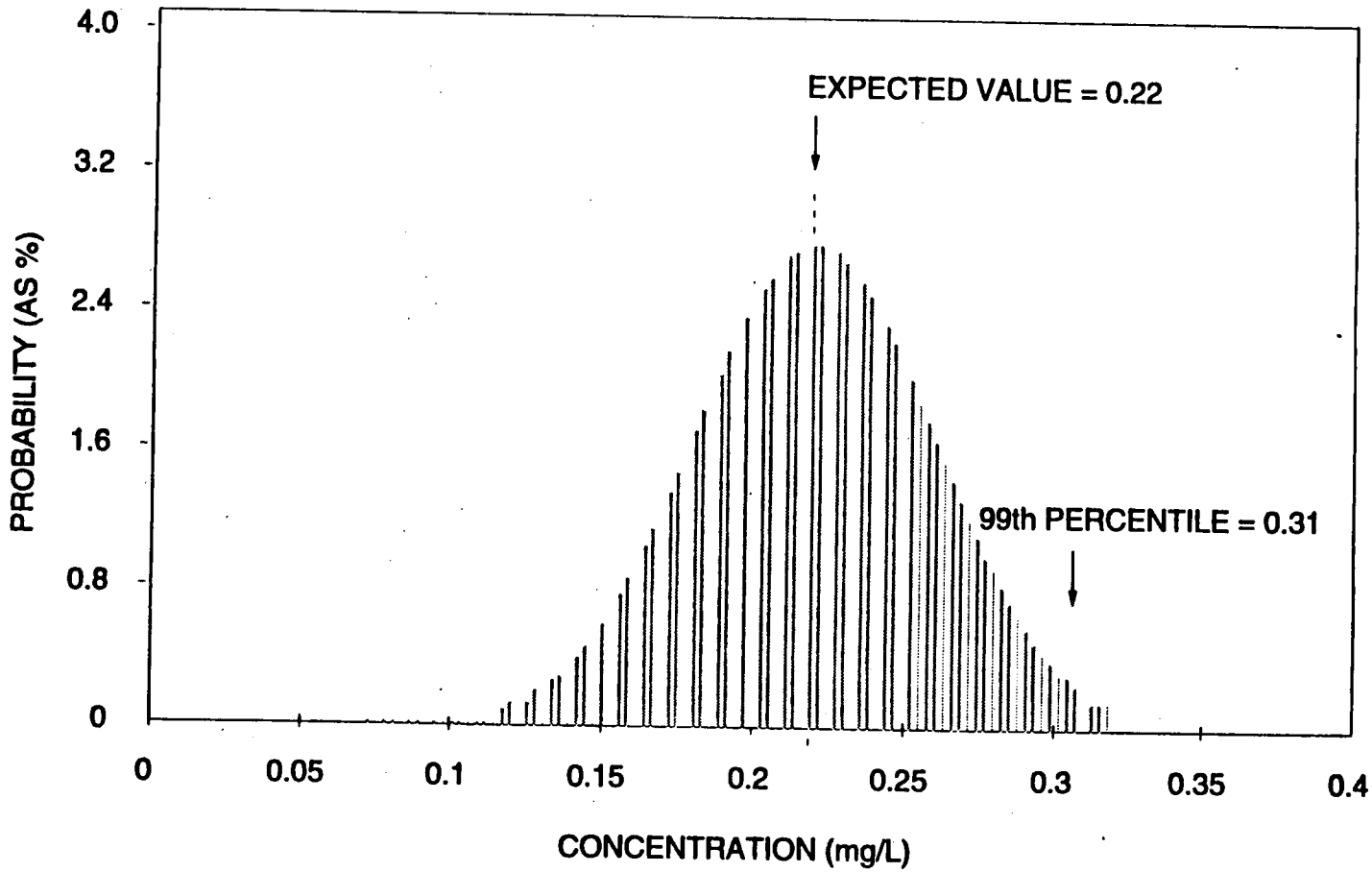


FIGURE 4.10
PROBABILITY DISTRIBUTION OF URANIUM CONCENTRATIONS
SALT LAKE CITY, UTAH, SITE

PATH I:\FL3.01\SLCBRA

URANCONC.DRW

during a 3-day period was recorded for 26,081 survey participants nationwide (Figure 4.11).

Body weight (kg)

Extensive national data on weights of males and females, by age, were collected by the National Health and Nutrition Survey between 1976 and 1980. These data were used to develop lognormal probability distributions for body weight by age and by sex. Then the distributions for males and females were combined, using census data on the national ratio of males and females within each age group (Figure 4.12).

Exposure frequency (days/year)

Individuals are generally not in their homes and drinking water from the same source for 365 days per year. Therefore, intake calculations assume only 350 days of exposure per year, allowing 14 days per year of drinking water intake from a different source. Because exposure to noncarcinogenic chemicals is expressed and compared in terms of average daily intake, 365 days per year is retained in the averaging-time term in the denominator.

Exposure duration (years)

Distributions of exposure duration were developed using data collected in 1985 and 1987 by the U.S. Department of Commerce, the Bureau of the Census, and the U.S. Department of Housing and Urban Development (Israeli and Nelson, 1992).

For noncarcinogens, the exposure duration in the numerator and denominator and the averaging time of the drinking water intake equations (see equation (1)) cancels out, assuming all exposures are chronic (i.e., at least 7 years). Thus, deviation from the standard residence time assumptions does not affect the results. For carcinogens, however, because risk is cumulative throughout a lifetime, deviation from the hypothesized residency distribution could considerably affect the risk estimate. Because residents living near the Vitro site frequently live in the same region for almost their entire lives, a fixed lifetime exposure of 30 years was used to model lifetime cancer risks.

Using exposure concentration distributions from Section 4.3 and the intake parameter distributions from this section, total intake distributions were determined for the three age groups (0 to 1, 1 to 10 and 11 to 65 years old) by simulation, using the @RISK software package and 10,000 iterations (DOE, 1995a). The 1-to-10-year-old age group consistently showed the highest intake-to-body weight distributions and therefore is the most conservative age group to evaluate. This age group is likely more susceptible to metal toxicity than adults because of higher gastrointestinal absorption efficiency and other toxicokinetic factors (Casarett and Doull, 1991). However, because infants are the most

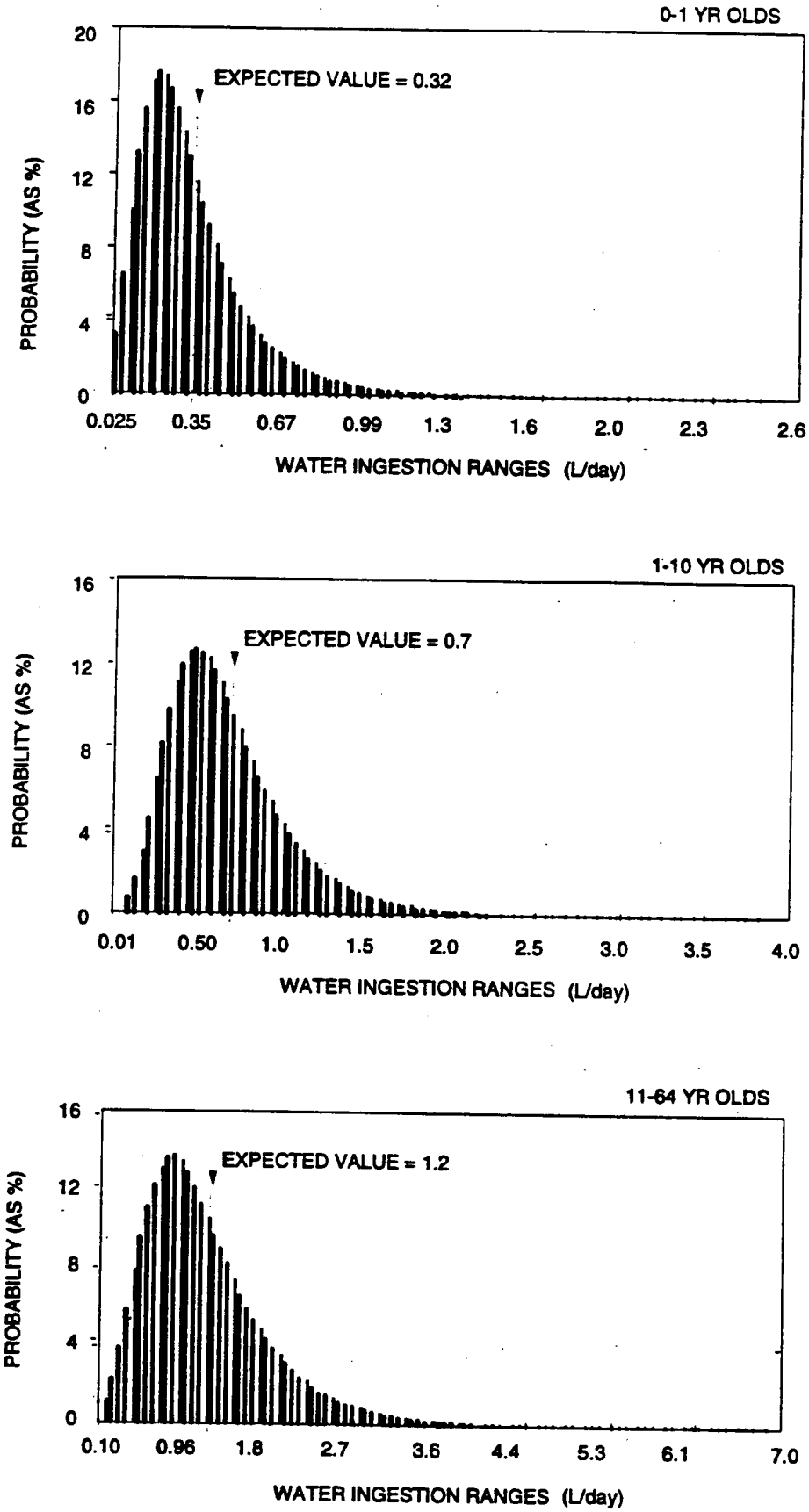
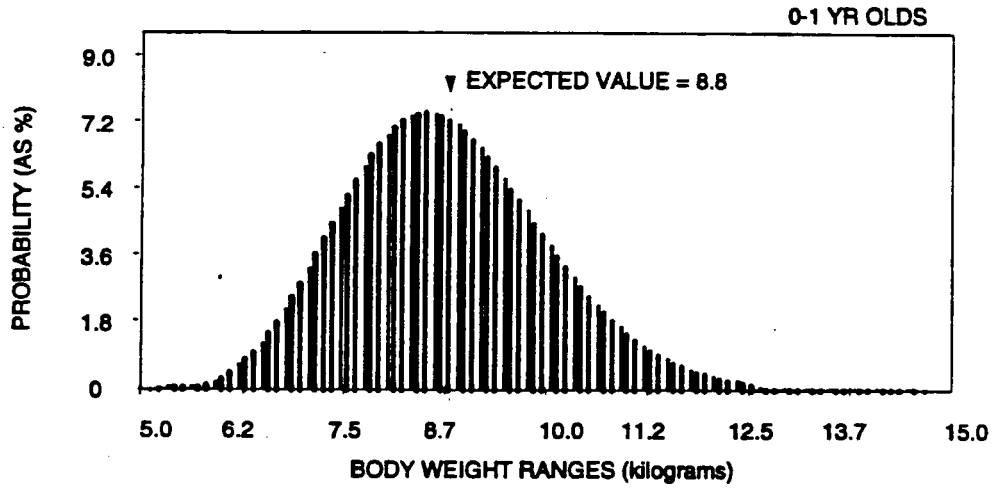
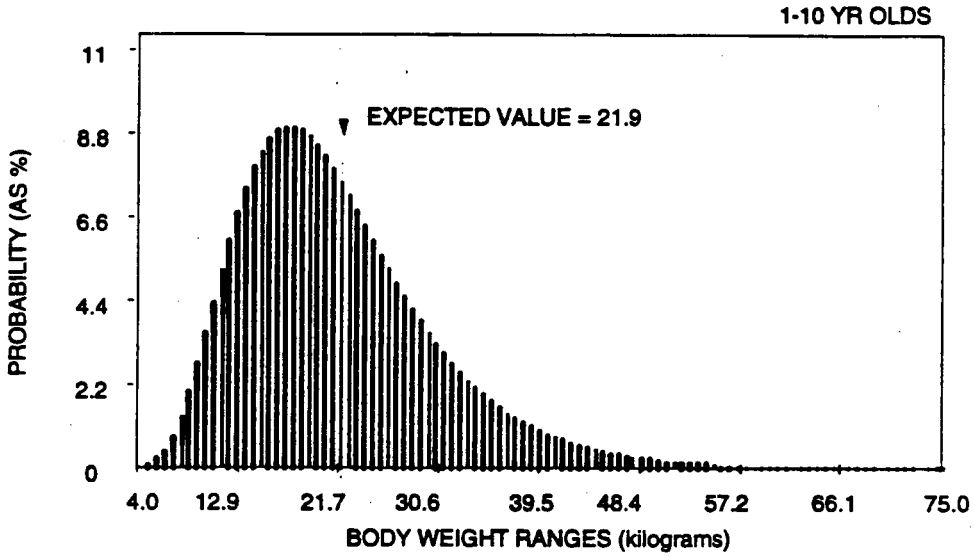


FIGURE 4.11
PROBABILITY DISTRIBUTIONS FOR TAP WATER INGESTION RATES





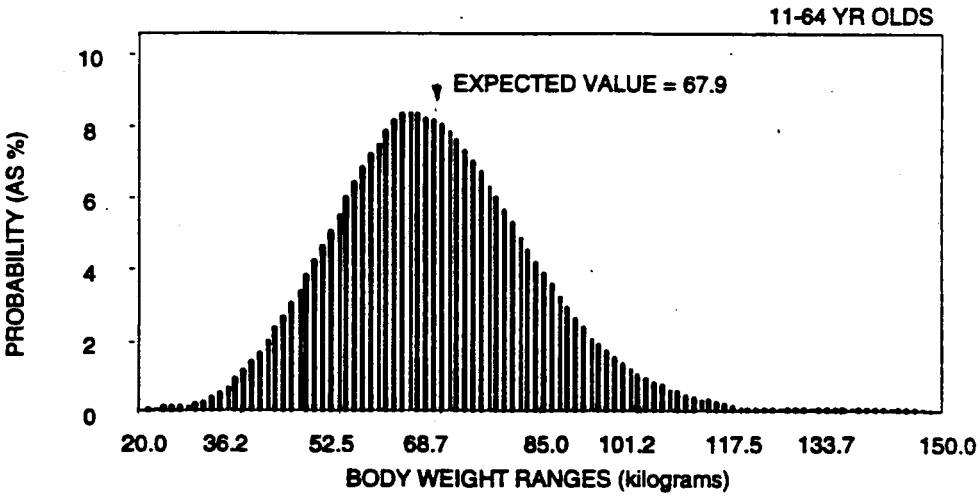


FIGURE 4.12
PROBABILITY DISTRIBUTIONS FOR BODY WEIGHT

susceptible receptors to sulfate toxicity, the intake distribution for this age group (i.e., age 0- to 1-year) is used. These results are shown for noncarcinogens in Figures 4.13 through 4.20. The total intake estimates used to calculate carcinogenic risk are shown in Figure 4.21 for uranium-234 and uranium-238.

4.5 EXPOSURE ASSESSMENT UNCERTAINTIES

Several potential sources of error may arise in all phases of an exposure assessment. Some meaningful sources of uncertainty are listed below.

- Lack of thorough environmental characterization of the site. The resulting uncertainty could lead to an underestimate or overestimate in the exposure analysis.

- Use of filtered versus unfiltered ground water samples. The results of exposure assessment presented in this document are based on filtered (0.45 μm) ground water samples. Therefore, the potential loss of certain ground water constituents as a consequence of filtration is associated with an additional source of uncertainties. For example, if concentrations of iron and lead measured in unfiltered ground water samples from monitor well 131 represent true values, ingesting this water could cause toxic effects. Because a high dose of uncertainty (see Section 3.0) is associated with these results, they could not be used in this risk evaluation.

- Assumption that the ground water contaminant source term at the site has reached a steady state and that contaminant concentrations at the exposure point will remain constant for chronic periods of exposure (generally greater than 7 years).

  Additivity of exposure from other pathways. Although the drinking water ingestion pathway is considered the major determinant of exposure in this risk assessment, the incremental contribution from the ground water-irrigated produce-ingestion pathway (that could not be estimated here) should be considered.

- Estimating the amount of contaminant absorbed through the skin.

Despite these uncertainties, using probability distributions that incorporate all definable sources of variability provide a representative picture of the potential range of exposure from drinking water ingestion pathway.

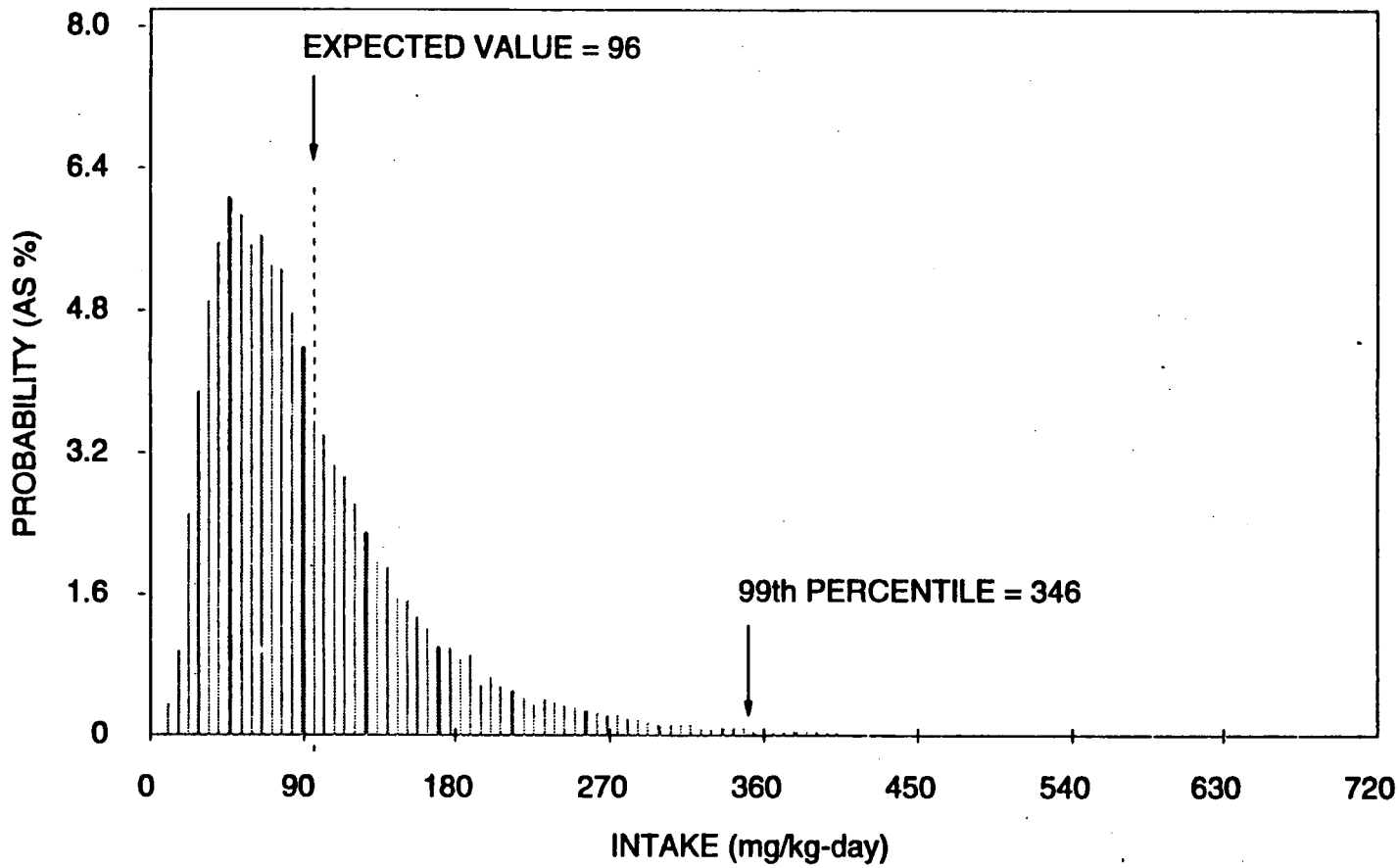


FIGURE 4.13
PROBABILITY DISTRIBUTION OF CHLORIDE INTAKES
SALT LAKE [illegible], UTAH, SITE

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CHLR1_10.DRW

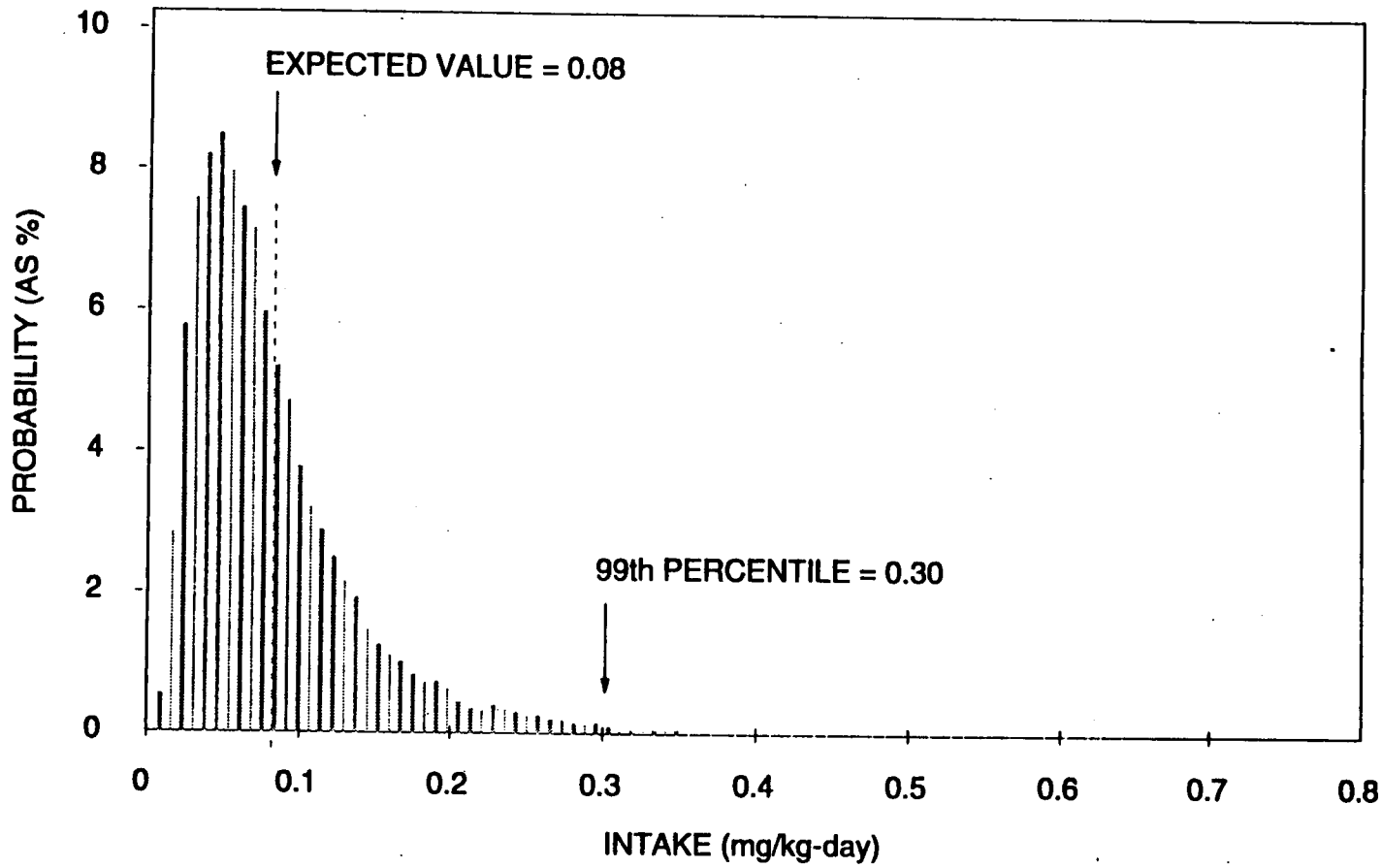

FIGURE 4.14
PROBABILITY DISTRIBUTION OF FLUORIDE INTAKES
SALT LAKE CITY, UTAH, SITE

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FLUO1_10.DRW

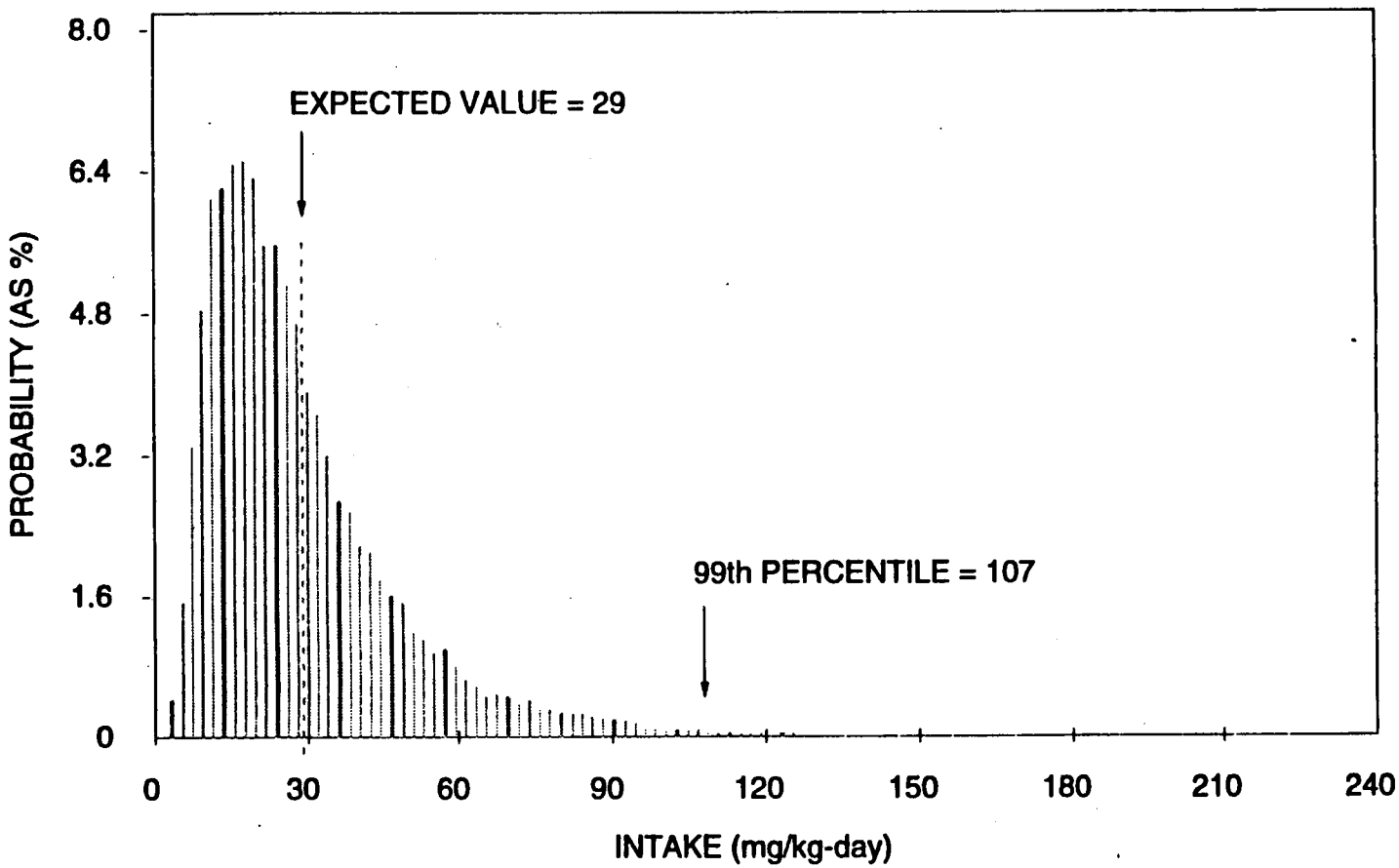

FIGURE 4.15
PROBABILITY DISTRIBUTION OF MAGNESIUM INTAKES
SALT LAKE ', UTAH, SITE

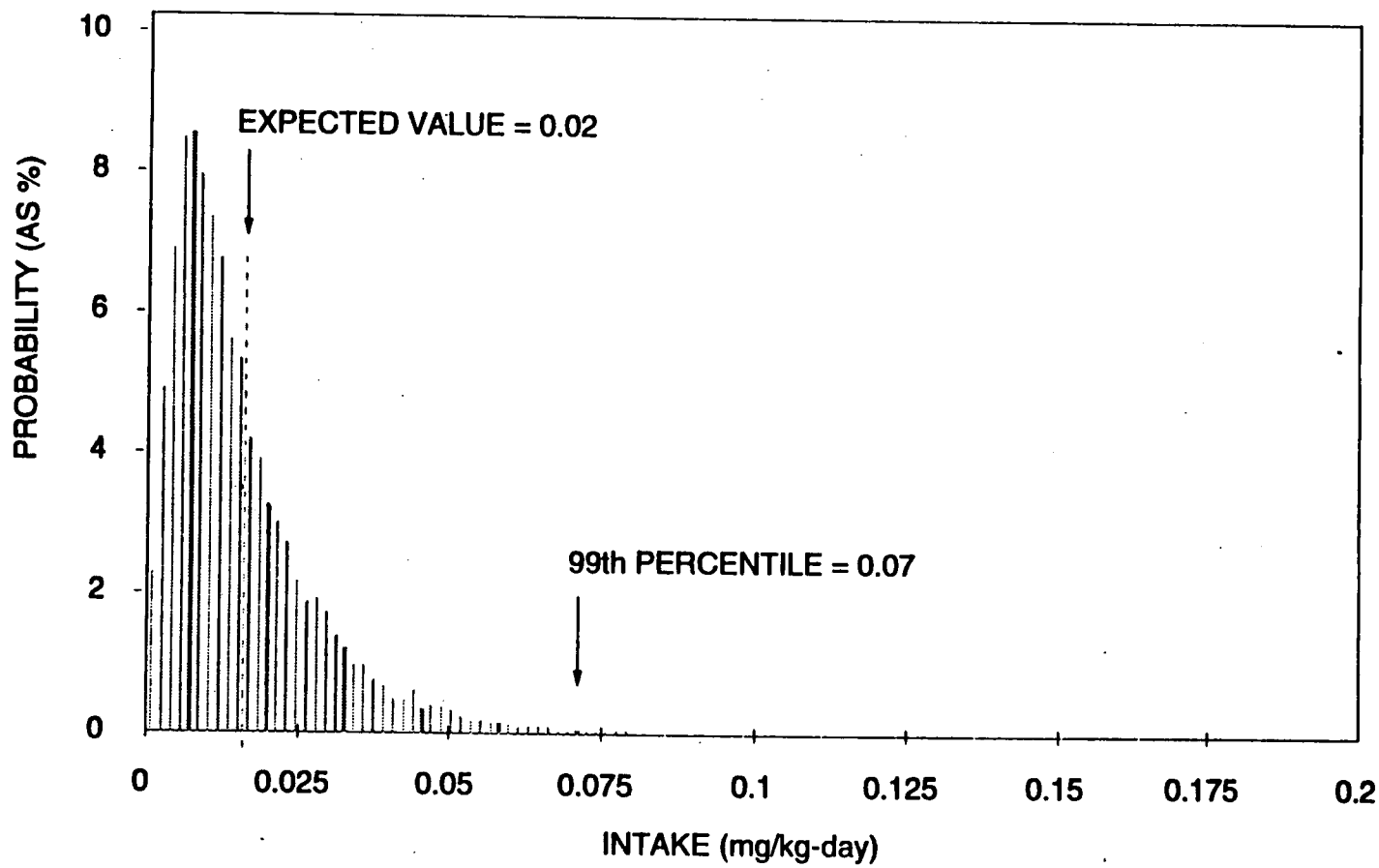

FIGURE 4.16
PROBABILITY DISTRIBUTION OF MANGANESE INTAKES
SALT LAKE CITY, UTAH, SITE

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MNGA1_10.DRW

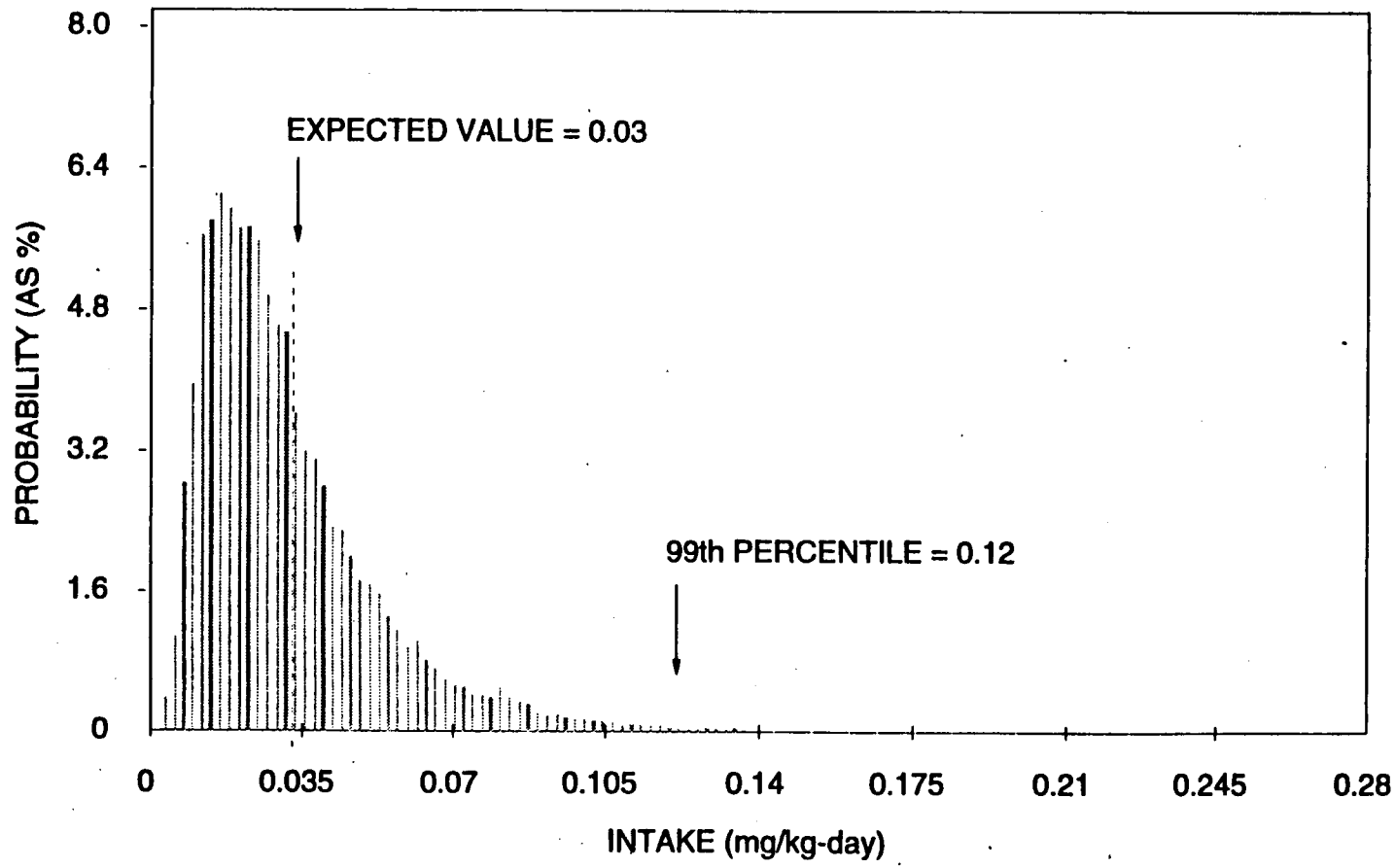

FIGURE 4.17
PROBABILITY DISTRIBUTION OF MOLYBDENUM INTAKES
SALT LAKE ', UTAH, SITE

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MOLY1_10.DRW

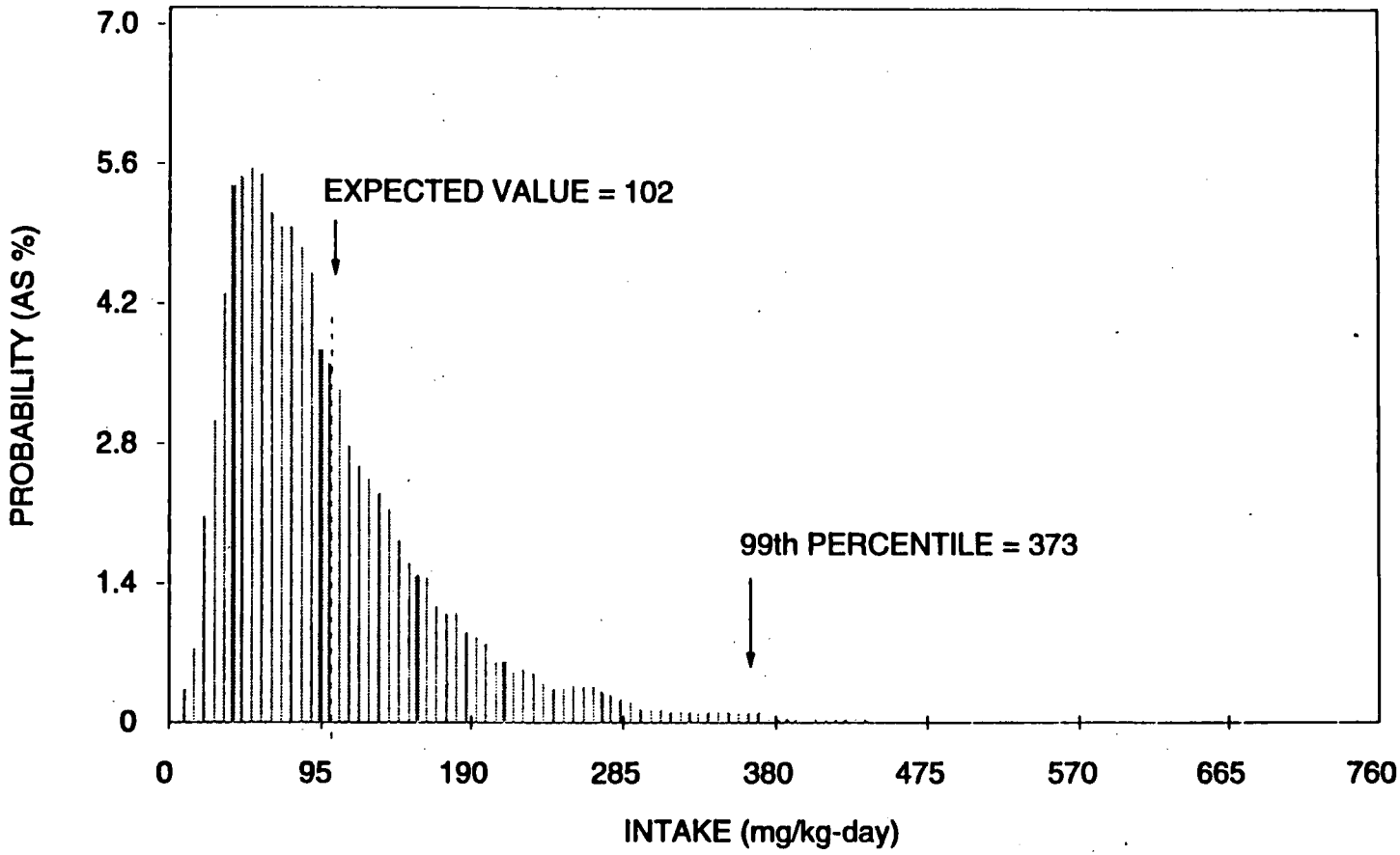

FIGURE 4.18
PROBABILITY DISTRIBUTION OF SODIUM INTAKES
SALT LAKE CITY, UTAH, SITE

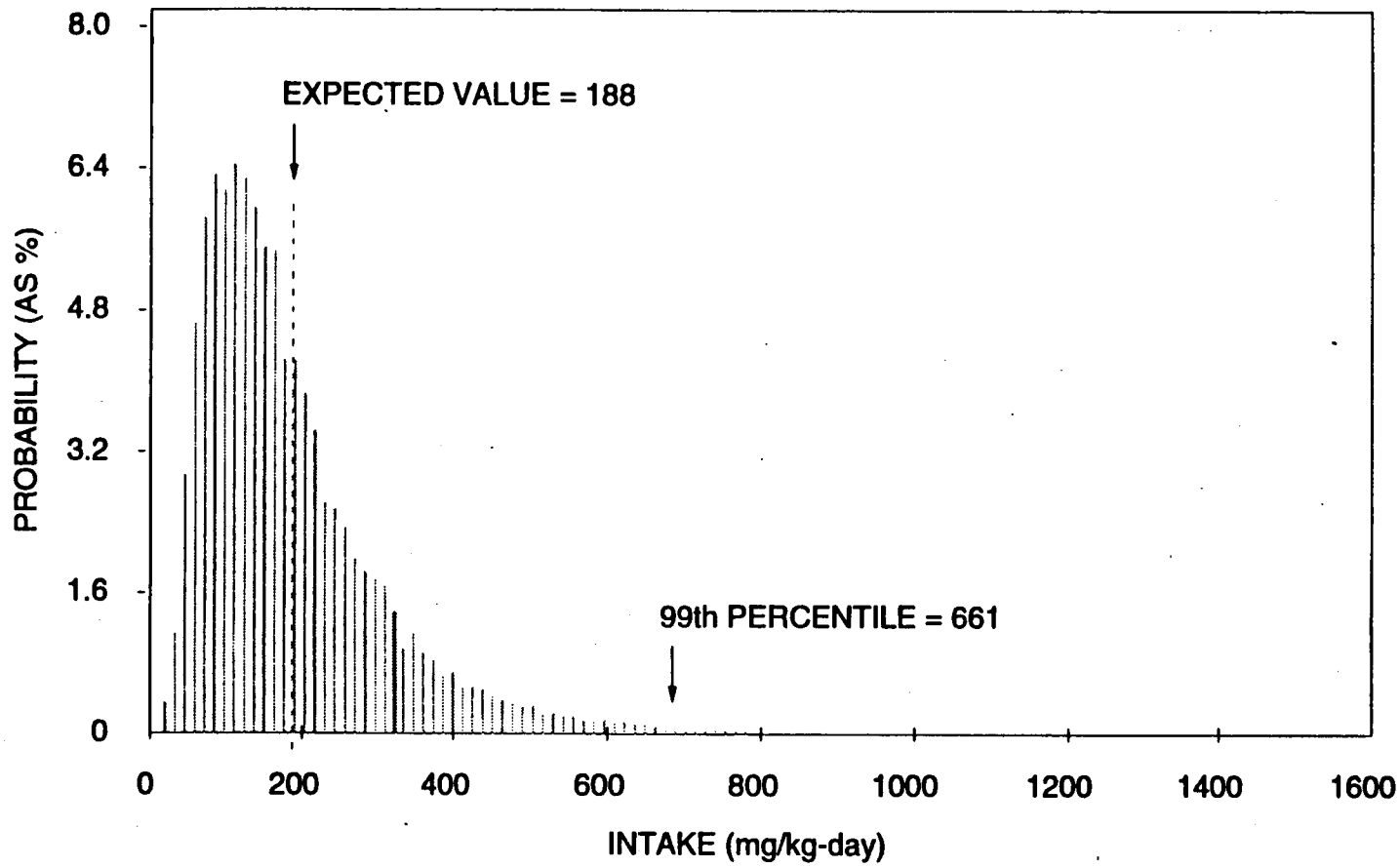

FIGURE 4.19
PROBABILITY DISTRIBUTION OF SULFATE INTAKES
SALT LAKE CITY, UTAH, SITE

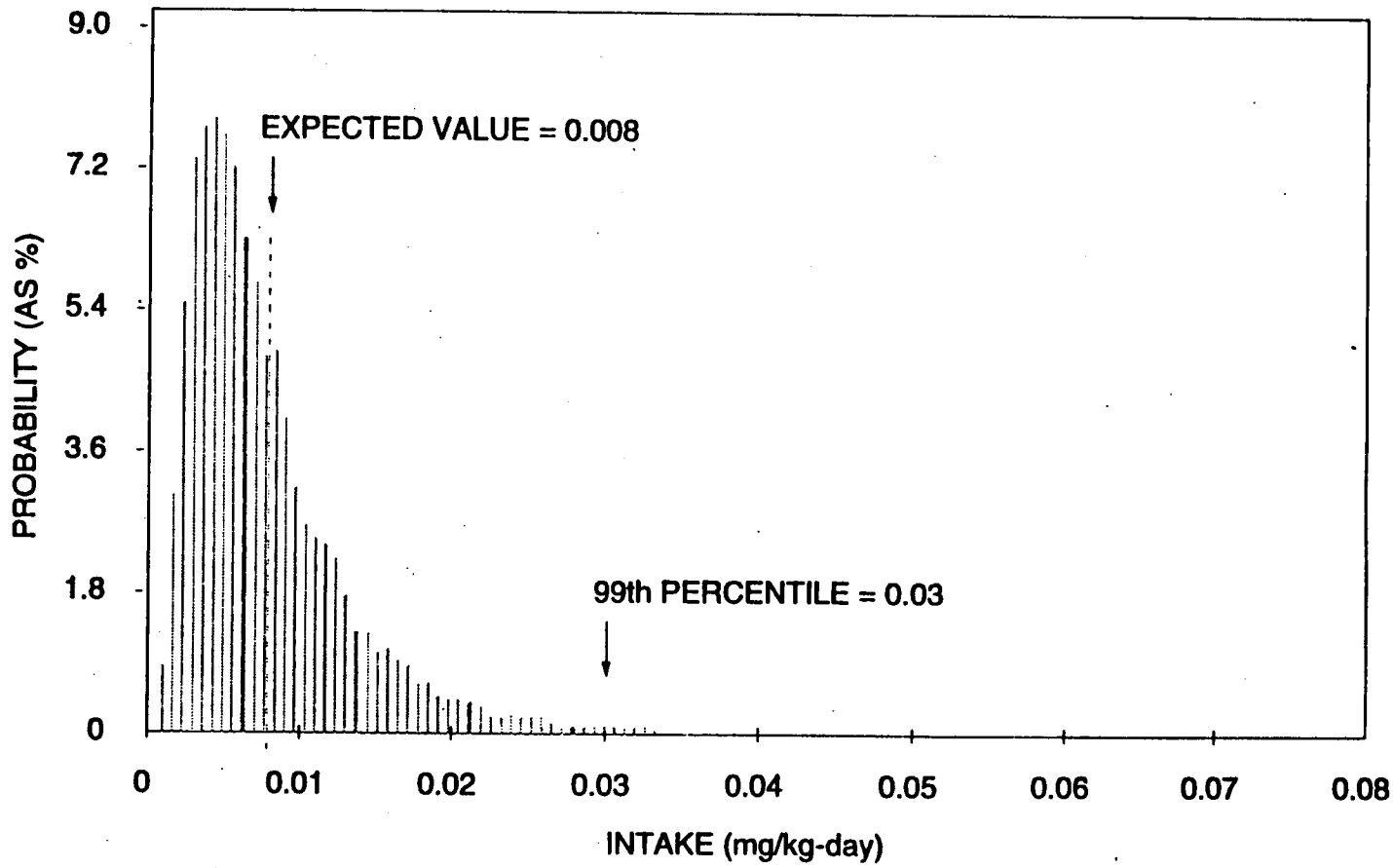

FIGURE 4.20
PROBABILITY DISTRIBUTION OF URANIUM INTAKES
SALT LAKE CITY, UTAH, SITE

PATH I:\FL3.01\SLCBRA

URA1_10.DRW

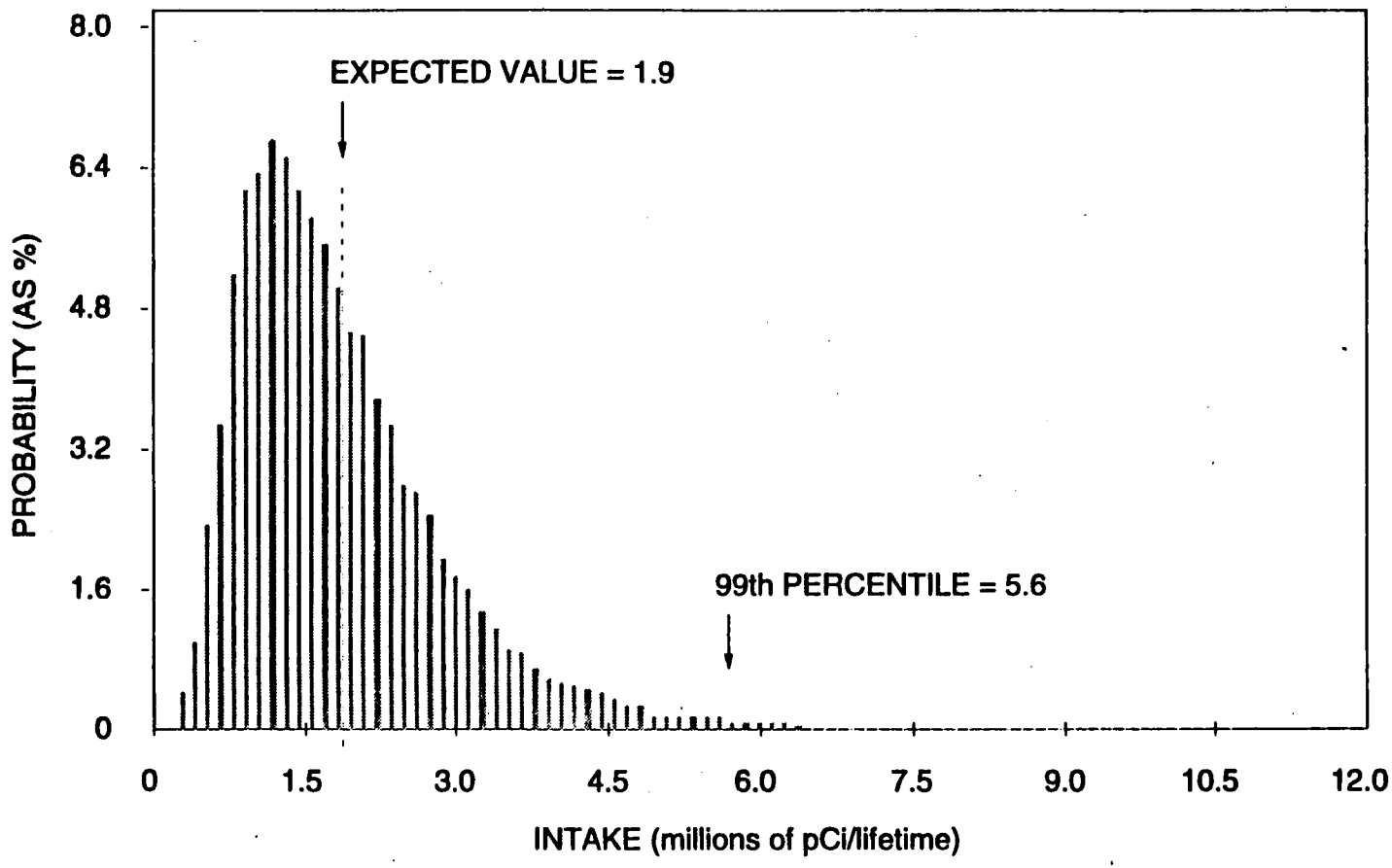

FIGURE 4.21
PROBABILITY DISTRIBUTION OF URANIUM-234 AND URANIUM-238 INTAKE OVER A LIFETIME
SALT LAKE CITY, UTAH, SITE

5.0 TOXICITY ASSESSMENT

Several contaminants that could adversely affect health and the environment have been detected in ground water at the site.

The following source materials were used to develop toxicological profiles on these chemical contaminants and the potentially carcinogenic radionuclides: Integrated Risk Information System (IRIS) (EPA, 1994a); the Agency for Toxic Substances and Disease Registry Toxicological Profiles published by the Department of Health and Human Services (DHHS); the *Handbook on the Toxicology of Metals* (Friberg et al., 1986); and peer-reviewed scientific literature when these review documents were not available. Basing toxicity information on the standardized review documents cited above ensures consistency in risk evaluation at all UMTRA sites.

The toxicity profiles presented here focus on drinking water data in humans, including animal information only when human data are not available. Animal data are represented on the toxicity range graphs by widely spaced, dotted lines. Uncertainty about the beginning or ending point of an exposure range that produces specific toxic effects is represented by closely spaced dots.

5.1 CONTAMINANT TOXICITY SUMMARIES

The following paragraphs address the basic toxicokinetics and toxicity of the 12 contaminants of potential concern at the Salt Lake City uranium processing site. The contaminants of potential concern are chloride, fluoride, magnesium, manganese, molybdenum, sodium, sulfate, uranium and its decay products (radium-226, lead-210, polonium-210, and thorium-230). Although the toxic effects of these contaminants vary with exposure levels, toxic effects observed in the exposure range most relevant to contamination at this site are discussed in this report.

5.1.1 Chloride

Absorption, tissue accumulation, and clearance

Chloride is rapidly and fully absorbed from the gastrointestinal tract. The chloride concentration in the human body is approximately 2000 mg/kg of fat-free body mass in newborns and 1920 mg/kg in adults (National Research Council, 1980). Chloride occurs in plasma at concentrations of 96 to 106 milliequivalents per liter (meq/L) (3400 to 3800 mg/L) and in a more concentrated form in cerebrospinal fluid and gastrointestinal secretions (National Research Council, 1989). Its concentration in most cells is low. The daily chloride turnover in adults (intake/output) ranges from 3000 to 8900 mg. Chloride is excreted mainly through urine, with appreciable amounts also excreted in feces, sweat, and tears.

Environmental sources of chloride

Dietary chloride comes almost entirely from sodium chloride (National Research Council, 1989). Much smaller amounts are supplied from potassium chloride. Thus, dietary sources of chloride (processed foods) essentially are the same as those for sodium. Rich sources of chloride are salt, cereals, breads, dried skim milk, teas, eggs, margarine, salted butter, bacon, ham, corned beef, canned meats, fish and vegetables, salted snack foods, and olives. Dietary chloride intake varies largely with salt intake. Estimates range from 2400 to 14,400 mg chloride/day from sodium chloride (equivalent to 34 to 206 mg/kg-day for a 70-kg man).

Human breast milk contains 11 meq/L of chloride (391 mg/L); a similar level has been suggested by the American Academy of Pediatrics for infant formulas (National Research Council, 1989).

Chloride is found in all natural water. Surface water contains only a few milligrams of chloride per liter, whereas streams in arid or semiarid regions contain several hundred milligrams per liter, especially in drained areas where chlorides occur in natural deposits or are concentrated from soils through evaporation. Contamination with sewage increases the chloride content of river water. Ground water usually contains larger quantities of chloride than surface water. Some public supply wells may contain 100 mg/L of chloride (about 3 mg/kg-day, assuming 2 L of water are consumed per 70 kg of body weight) (National Research Council, 1980).

A typical chloride concentration in drinking water of about 21 mg/L would contribute 0.6 mg/kg-day (assuming 2 L per day consumption rate and 70 kg of body weight), or about 2 percent of the lower estimates of total chloride intake.

The recommended drinking water level for chloride is 250 mg/L (equivalent to 7 mg/kg-day, for a 70-kg man consuming 2 L of water per day) (National Research Council, 1980). This amount of chloride in drinking water can cause an objectionably salty taste in water. The taste threshold for the chloride anion in water varies from 210 to 310 mg/L.

Toxicity of chloride

Chloride is an important inorganic anion in the extracellular fluid compartment. It is essential in maintaining fluid and electrolyte balance and is a necessary component of gastric juice.

Chloride loss from the body generally parallels sodium loss. Thus, conditions associated with sodium depletion (e.g., heavy, persistent sweating; chronic diarrhea or vomiting; trauma; renal disease) will also cause chloride loss, resulting in hypochloremic metabolic alkalosis.

Although the basic need for chloride is generally recognized, a recommended daily allowance (RDA) has not been determined. The estimated minimum requirement for healthy persons ranges from 180 mg/day for infants to 750 mg/day for adults (National Research Council, 1989).

The toxicity of salts containing the chloride ion depends primarily on the characteristic of the cation (National Research Council, 1980; 1989).

Large amounts of chloride intake may cause an increased chloride plasma concentration and a decreased bicarbonate plasma concentration, with an acidifying effect. This reaction results in hyperkalemic metabolic acidosis (National Research Council, 1980). When metabolic acidosis develops, potassium leaves the cells and is excreted by the kidney (Brater, 1992).

The only known dietary hyperchloremia results from water-deficiency dehydration. Sustained ingestion of high levels of chloride (as salt) is associated with hypertension in sensitive individuals and in animal models. Although the level of chloride attributable to hypertension has not been determined, it may be estimated based on the level of sodium intake (from sodium chloride) causing hypertension in approximately 15 percent of adults (Freis, 1976). This indirectly estimated amount of chloride presumably associated with hypertension in sensitive individuals would be in the range of 36 to 180 mg/kg-day.

Figure 5.1 shows the toxicity of chloride as a function of dose.

5.1.2 Fluoride

Absorption

Fluorides in water are absorbed primarily from the gastrointestinal tract, with the degree of fluoride absorption depending on the solubility of a particular fluoride compound.

Fluoride is absorbed differently from food and drinking water. The absorption of fluoride from water is estimated to be 100 percent, while protein-binding in food sources reduces dietary fluoride absorption. Fluoride absorption from milk or baby formula is determined to be only 72 and 65 percent, respectively, of that from water (National Research Council, 1989). Poorer absorption, from 37 to 54 percent, has been reported for the fluorine in bone meal.

Tissue accumulation and clearance

Fluoride has been detected in all organs and tissues. Following gastrointestinal absorption, fluoride is distributed primarily to bones and is deposited in the skeleton and tooth enamel with lesser deposition in the thyroid, aorta, and kidney (Gilman et al., 1990; National Research Council, 1989). The degree of skeletal storage is related to intake and age. Storage in bone is thought to be a function of the turnover rate of skeletal components, with growing bone

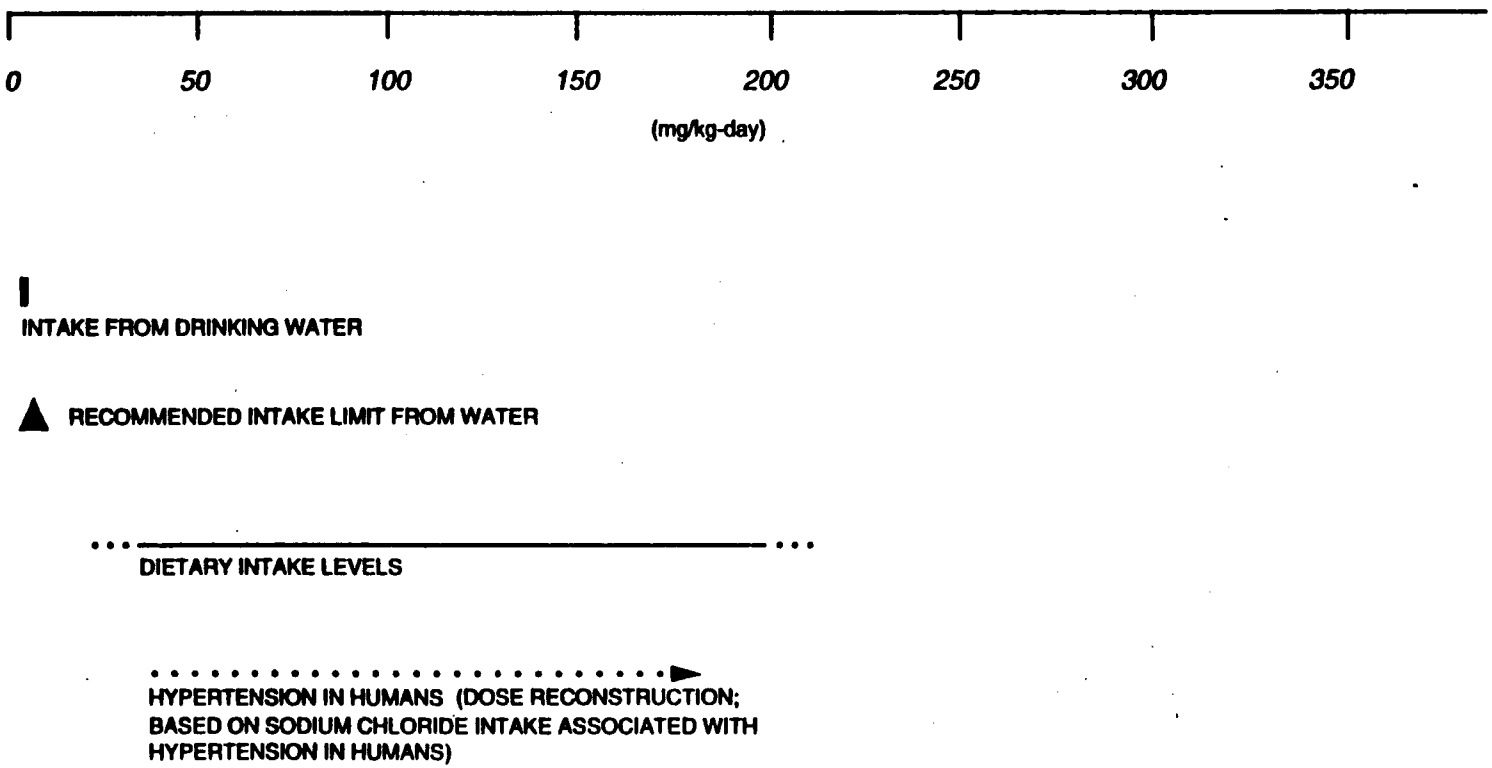

FIGURE 5.1
CHLORIDE T[illegible]ITY RANGES

MAC: SITE/SL[illegible]/CHL-GEN

showing a greater fluoride deposition than mature organisms. Prolonged periods of time are required for mobilization of fluoride from bone. The half-time for turnover in the young adult skeleton is about 8 to 10 years (Maheshwari et al., 1981).

The major route of fluoride excretion is the kidney. However, fluoride is also excreted in small amounts through the sweat glands, breast milk, and the gastrointestinal tract. Under conditions of excessive sweating, the fraction of total fluoride excretion contributed by sweating can reach nearly one half (Gilman et al., 1990). About 70 percent of the ingested fluoride is excreted in urine, and about 5 percent of that retained and absorbed is excreted in the feces (Maheshwari et al., 1981). About 90 percent of the fluoride filtered by the glomerulus is reabsorbed by the renal tubules (Gilman et al., 1990).

Environmental sources of fluoride

Drinking water and food are the primary sources of fluoride intake by humans. Drinking water, whether fluoridated or not, can contribute considerably to the total daily fluoride intake. In fluoridated areas, the contribution ranges from about 26 to 54 percent of the total intake (National Research Council, 1980). In unfluoridated areas, it ranges from about 14 to 48 percent.

Most public water supplies contain fluoride, and the majority contain less than 1 mg/L (0.04 mg/kg-day for a 25-kg child ingesting 1 L of water per day or 0.03 mg/kg-day for a 70-kg adult ingesting 2 L of water per day) (National Research Council, 1980). Fluoride concentrations in river water may be up to 6.5 mg/L. The concentrations in lakes may be up to 1627 mg/L. The average fluoride concentration of sea water is 1.2 mg/L.

The richest dietary sources of fluoride are tea and marine fish consumed with their bones (National Research Council, 1989). In the United Kingdom, tea accounted for 72 percent (1.3 mg) of the total adult daily intake of 1.8 mg (National Research Council, 1989). The fluoride content of cow's milk is approximately 0.02 mg/L. Mean reported values for human milk range from 0.005 to 0.025 mg/L, depending on maternal intake (mothers were drinking water containing 0.2 and 1.7 mg/L, respectively). Dietary fluoride intake up to 3.44 mg/day (0.05 mg/kg-day for a 70-kg adult) has been reported in some areas of the United States (National Research Council, 1980). An average fluoride dietary intake of 0.01 mg/kg-day has been reported for both a 20-kg child and a 70-kg adult (EPA, 1994a).

Food processing substantially influences the fluoride content of foods. The fluoride content of many foods can increase severalfold by cooking in fluoridated water. Cooking in utensils treated with Teflon®, a fluoride-containing polymer, can increase the fluoride content, whereas an aluminum surface can reduce it (National Research Council, 1989).

The estimated safe and adequate daily dietary intake (ESADDI) of fluoride for adults is 1.5 to 4.0 mg/day (equivalent to 0.02 to 0.06 mg/kg-day for a 70-kg man) (National Research Council, 1989). This range accounts for widely varying

fluoride concentrations consumed in the United States and includes both food sources and drinking water. For younger age groups, the estimated maximum level of this intake is 2.5 mg/day (equivalent to 0.1 mg/kg-day for a 25-kg child). Ranges of 0.1 to 1 mg/day during the first year of life (equivalent to 0.03 to 0.3 mg/kg-day for a 4-kg infant), and 0.5 to 1.5 mg/day during the subsequent 2 years, are suggested as adequate and safe (National Research Council, 1989).

In view of fluoride's beneficial effects on dental health and its suggested safety at the ESADDI levels, the Food and Nutrition Board recommends fluoridation of public water supplies if natural fluoride levels are substantially below 0.7 mg/L (National Research Council, 1989).

Toxicity of fluoride

Although at low doses fluoride can have beneficial effects on teeth and bone, at higher doses fluoride can be toxic. Children are particularly sensitive to dental fluorosis, the critical toxic effect of fluoride (EPA, 1994a). Fluoridation of water to a concentration of 1 mg/L (0.04 mg/kg-day for a 25-kg child assuming ingestion of 1 L of water) is established as a safe and practical public health measure that results in a substantial reduction in the incidence of caries in permanent teeth (Gilman et al., 1990). Fluoride is also used to treat osteoporosis in larger doses than those used to prevent dental caries (Maheshwari et al., 1981). However, the optimal level of fluoride intake for osteoporosis therapy is not determined.

Fluoride is an inhibitor of several enzyme systems and diminishes tissue respiration and anaerobic glycolysis. It also binds Ca(+2), and inhibits the glycolytic utilization of glucose by erythrocytes (Gilman et al., 1990).

Acute fluoride poisoning usually results from accidental ingestion of insecticides or rodenticides containing fluoride salts (Gilman et al., 1990). The lethal dose of fluoride for a 70-kg adult is approximately 32 mg/kg.

In man, the major manifestations of chronic ingestion of excessive amounts of fluoride are dental fluorosis (mottled enamel) and osteosclerosis (crippling skeletal fluorosis) (Gilman et al., 1990; National Research Council, 1989; Casarett and Doull, 1991). Long-term exposure to excess fluoride causes increased osteoblastic activity (a process of bone development).

In very mild tooth mottling, the gross changes consist of small, opaque, paper-white areas scattered irregularly over the tooth surface. In severe cases, discrete or confluent, deep brown- to black-stained pits give the tooth a corroded appearance.. Mottled enamel or dental fluorosis is the result of a partial failure of the enamel-forming cells to elaborate properly and lay down enamel. It is a nonspecific response to several stimuli, one of which is excessive fluoride ingestion.

Because mottled enamel is a developmental disease, fluoride ingestion following tooth eruption has no effect on the disease (Gilman et al., 1990). Mottling is one of the first visible signs of excessive fluoride intake during childhood. Continuous use of water containing about 0.7 to 1.3 mg fluoride/L (equivalent to 0.03 to 0.05 mg/kg-day for a 25-kg child, assuming ingestion of 1 L of water per day), depending on ambient temperature and diet, produces dental mottling and changes in tooth structure in 10 percent of children (National Research Council, 1980; Gilman et al., 1990). These effects were evaluated as the very mildest form of mottled enamel. At fluoride levels of 4 to 6 mg/L (0.16 to 0.24 mg/kg-day for a 25-kg child, assuming ingestion of 1 L of water) the incidence reaches 100 percent, with marked increase in severity.

In osteosclerosis, as opposed to osteoporosis, bone density and calcification increases. Fluoride intoxication is thought to represent the replacement of hydroxyapatite by the denser fluorapatite. However, the mechanism of its development is unknown. The degree of skeletal involvement varies from changes that are barely detectable radiologically to marked thickening of the cortex of the long bones, numerous exostoses scattered throughout the skeleton, and calcification of ligaments, tendons, and muscle attachments to bone. In its severest form, osteosclerosis is a disabling disease and is designated as crippling fluorosis. It has been estimated that the development of crippling skeletal fluorosis in humans requires daily ingestion of 20 to 80 mg fluoride (0.29 to 1.1 mg/kg-day for a 70-kg adult) over a 10- to 20-year period (National Research Council, 1980; 1989; EPA, 1994a). Although the no observed adverse effect level (NOAEL) for crippling skeletal fluorosis in humans is unknown, a safe total fluoride exposure level (from food and drinking water) for adults is suggested to be 0.12 mg/kg-day. This exposure level corresponds to the consumption of 2 L of water per day containing 4 mg fluoride/L by a 70 kg adult and ingestion of 0.01 mg fluoride per day in the diet.

The EPA oral reference dose (RfD) of 0.06 mg/kg-day was developed based on the NOAEL of 1 mg fluoride per liter of drinking water, determined in children from 12 to 14 years old, and the assumption that a 20-kg child consumes 0.01 mg fluoride/kg-day in the diet (EPA, 1994a).

Figure 5.2 shows the health effects of fluoride as a function of dose.

5.1.3 Magnesium

Absorption

Ingested magnesium is absorbed mainly in the small intestine. Absorption of dietary magnesium has been determined to be 30 to 40 percent. Calcium and magnesium are competitive with respect to their absorptive sites, and excess calcium may partially inhibit magnesium absorption (Aikawa, 1963).

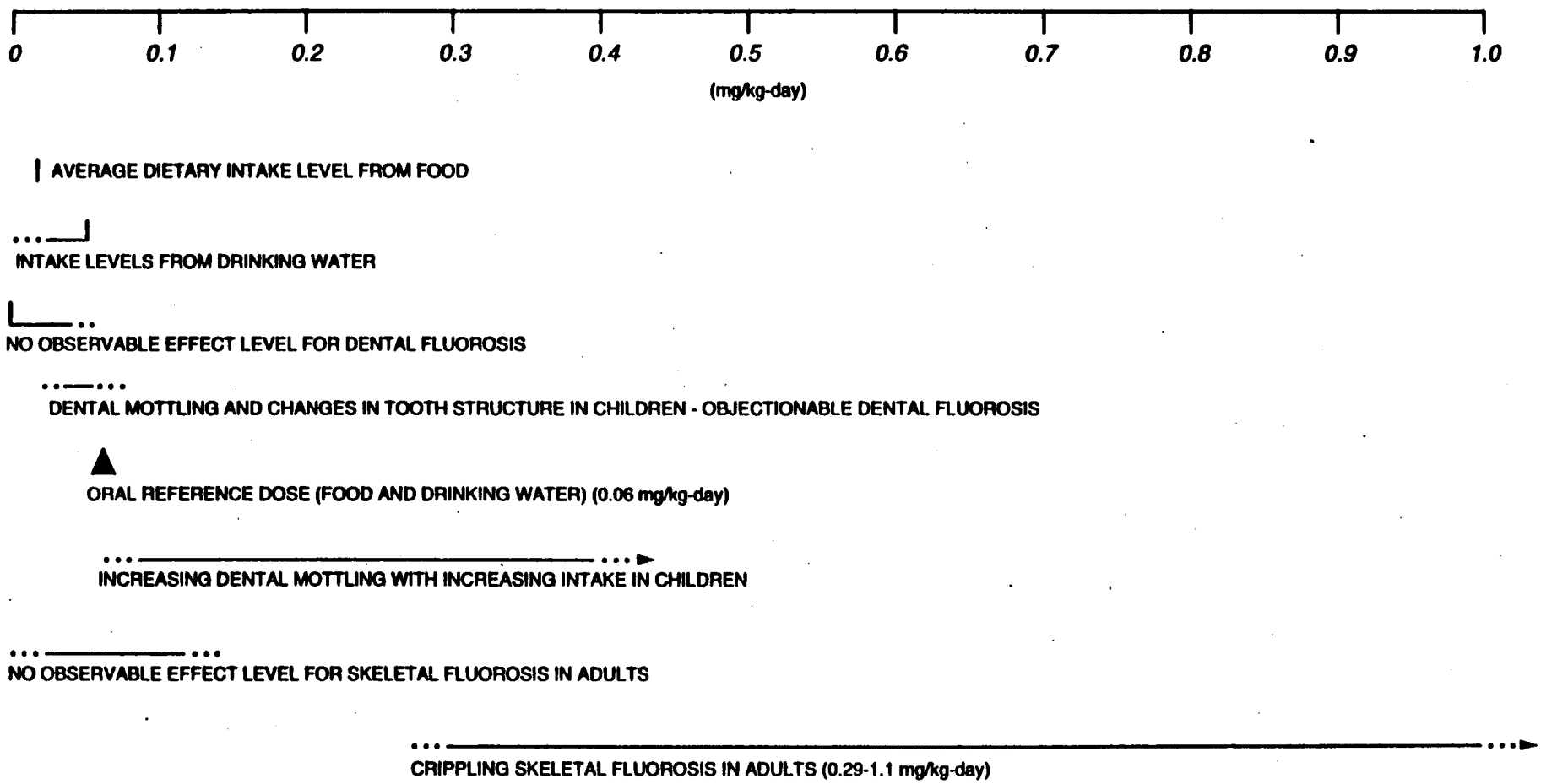

FIGURE 5.2
FLUORIDE T[illegible]CITY RANGES

MAC: SITE/SL[illegible]A/FLR-GEN

Tissue accumulation and clearance

Most magnesium in the body is in the bones. Bone magnesium seems to be a reservoir, ensuring that some magnesium will be on hand for vital reactions, regardless of dietary intake. Magnesium, a principal intracellular cation of soft tissue, is mainly a cofactor in enzymatic reactions associated with the metabolism of carbohydrates and proteins. It is also involved in neurochemical transmission and neuromuscular excitability (AHFS, 1991).

The major excretory pathway for absorbed magnesium is the kidney. In subjects on a normal diet, one-third or less of the ingested magnesium is excreted by the kidney and approximately two-thirds is excreted in the feces.

Environmental sources of magnesium

Magnesium is readily available in food, particularly nuts, cereals, seafood, and meats. The average city water supply contains about 6.5 mg/L of magnesium, but amounts vary considerably, increasing with the hardness of the water.

The magnesium RDA ranges from 4.5 to 6.7 mg/kg-day. In the United States, the average adult ingests between 240 and 480 mg of magnesium daily (from 3.4 to 6.9 mg/kg-day).

Toxicity of magnesium

Available data on human chronic magnesium toxicity following ingestion is limited. It has been reported that therapeutic doses of ingested magnesium as low as 6.9 mg/kg-day may have a laxative effect (AHFS, 1991).

In patients with severe renal impairment, hypermagnesemia (characterized by hypotension, nausea, vomiting, electrocardiogram changes, respiratory or mental depression, and coma) has occurred after administration of antacids containing magnesium (AHFS, 1991). However, the threshold dose level for these side effects has not been reported. Figure 5.3 summarizes the health effects of exposure to magnesium as a function of dose.

5.1.4 Manganese

Absorption

Following ingestion, manganese absorption is homeostatically controlled: the absorption rate depends on both the amount ingested and the existing manganese levels in tissue. Adults absorb approximately 3 to 4 percent of dietary manganese (Saric, 1986). Manganese can be absorbed following exposure by inhalation, ingestion, and dermal contact. In humans, available data indicate that only 3 percent of an ingested dose of manganese chloride is absorbed (Mena et al., 1969). Manganese in water appears to be more efficiently absorbed than

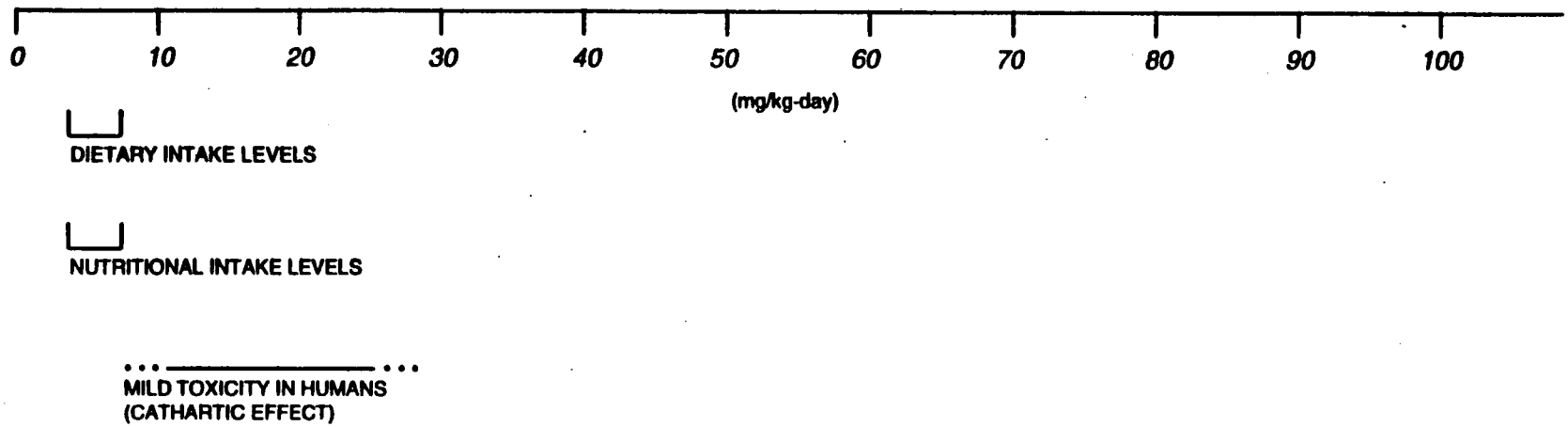

FIGURE 5.3
MAGNESIUM T[illegible]CITY RANGES

manganese in foodstuff (EPA, 1994a). The absorption rate is influenced by iron and other metals. In states of iron deficiency, manganese is actively absorbed from the intestine. Individuals with anemia can absorb more than twice the percentage of an ingested dose. However, in states of excess iron, manganese absorption is by diffusion only (Saric, 1986). High levels of dietary calcium and phosphorus are shown to increase the requirements for manganese in several species (Lönnerdal et al., 1987).

Tissue accumulation and clearance

Absorbed manganese is widely distributed throughout the body. The highest concentrations are found in the liver and kidney. The manganese elimination half-time from the human body is 2 to 5 weeks, depending on body stores. Manganese readily crosses the blood-brain barrier and is more slowly cleared from the brain than from other tissue (Goyer, 1991). Normal concentrations in the brain are low, but the half-time in the brain is longer and the metal may accumulate in the brain with excessive absorption (National Research Council, 1973).

Absorbed manganese is rapidly eliminated from the blood and concentrates in mitochondria. Initial concentrations are greatest in the liver. Manganese penetrates the placental barrier in all species and is more uniformly distributed throughout the fetus than in adults. It is secreted into milk.

Absorbed manganese is almost totally secreted in bile and reabsorbed from the intestine as needed to maintain body levels. At excessive exposure levels, other gastrointestinal routes may participate. Excess manganese is eliminated in the feces; urinary excretion is negligible (Goyer, 1991; Saric, 1986).

Environmental sources of manganese

On the whole, food constitutes the major source of manganese intake for humans. The highest manganese concentrations are found in plants, especially wheat and rice. Drinking water generally contains less than 0.1 mg/L. Manganese levels in soil range from 1 to 7000 mg/kg, with an average of 600 to 900 mg/kg. Mining and natural geological background variations contribute to this variability. Manganese bioaccumulates in marine mollusks up to 12,000-fold, and there is evidence for toxic effects in plants (phytotoxicity) and plant bioaccumulation. The Illinois Institute for Environmental Quality has recommended a criterion of 1 to 2 mg/kg for manganese in soil and 200 mg/kg in plants (Saric, 1986).

Variations in manganese intake can be explained to a large extent by differences in nutritional habits. In populations using cereals and rice as main food sources, the intake will be higher than in areas where meat and dairy products are a larger part of the diet. The average daily intake has been estimated to be between 2.0 to 8.8 mg/day (0.03 to 0.13 mg/kg-day) (EPA, 1994a), but intakes as high as

12.4 mg (about 0.2 mg/kg-day) are reported in countries with high cereal intake (Saric, 1986).

Drinking water generally results in an intake of less than 0.2 mg (0.003 mg/kg-day), although some mineral waters can increase this amount by more than threefold (Saric, 1986). One study from Greece reported drinking water concentrations of manganese in excess of 2 mg/L, which would result in daily intakes in the range of 0.06 to 0.07 mg/kg-day (EPA, 1994a).

Toxicity of manganese

Manganese is an essential nutrient. The estimated safe and adequate daily dietary intake ranges from 0.03 to 0.07 mg/kg-day for adults (Saric, 1986). The EPA no-observed-adverse-effect level (NOAEL) for drinking water is identified at 0.005 mg/kg-day, while the lowest-observed-adverse-effect level (LOAEL) for drinking water is 0.06 mg/kg-day (EPA, 1994a). The EPA RfD for drinking water of 0.005 mg/kg-day is based on human data (Kondakis et al., 1989). The study group was a population of older adults exposed to manganese in drinking water for one lifetime; because this population was considered sensitive, an uncertainty factor of 1 was applied (EPA, 1994a). The RfD for ingested food is 0.14 mg/kg-day. Manganese in drinking water may be more bioavailable (i.e., more readily absorbed) than manganese in dietary food sources. This bioavailability would result in toxic effects at lower ingested doses in drinking water than in food (EPA, 1994a).

Industrial settings are the largest source of data on chronic manganese toxicity. The data indicate that inhalation of manganese can result in a central nervous system disorder characterized by irritability, difficulty in walking, speech disturbances, and compulsive behavior that may include running, fighting, and singing. With continued exposure, this condition can progress to a mask-like face, retropulsion or propulsion, and a Parkinson-like syndrome. These effects are largely irreversible, although some recovery can be expected when exposure ceases (DHHS, 1992b). Metal-chelating agents are ineffective in treatment, but L-dopa has been effective in treatment (Goyer, 1991).

Information on the effects of manganese ingestion is limited. Because effects from manganese in drinking water can appear at lower manganese levels than in food sources, only studies on water consumption will be considered here. A Japanese study of 25 people drinking well water with manganese concentrations of 14 mg/L (0.4 mg/kg-day estimated intake) reported symptoms of intoxication, including a mask-like face, muscle rigidity and tremors, and mental disturbances. Two deaths (8 percent) occurred among the intoxicated people. A Greek study of more than 4000 adults at least 50 years old drinking water with manganese concentrations varying from 0.081 to 2.3 mg/L (estimated intakes at 2 L/day for a 70-kg individual range from 0.002 to 0.07 mg/kg-day) showed varying degrees of neurological effects in individuals drinking from 0.007 to 0.07 mg manganese/kg-day, but no effects in individuals drinking less than 0.005 mg/kg-day (Kondakis et al., 1989). However, there are many limitations to

these studies that make data interpretation difficult. Among the limitations is uncertainty regarding the exposure level or whether the effects seen were solely attributable to manganese. Despite these limitations, the similarity of the effects seen in the cases of oral exposure compared with those associated with inhalation exposure suggests that excess manganese intake by humans might lead to neurological injury (DHHS, 1992b).

The chemical form of manganese has complex effects on its toxicity. Although the more soluble forms are more readily absorbed from the gastrointestinal tract, they also appear to be more rapidly cleared. Exposure to insoluble forms results in lower manganese absorption but higher chronic tissue levels and therefore greater toxicity (EPA, 1994a). Information on the effects of various forms of manganese is limited.

Few data are available on manganese toxicity in infants, but infants are probably more susceptible to manganese toxicity due to greater absorption and greater penetration into the central nervous system (EPA, 1994a; Saric, 1986). Figure 5.4 summarizes manganese toxicity as a function of dose.

5.1.5 Molybdenum

Absorption

Molybdenum absorption in the gastrointestinal tract depends on the species of the metal. Inorganic hexavalent forms such as molybdenum trioxide, sodium molybdate, and ammonium molybdate are readily absorbed from both food and water, whereas molybdenite is not. Based on the geochemical models for the Salt Lake City site, all of the molybdenum exists in the form of well absorbable molybdate in ground water (Table 3.6). Human absorption rates of 40 to 70 percent have been observed for the soluble forms of molybdenum (Tipton et al., 1969; Robinson et al., 1973; Alexander et al., 1974).

Tissue accumulation and clearance

In humans, the highest concentrations of molybdenum occur in the liver, kidney, and adrenals (Casarett and Doull, 1991). With normal dietary intake, molybdenum levels in the body slowly increase until approximately age 20, then begin to decline steadily. Urine is the principal excretion route in humans. Human studies indicate that the biological half-life in humans is considerably longer than in animals and may be as long as 2 weeks (Rosoff and Spencer, 1964).

Environmental sources of molybdenum

Molybdenum occurs naturally in combination with other metals, including uranium, lead, iron, cobalt, and calcium. Native soil concentrations can vary by as much as 2 orders of magnitude, from 0.1 to 10 mg/kg, leading to large

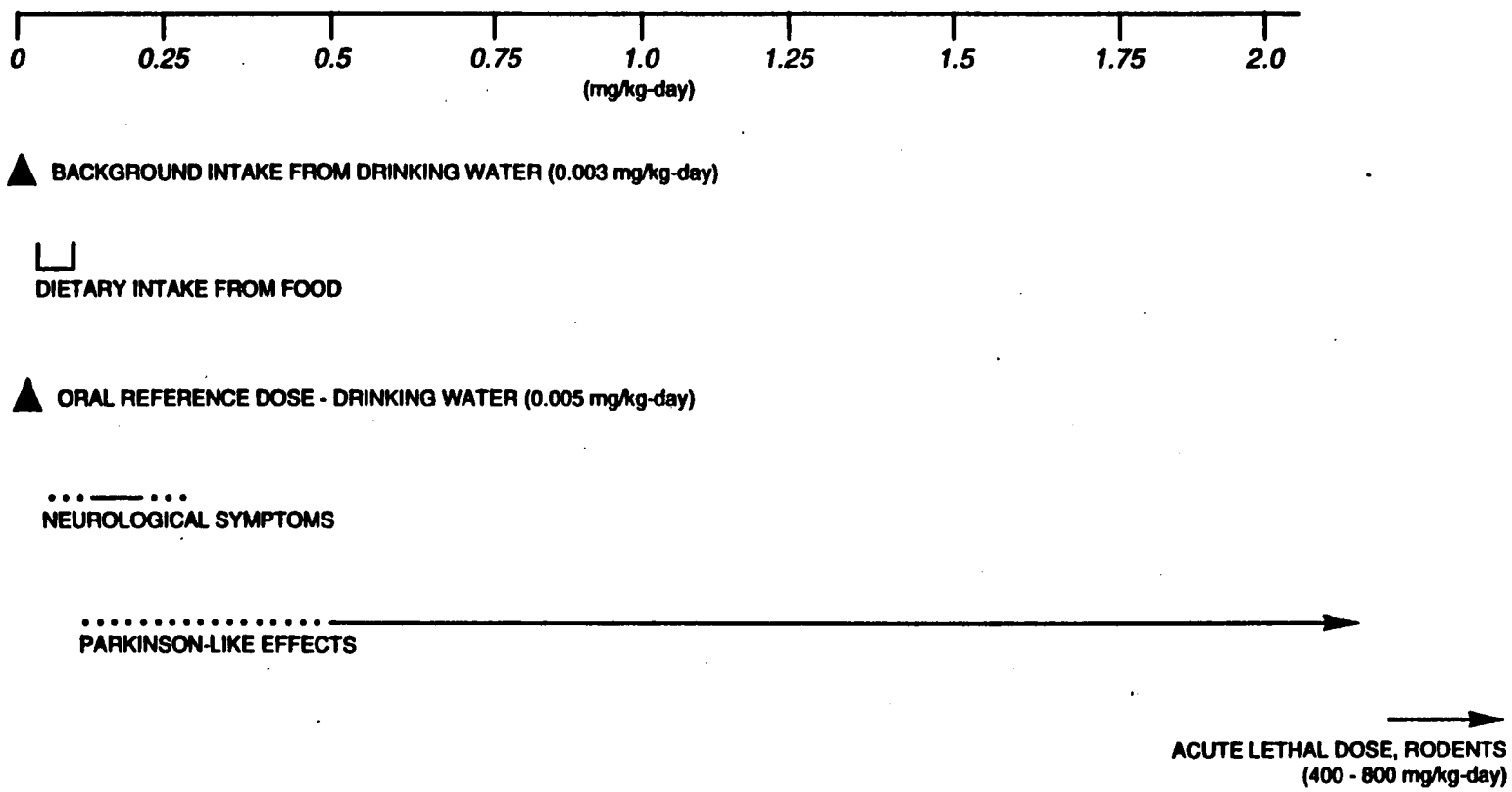

FIGURE 5.4
MANGANESE T ICITY RANGES

MAC: SITE/SL /MAN-GEN

variations in molybdenum concentrations in plant materials. Natural concentrations in ground water are reported from 0.00011 to 0.0062 mg/L. Human dietary intake of molybdenum is estimated at 0.05 to 0.24 mg/day (0.0007 to 0.003 mg/kg-day). The contribution of drinking water is estimated to range from 0 to 95 percent. The nutritional intake range for molybdenum is from 0.0015 to 0.0054 mg/kg-day. No symptoms of molybdenum deficiency have been reported in humans. Nonetheless, molybdenum is an essential trace element that functions as a necessary constituent of several enzymes, including xanthine oxidase (which is involved in the metabolism of uric acid) and nitrate reductase (Friberg et al., 1986).

Toxicity of molybdenum

Acute toxic effects of molybdenum have not been reported. No adverse health effects have been reported with a chronic intake of less than 0.008 mg/kg-day of molybdenum (EPA, 1994a). Molybdenum toxicity primarily is related to its interactions with copper and sulfur, leading to altered excretion patterns for these elements. Increased levels of molybdenum also increase the levels of xanthine oxidase, which is responsible for the production of uric acid. Uric acid can accumulate in joints, leading to symptoms of gout and other joint disorders.

A molybdenum intake of 0.008 to 0.022 mg/kg-day can produce a mineral imbalance as a result of increased copper excretion (EPA, 1994a). Copper excretion is reported to double with molybdenum intake at the upper end of this range. Copper is an essential nutrient important in many metabolic pathways, including the synthesis and function of hemoglobin. A copper deficiency resulting from excess excretion will impair the oxygen-carrying capacity of the blood, and severe copper deficiencies can lead to hypochromic microcytic anemia. In humans, gout-like symptoms and joint deformities have been reported in regions of Russia where elevated molybdenum concentrations in soil, and the resulting increased molybdenum concentrations in food, lead to molybdenum intakes in the range of 0.14 to 0.21 mg/kg-day. The EPA oral reference dose of 0.005 mg/kg-day for molybdenum was derived from results of these studies (EPA, 1994a). An uncertainty factor of 30 was used for two reasons: to protect the sensitive human population and to use the lowest-observed-adverse-effect level (LOAEL) of 0.14 mg/kg-day) rather than the preferred no-observed-adverse-effect level (NOAEL), which should be identified from a long-term study in a human population. Figure 5.5 summarizes the health effects of molybdenum as a function of dose.

5.1.6 Sodium

Absorption

Sodium is rapidly and fully absorbed from the gastrointestinal tract. The skin and lungs also absorb sodium rapidly, by simple diffusion and ion exchange (National Research Council, 1980).

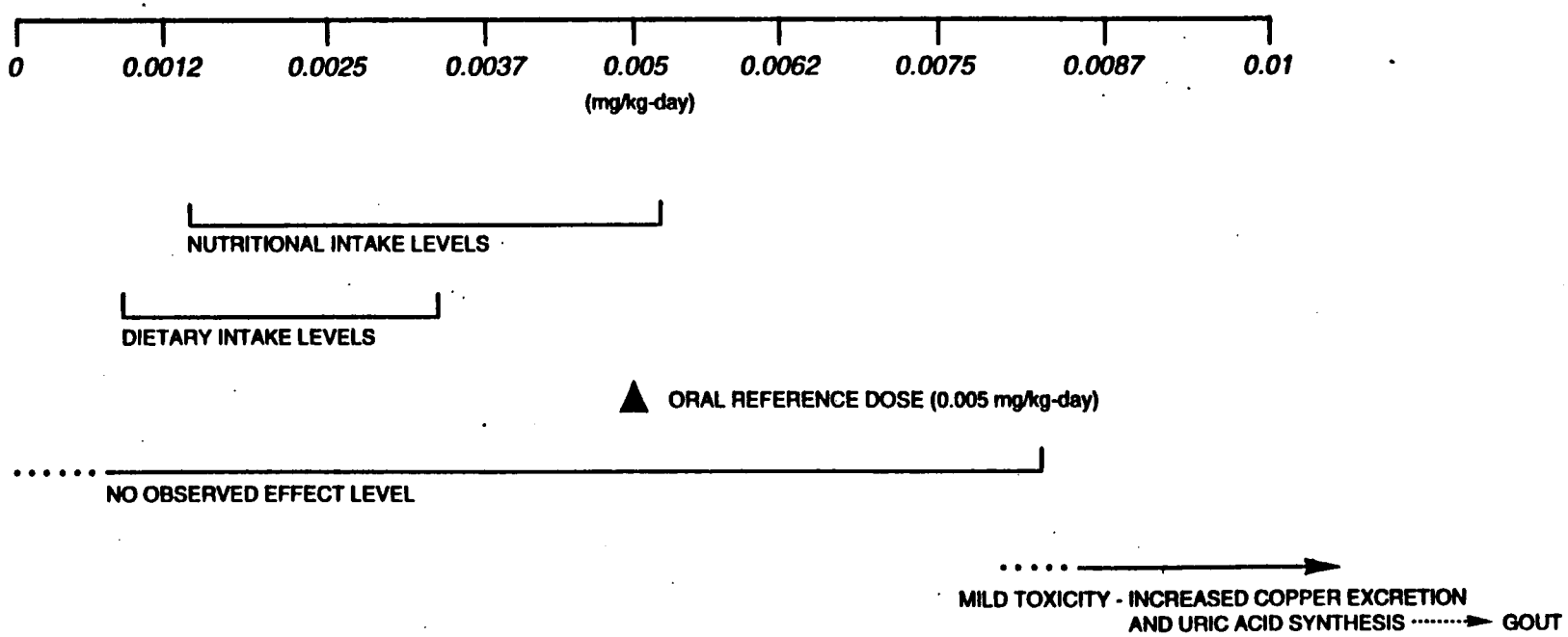

FIGURE 5.5
MOLYBDENU' OXICITY RANGES

MAC: SITE/... GRA/MOL-GEN

Tissue accumulation and clearance

Sodium is the major extracellular ion. The sodium ion is essential to the regulation of the acid-base balance and is an important contributor to extracellular osmolarity. It is an essential constituent in the electrophysiological functioning of cells and is required for impulse propagation in excitable tissues. Furthermore, sodium is essential for active nutrient transport, including the active transport of glucose across the intestinal mucosa. About 30 to 40 percent of the body's sodium is thought to be stored on the surfaces of the bone crystals, where it is easily recovered if blood sodium levels drop. Sodium is excreted mainly in urine, with appreciable amounts also excreted in feces, sweat, and tears (Venugopal and Luckey, 1978). Mammalian renal sodium excretion is a two-phase process involving glomerular filtration and reabsorption in proximal tubules; of about 600 grams of sodium involved in 24-hour glomerular filtration, approximately 99.5 percent is reabsorbed in human adults. A homeostatic mechanism for sodium functions at the renal excretory level.

Environmental sources of sodium

The total sodium intake is influenced mainly by the amount of salt (sodium chloride) added to food, the inherent salt content of the foods consumed, and the amount of other sodium salts in the diet and in medication. Sodium is a natural constituent of both vegetable and animal products in varying concentrations. Other sources of sodium are drinking water, cooking water, soft drinks, and alcoholic beverages.

At 2 months, infants consume approximately 300 mg of sodium a day; at 12 months, approximately 1400 mg/day. Human breast milk contains 161 mg/L, and cow's milk contains approximately 483 mg/L (Carson et al., 1986).

No RDA is set for sodium. The National Research Council recommends limiting daily sodium intake to less than 2400 mg (34 mg/kg-day); the American Heart Association recommends limiting dietary sodium intake to 3000 mg daily. A healthy person requires about 115 mg sodium daily (1.6 mg/kg-day), yet sodium dietary intake is estimated at 57 to 85 mg/kg-day. However, dietary sodium intakes as high as 134 mg/kg-day are reported (National Research Council, 1980).

The sodium content of drinking water is extremely variable. Analyses of water supply systems indicate sodium concentrations in 630 systems range from less than 1 to 402 mg/L (resulting in sodium intake from less than 0.03 to 11 mg/kg-day), with 42 percent greater than 20 mg/L and 3 percent over 200 mg/L (Carson et al., 1986).

Toxicity of sodium

Symptoms of acute sodium chloride toxicity accompanied by visible edema may occur in healthy adult males with an intake as low as 35 to 40 grams of salt per day (200 to 223 mg/kg-day, because sodium is 39 percent of the weight of sodium chloride) (Meneely and Battarbee, 1976). The mean lethal dose of sodium for humans is reportedly 3230 mg/kg (Venugopal and Luckey, 1978).

Epidemiological studies indicate that long-term, excessive sodium intake is one of many factors associated with hypertension in humans. A high sodium-to-potassium ratio in the diet may be detrimental to persons susceptible to high blood pressure. Some adults, however, tolerate chronic intake above 40 grams of sodium chloride per day (equivalent to 223 mg/kg-day) (Carson et al., 1986).

Research indicates that critical levels of sodium ingestion cause blood pressure to rise with age, leading to hypertension. Freis (1976) reports that with sodium intake below 227 mg/day (3 mg/kg-day for a 70-kg adult), hypertension was absent. In the range of 227 to 1591 mg/day (3 to 23 mg/kg-day for a 70-kg adult), a few cases of hypertension may appear, while in the range of 1591 to 8000 mg/day (23 to 114 mg/kg-day for a 70-kg adult), approximately 15 percent of adults exhibit hypertension. When sodium intake rises above 8000 mg/day, hypertension may be found in about 30 percent of the population. Because sodium chloride is present in nearly all processed and packaged foods, limiting dietary intake is difficult. The average daily dietary intake in the United States often causes hypertensive effects.

Drinking water generally contains relatively low levels of sodium and therefore does not substantially contribute to the total intake unless sodium is at higher-than-average levels in the water supply. However, people on sodium-restricted diets can obtain a considerable portion of daily sodium from drinking water. Because the kidney is the major organ involved in regulating sodium balance, individuals with compromised kidney function may be placed on a low-sodium diet. Other individuals may be on low-sodium diets to control hypertension. Because of the high prevalence of such individuals in our society, the American Heart Association has proposed that public drinking water supplies in the United States adopt a standard of 20 mg/L sodium (Calabrese and Tuthill, 1977). This standard measure would limit the additional intake of sodium from drinking water to approximately 0.6 mg/kg-day for a 70-kg adult. Figure 5.6 summarizes the potential health effects of sodium as a function of dose.

5.1.7 Sulfate

Absorption

Sulfate absorption from the gastrointestinal tract is similar in humans and other animals. Generally, greater than 90 percent absorption is reported for sulfate doses below 150 mg/kg, decreasing to 50 to 75 percent as the dose increases into the grams-per-kilogram range.

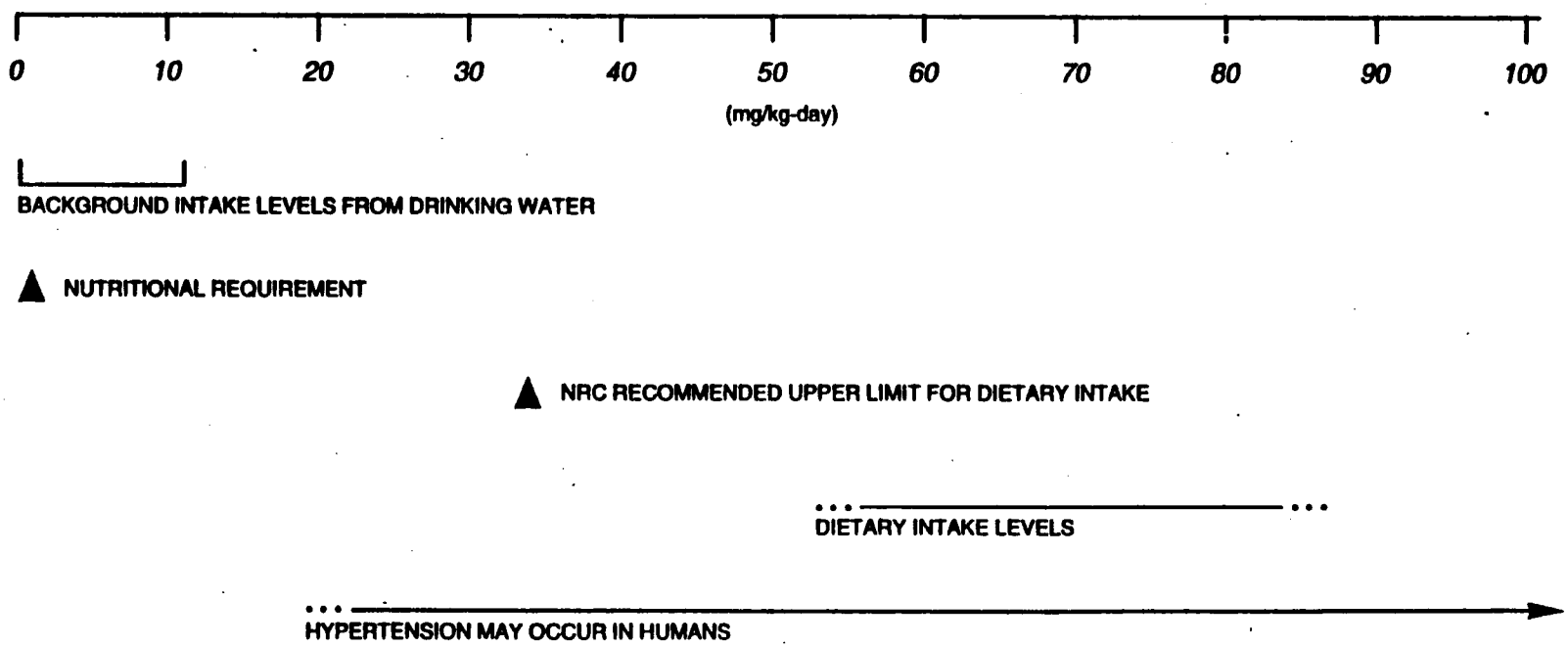

FIGURE 5.6
SODIUM TOXICITY RANGES

MAC: SITE/SLC/BRA/SOD-GEN

Tissue accumulation and retention

Ingesting high levels of sulfate results in transient increases in both blood and urine concentrations. Approximately 50 percent of a 75-mg/kg dose is excreted over 72 hours. The urinary excretion mechanism is transport-limited and can become saturated at high doses of sulfate. Excess sulfate is also excreted in feces in its inorganic form. To date, no data indicate that sulfate accumulates, even with chronic ingestion of above-normal levels. However, extremely high chronic doses have not been examined in humans.

Sulfate is used to biosynthesize collagen, cartilage, and dentin and to form sulfate esters of both endogenous compounds (such as lipids and steroids) and exogenous compounds (such as phenols). Sulfation is important in detoxication pathways because it increases the solubility of these compounds, enhancing their excretion in the urine. Exposure to high concentrations of compounds that are conjugated with sulfate and excreted can produce a transient decrease in plasma sulfate concentrations.

Environmental sources of sulfate

In 1978, drinking water sulfate concentrations in the western United States (EPA, 1992a) ranged from 0 to 820 mg/L, with a mean concentration of 99 mg/L. The EPA estimates a normal sulfate intake range of 0.00023 to 0.0064 mg/kg-day from air and up to 2.9 mg/kg-day from drinking water in the western United States. Estimates on sulfate intake from food are not available.

Toxicity of sulfate

The acute and chronic effects of sulfate toxicity differ more in severity than in symptoms or mechanisms. Therefore, this discussion will combine acute and chronic toxicity. As discussed above, no data indicate sulfate bioaccumulation with chronic exposure. Sulfate salts of magnesium and sodium are used medicinally as cathartics. High concentrations of unabsorbed sulfate salts in the gut can pull large amounts of water into the gut, greatly increasing the normal volume of feces. This action is also the basis of sulfate's toxic effects.

Toxicity in humans is primarily manifested in diarrhea; the severity of the diarrhea is dose-dependent. Chronic sulfate ingestion can result in persistent diarrhea, leading to ionic imbalance and dehydration similar to that seen with extremely high acute doses. Serious gastroenteritis is reported in some infants and adults drinking water containing 400 to 1000 mg/L sulfate (EPA, 1992a). When drinking water is contaminated with sulfate, the taste of the water may make it unpalatable and reduce consumption. However, this is not necessarily the case. In regions with high sulfate concentrations in the drinking water (such as Saskatchewan), residents adapt to the taste and find the water palatable (EPA, 1992a). A lower water intake could compound the dehydration effects of the diarrhea. Extreme dehydration can lead to death. Infants appear to be the most susceptible population for sulfate-induced diarrhea. Also, some data

indicate that diabetic and elderly populations with compromised kidney function may be more sensitive than healthy adults to the effects of sulfates (EPA, 1992a). Figure 5.7 summarizes these health effects as a function of dose.

Sulfate toxicity data are based primarily on epidemiologic studies of human adults and infants who report to hospitals with symptoms of sulfate exposure. In most cases, exposure doses have been back-calculated from sampling their drinking water. Therefore, these data do not represent well-controlled studies with readily defined dosage ranges.

5.1.8 Uranium

The uranium that occurs naturally at UMTRA Project sites consists of three radioactive isotopes: uranium-234, uranium-235, and uranium-238. More than 99 percent of natural uranium occurs in the form of uranium-238 (Cothern and Lappenbusch, 1983). Uranium-238 undergoes radioactive decay by emitting alpha particles to form uranium-234, thorium-230, radium-226, radon-222, polonium-210, lead-210, and other radioisotopes. Figure 5.8 summarizes the radioactive decay chain of uranium-238 and uranium-234. Because all natural uranium isotopes are radioactive, the hazards of a high uranium intake are from both its chemical toxicity and its potential radiological damage. The chemical toxicity of natural uranium is discussed here; the carcinogenic potential associated with exposure to radioactive isotopes of natural uranium is discussed in Section 5.3.

Absorption

Uranium absorption in the gastrointestinal tract depends on the solubility of the uranium compounds. The hexavalent uranium compounds, especially the uranyl salts, are water soluble, while tetravalent compounds generally are not (Weigel, 1983). However, only a small fraction of the soluble compounds is absorbed. Wrenn et al. (1985) have determined human gastrointestinal absorption rates of 0.76 to 7.8 percent.

Uranium may absorb through the skin when applied in concentrated solutions (the concentration level was not reported). The extent of absorption appears to be dose-dependent.

Tissue accumulation and clearance

In humans exposed to background levels of uranium, the highest concentrations were found in the bones, muscles, lungs, liver, and kidneys (Fisenne et al., 1988). Uranium retention in bone consists of a short retention half-time of 20 days, followed by a long retention half-time of 5000 days for the remainder (Tracy et al., 1992).

In body fluids, uranium tends to convert into water-soluble hexavalent uranium (Berlin and Rudell, 1986). Approximately 60 percent of the uranium in plasma

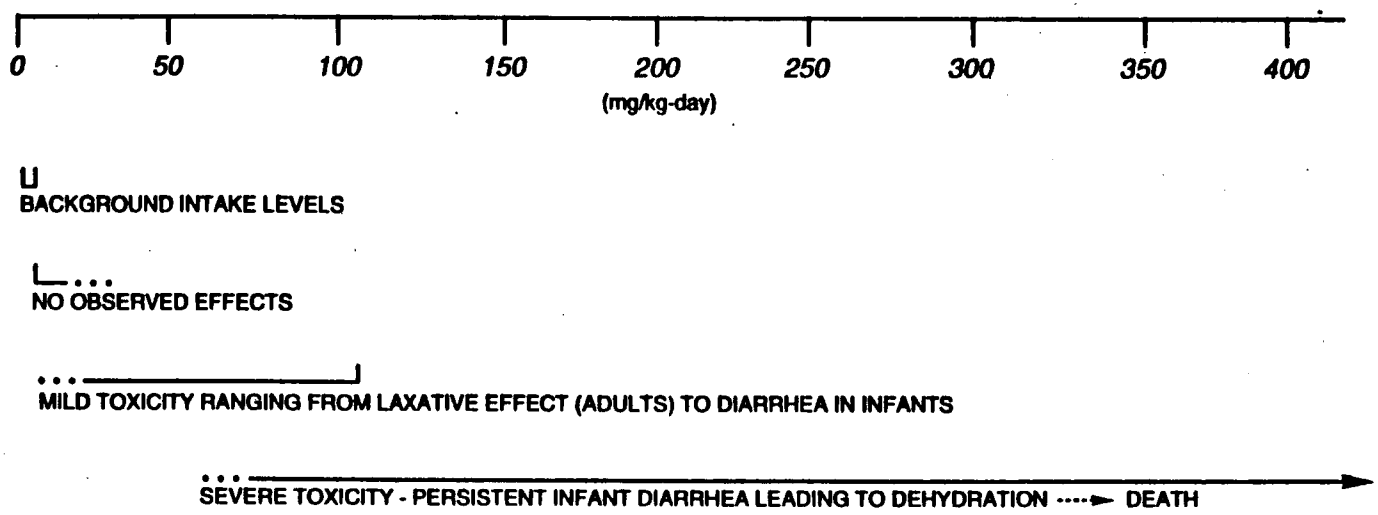

FIGURE 5.7
SULFATE TO[illegible]TY RANGES

MAC: SITE/SLC/B[illegible]/SUL-GEN

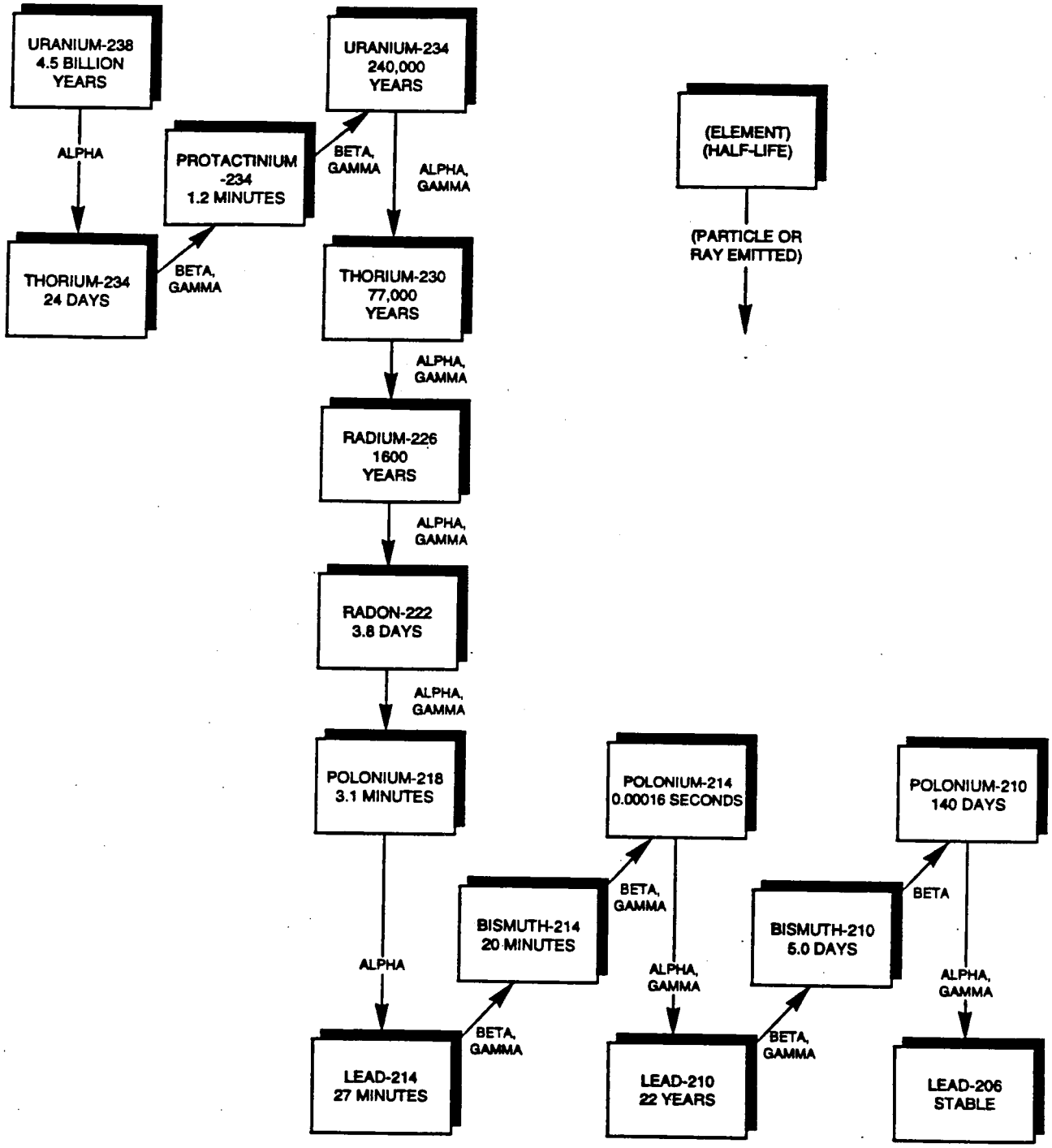

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FIGURE 5.8
HALF-LIVES AND EMISSIONS FROM DECAY CHAIN OF URANIUM-238

MAC: SITE/SLC/BRA/HALFLIVES

complexes with low-molecular-weight anions (e.g., bicarbonates, citrates), while the remaining 40 percent binds to the plasma protein transferring (Stevens et al., 1980). Following oral exposure to uranium, humans excrete more than 90 percent of the dose in the feces. Of the small percent that is absorbed (typically less than 5 percent), animal studies show that approximately 60 percent is excreted through the urine within 24 hours, whereas the remainder is distributed to the skeleton and soft tissue; 98 percent of that amount is excreted within 7 days (Ballou et al., 1986; Leach et al., 1984; Sullivan et al., 1986). A small portion of the absorbed uranium is retained for a longer period.

Environmental sources of uranium

Uranium is a ubiquitous element, present in the earth's crust at approximately 4 ppm. Uranium concentrations in ground water and surface water average 1 picocurie per liter (pCi/L) and 3 pCi/L, respectively (NCRP, 1984). The extent of uptake from the soil into plant tissues depends on the plant species and the depth of its root system (Berlin and Rudell, 1986). Tracy et al. (1983) report plant uranium concentrations averaging 0.075 mg/kg of fresh plant material.

The main dietary source of natural uranium for the general population is food (e.g., potatoes, grains, meat, and fresh fish) that may contain uranium concentrations between 10 and 100 mg/kg (Prister, 1969). The total uranium dietary intake from consuming average foods is approximately 1 microgram (µg)/day; approximately 20 to 50 percent of that total can come from drinking water. Cereals and vegetables, particularly root crops, probably contribute most to daily uranium intake (Berlin and Rudell, 1986).

Toxicity of uranium

No human deaths are reported that are definitely attributable to uranium ingestion; therefore, no lethal dose has been determined for humans. Lethal doses of uranium ($LD_{50,23}$) are reported to be 14 mg/kg-day following 23-day oral exposure, depending on the solubility of the uranium compound tested (higher solubility compounds have greater toxicity), exposure route, and animal species. High doses of uranium cause complete kidney and respiratory failure.

No chronic toxic effects are reported in humans following oral exposure to uranium. Data from populations occupationally exposed to high concentrations of uranium compounds through inhalation and information from studies on experimental animals indicate that the critical organ for chronic uranium toxicity is the proximal tubule of the kidney (Friberg et al., 1986). In humans, chemical injury reveals itself by increased catalase excretion in urine and proteinuria. Dose-response data for the toxic effects of uranium on the human kidney are limited.

The lowest dose of uranyl nitrate that caused moderate renal damage was given to rabbits in diet at 2.8 mg/kg-day (Maynard and Hodge, 1949). The EPA oral reference dose of 0.003 mg/kg-day was derived based on this study (EPA,

1994a). Figure 5.9 summarizes the health effects of uranium as a function of dose.

5.2 CONTAMINANT INTERACTIONS

Although some information is available on potential interactions between the contaminants found at UMTRA Project sites, discussions of potential interactions generally can be presented only qualitatively. In addition to individual physiological variables that can affect toxicity, interaction uncertainties also can be expected because exposure concentrations may be different than the concentrations tested experimentally. In addition, some ground water constituents may be present in sufficient quantities to modify predicted toxicities even though they are not considered contaminants of concern to human health. Therefore, the interactions described below should be recognized as factors that can influence the predicted toxicity, although the precise nature and magnitude of that influence cannot be determined.

A primary concern at the Salt Lake City site is the potential for interactions between metals. Interactions between several similar metals can alter the predicted absorption, distribution in the body, metabolism, toxicity, or clearance of a metal of interest.

For example, manganese absorption can be considerably altered under conditions of high calcium or iron or by a low-protein diet (Elinder, 1986). Manganese absorption from the intestine may considerably decrease in the presence of high dietary iron, leading to decreased manganese toxicity (DHHS, 1992). Conversely, high levels of manganese lead to decreased iron absorption. Short-term effects of this type are probably the result of kinetic competition between iron and manganese for a limited number of binding sites on intestinal transport enzymes, while longer-term effects of excess iron probably are due to adaptive changes in the level of intestinal transport capacity. Additionally, a physiological interaction between manganese and the metal-binding protein metallothionein can occur (DHHS, 1992; Casarett and Doull, 1991). Manganese can induce metallothionein synthesis and the formation of a metallothionein-manganese complex would enhance manganese excretion, decreasing its toxicity.

Because calcium, barium, magnesium, and strontium are competitive with respect to their absorptive sites, an excess of any of these elements may partially inhibit the absorption of others. Calcium salts also decrease the gastrointestinal absorption of fluoride (National Research Council, 1980). In addition, magnesium decreases fluoride absorption somewhat less effectively than calcium. However, molybdenum may promote fluoride retention and thereby intensify the toxic response (Casarett and Doull, 1991).

In animal studies, iron status affected the gastrointestinal absorption of uranium; however, the reported results were inconclusive (EPA, 1989b). No other

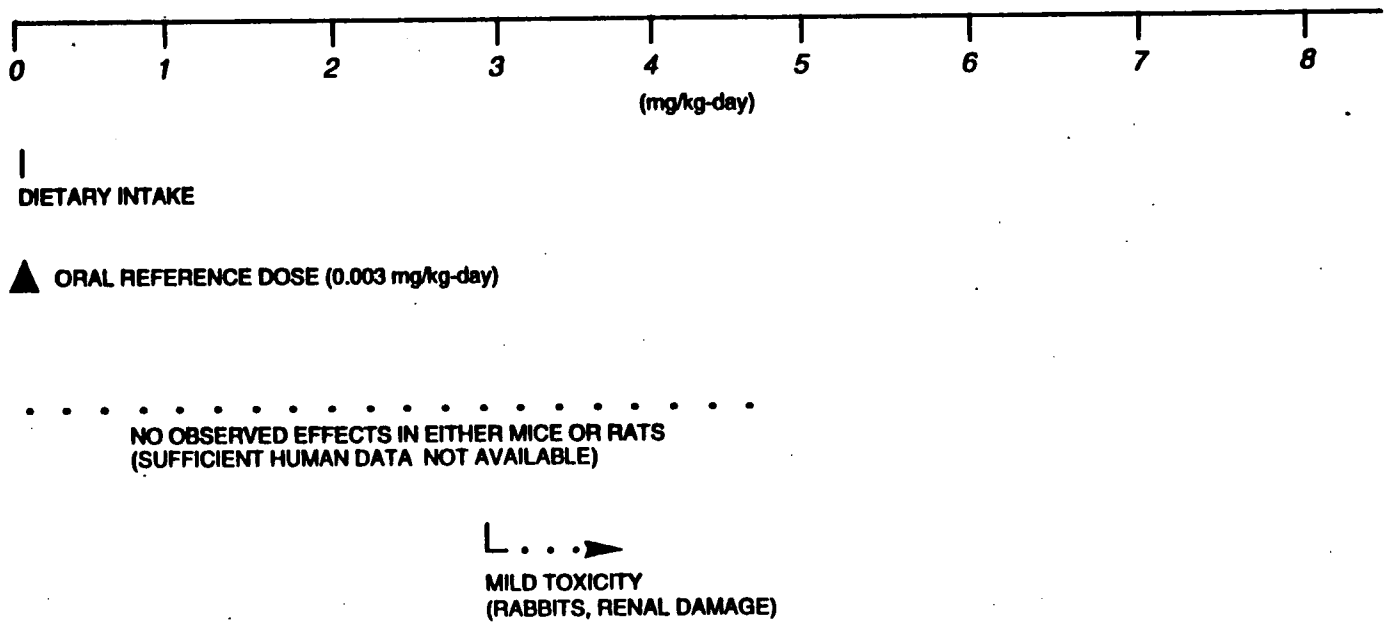


FIGURE 5.9
URANIUM TOXICITY RANGES

MAC: SITE/SLC / BRA/URN-GEN

information has been found on the interactions of uranium with other metals. However, the common target organ suggests uranium, manganese, and molybdenum interact to produce kidney toxicity.

Sulfate also interacts in a complex manner with molybdenum and copper. Sulfate reduces molybdenum accumulation by competing for protein carriers and enhances its excretion by inhibiting tubular reabsorption. Molybdenum can produce a functional copper deficiency. The antagonism of molybdenum to copper is augmented by sulfate. Ruminants seem to be the most susceptible species to imbalances between molybdenum, copper, and sulfate. In ruminants, copper sulfate can protect against molybdenum toxicity. It has also been suggested that sulfide (a reduced form of sulfate) can displace molybdate in the body. In laboratory animal models, molybdenum toxicity is more pronounced when dietary copper intake is low (EPA, 1994a).

Because ingesting high levels of sulfate and magnesium produces diarrhea that leads to dehydration, and ingesting of high levels of sodium and chloride leads to water retention, a physiological interaction might be expected to occur with simultaneous ingestion of all of them. However, available data do not predict the net effects of chronic ingestion of sulfate and sodium at high concentrations. Although high-concentration sodium chloride solutions are used to treat diarrhea-induced hyponatremia and hypochloremic metabolic alkalosis, the electrolyte concentrations in these solutions are physiologically balanced. Disproportionately high sodium and chloride levels could intensify the electrolyte loss produced by severe diarrhea.

In addition, diarrhea-induced dehydration may cause contaminants excreted in urine to concentrate in the kidney. Thus, diarrhea-induced dehydration may enhance the predicted toxicities of these contaminants.

5.3 CONTAMINANT RISK FACTORS

The EPA Office of Research and Development has calculated acceptable intake values, or RfDs, for long-term (chronic) exposure to noncarcinogens. These values are estimates of route-specific exposure levels that are not expected to cause adverse effects when exposure occurs for a meaningful portion of a lifetime. The RfDs include safety factors to account for uncertainties associated with limitations of the toxicological data base. These safety factors include extrapolating results from animal studies to humans and accounting for response variabilities in sensitive individuals. These values are updated quarterly and are published in the Health Effects Assessment Summary Tables (HEAST) (EPA, 1994b). Following more stringent review, they are published through the EPA's IRIS data base. Table 5.1 summarizes the most recent oral RfDs for the noncarcinogenic contaminants of concern.

The EPA currently classifies all radionuclides as Group A, or known human carcinogens, based on their property of emitting ionizing radiation and on the evidence provided by epidemiological studies of radiation-induced cancer in

Table 5.1 Toxicity values: potential noncarcinogenic effects

Chemical	Chronic oral RfD[a] (mg/kg-day)	Confidence level	Critical effect/organ	RFD basis/RFD source	Uncertainty factor
Chloride	ND	NA	Hypertension	NA	NA
Fluoride	0.06	High	Tooth, fluorosis	Water/IRIS[b]	1
Magnesium	ND	NA	Diarrhea, central nervous system depression, methemoglobinemia	NA	NA
Manganese	0.005	NA	Central nervous system effects	Water/IRIS[b]	1
Molybdenum	0.005	Medium	Increased uric acid production; joints (pain, swelling); blood (decreased copper levels)	Diet/IRIS[b]	30
Sodium	ND	NA	Hypertension	NA	NA
Sulfate	ND	NA	Diarrhea	NA	NA
Uranium (soluble salts)	0.003	Medium	Nephrotoxicity, decreased body weight	Diet/IRIS[b]	1000

[a]These doses are adopted as subchronic oral RfDs with the exception of uranium.
[b]From EPA (1994a).
[c]From EPA (1994b).

NA - not applicable.
ND - not determined.

humans. At sufficiently high doses, ionizing radiation acts as a complete carcinogen (both initiator and promoter), capable of increasing the probability of cancer development. However, the actual risk is difficult to estimate, particularly for the low doses and dose rates encountered in the environment. Most reliable data were obtained under conditions of high doses delivered acutely. It is not clear whether cancer risks at lower doses are dose-proportional (i.e., the linear dose-response hypothesis) or whether the risk is greatly reduced at low doses and rates (i.e., the threshold hypothesis). A conservative assumption rejects the threshold hypothesis and assumes that any dose adds to the risk of cancer.

Risk factors published in HEAST and IRIS correlate the intake of carcinogens over a lifetime with the increased excess cancer risk from that exposure. Table 5.2 gives the most recent cancer slope factors for the uranium-234 and -238 radioactive decay series.

Table 5.2 Toxicity values: carcinogenic effects

Parameter	Oral slope factor (SF)[a] $(pCi)^{-1}$	Weight of evidence classification	Type of cancer	Slope factor basis/slope factor source[b]
Lead-210[c]	1.01E-09	A	Bone	HEAST
Polonium-210	3.26E-10	A	Liver, kidney, spleen	HEAST
Radium-226[c]	2.96E-10	A	Bone	HEAST
Thorium-230	3.75E-11	A	d	HEAST
Uranium-238[c]	6.20E-11	A	e	HEAST
Uranium-234	4.44E-11	A	e	HEAST

[a]For each individual radionuclide listed, oral slope factors correspond to the risks per unit intake (risk/pCi) for that radionuclide, except as noted.
[b]From EPA (1994b).
[c]Oral slope factor includes the contributions from short-lived decay products, assuming equal activity concentrations (i.e., secular equilibrium) with the principal nuclide in the environment.
[d]Target organ systems have not been identified for oral exposure to thorium.
[e]No human or animal studies have shown a definite association between oral exposure to uranium and development of cancer.

A - Known human carcinogen.
HEAST - Health Effects Assessment Summary Tables

6.0 HUMAN HEALTH RISK EVALUATION

Health risks to an individual or population are evaluated by combining the results of both the exposure and toxicity assessments. As discussed in Section 5.0, potential adverse health effects and their severity depend on the amount of the contaminant an individual takes into his or her body. At lower levels, many contaminants associated with uranium processing are beneficial to health, because they are essential nutrients. At higher levels, these same elements can cause adverse health effects. Also, some individuals may be more sensitive to a given level of exposure than others.

6.1 POTENTIAL NONCARCINOGENIC HEALTH EFFECTS

The results from the exposure assessment showing either the highest intake-to-body-weight ratios (i.e., highest doses) or the toxicologically most sensitive group are used here to evaluate the potential health effects of noncarcinogens. For chloride, fluoride, magnesium, manganese, molybdenum, sodium, and uranium, the highest intake-per-body-weight group is children 1 to 10 years old. Infants are used to evaluate the health risks of sulfate exposure because they are the most toxicologically sensitive population.

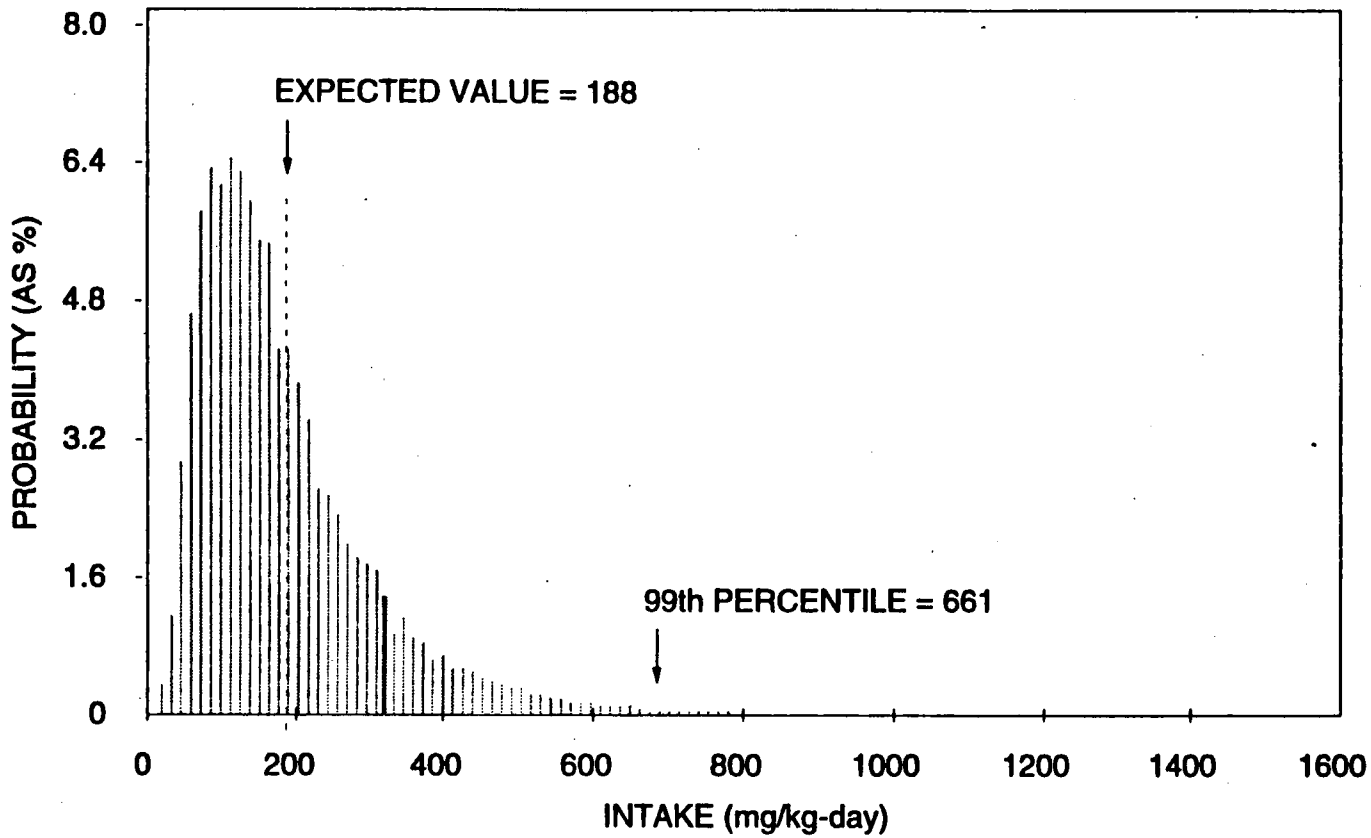
Exposure to sulfate presents the most important health risk associated with the contaminated ground water at the Vitro site. As can be seen in Figure 6.1, if ground water were used for drinking water, more than 70 percent of the expected exposures would be in the range of severe diarrhea in infants, which can lead to dehydration. However, these high-sulfate concentrations may cause the water to be unpalatable to infants, thus reducing their exposure.

Because the predicted sulfate toxicity from drinking water is so severe, and because this is the only exposure pathway for infants, the additive contribution from other sources would not alter the interpretation of health risks. Therefore, the contributions from other sources will not be evaluated at this time.

Note also that the exposure distribution for infants is based on tap water intake rates across a population that includes breast-fed and canned-formula-fed infants. Those infants consuming powdered formula reconstituted with well water would be in the upper percentiles of this exposure distribution and could be at higher risk of severe diarrhea. Further, these effects could be expected even after very short-term exposures.

In addition to sulfate-induced diarrhea, magnesium alone could cause diarrhea. More than 90 percent of the predicted range of children exposures to magnesium could be associated with mild diarrhea (Figure 6.2).

Infants exposed to magnesium from the drinking water ingestion route would have about 5 times the exposures of children. Thus, expected magnesium toxicity would be more serious in infants than in children. Simultaneous



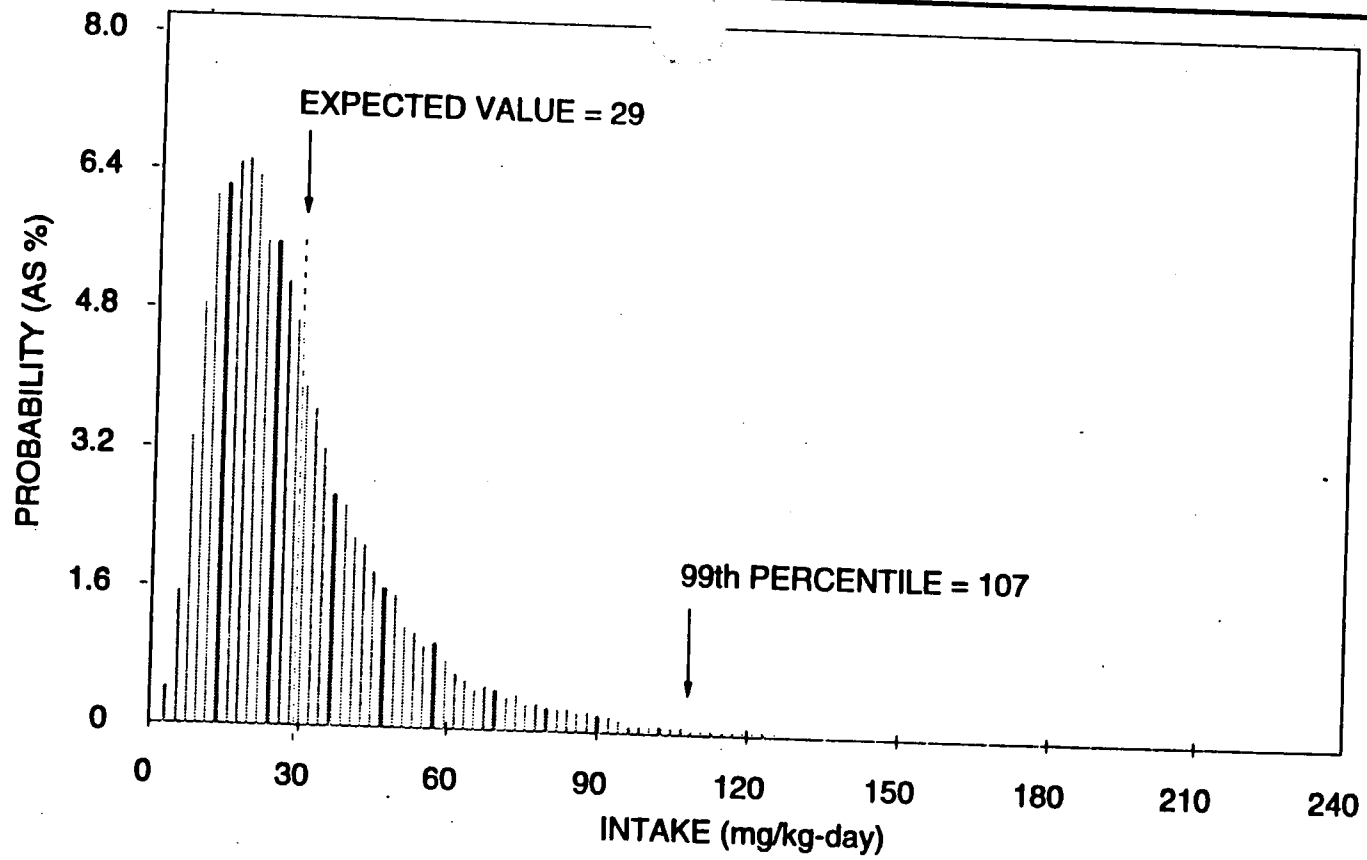
BACKGROUND INTAKE LEVEL

MILD TOXICITY RANGING FROM LAXATIVE EFFECT (ADULTS) TO DIARRHEA IN INFANTS

SEVERE TOXICITY - - - - → DEATH
PERSISTENT DIARRHEA
LEADING TO DEHYDRATION

NOTE: SEVERE TOXIC EFFECTS MANIFESTED AS PERSISTENT DIARRHEA LEADING TO DEHYDRATION WOULD RESULT FROM THE MAJORITY OF PREDICTED EXPOSURES.

FIGURE 6.1
HEALTH EFFECTS OF POTENTIAL SULFATE EXPOSURE RANGES FOR INFANTS
SALT LAKE C[illegible] UTAH, SITE



DIETARY INTAKE LEVELS

NUTRITIONAL INTAKE LEVELS

MILD TOXICITY IN HUMANS
(CATHARTIC EFFECT)

NOTE: MILD TOXICITY MANIFESTED AS DIARRHEA WOULD RESULT FROM PREDICTED EXPOSURES.

FIGURE 6.2
HEALTH EFFECTS OF POTENTIAL MAGNESIUM EXPOSURE RANGES FOR CHILDREN
SALT LAKE CITY, UTAH, SITE

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HLTHMAGN.DRW

exposure to magnesium and sulfate in drinking water could augment the severity of sulfate-induced diarrhea. When renal impairment exists and magnesium excretion is impaired, magnesium exposure also could induce symptoms of central nervous system depression, such as sleepiness, confusion, and muscle weakness.

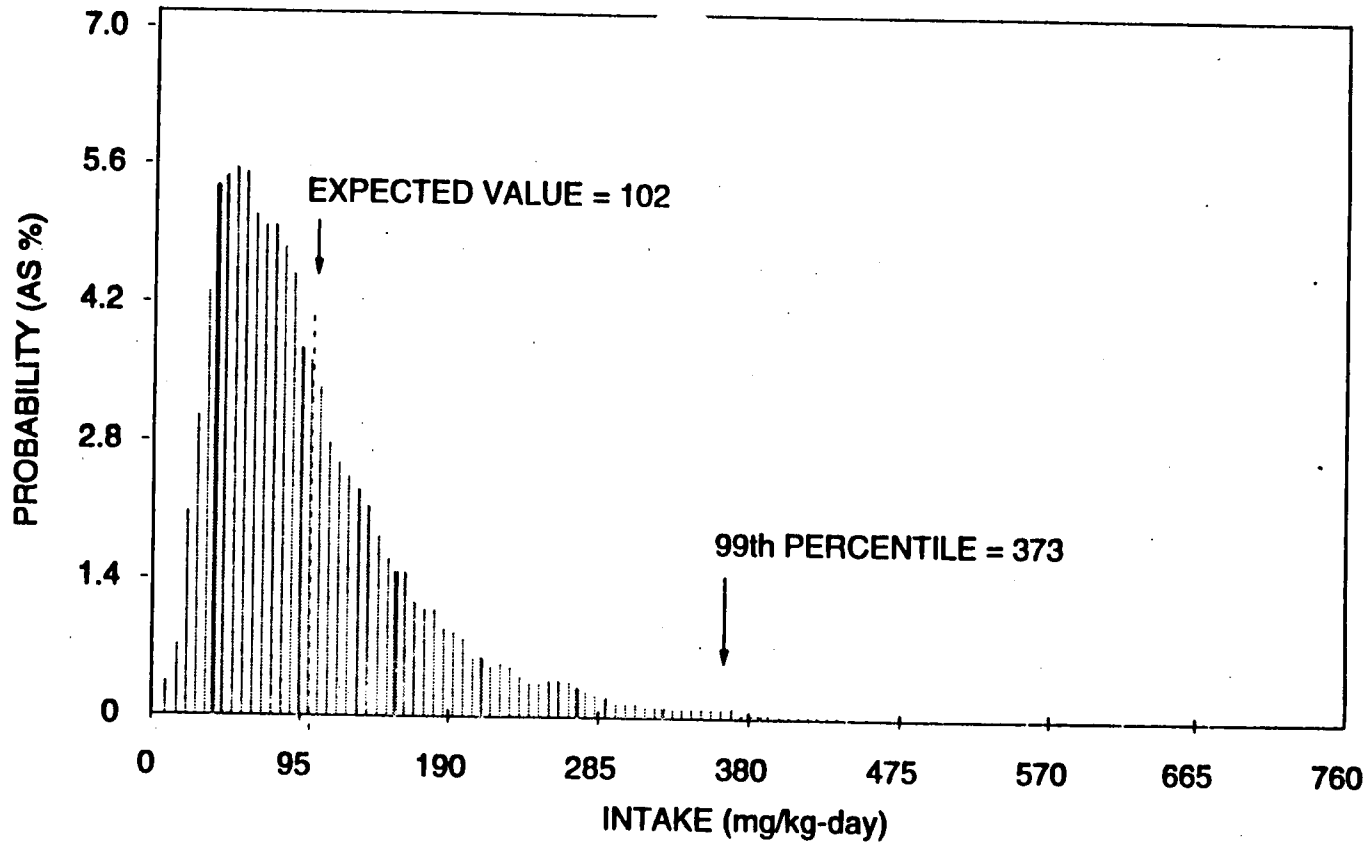
Chronic sodium exposure could be associated with the development of hypertension in children as well as in adults. As can be seen in Figure 6.3, 97 percent of the exposure distribution for sodium is above the threshold level of hypertension in humans. In addition, chloride exposure may contribute to the development of hypertension. About 90 percent of the exposure distribution for chloride alone may be associated with hypertension in sensitive individuals, although some uncertainty is associated with these literature data (Figure 6.4). Renal insufficiency would augment this health effect. Although solutions with physiologically balanced electrolyte concentrations containing high levels of sodium chloride have been used to alleviate diarrhea-induced hyponatremia, it is not possible to predict the net effect of simultaneous chronic ingestion of sodium chloride, sulfate, and magnesium at high concentrations without balanced electrolytes.

More than 70 percent of the exposure distribution for manganese (Figure 6.5) falls above the threshold level of mild neurological symptoms, and 85 percent of this distribution is above the EPA RfD (RfD of 0.005 mg/kg-day) derived from drinking water consumption studies. As discussed in Section 5.1.4, infants may be more sensitive to manganese toxicity than children and adults. Therefore, toxic effects may appear in infants at levels lower than those in children. However, insufficient data exist to support a quantitative analysis.

More than 90 percent of the fluoride intake distribution falls above the threshold level of the cosmetic dental mottling in children (Figure 6.6). About 40 percent of this distribution is within the exposure range associated with dental fluorosis recognized as a pathology. About 60 percent of this distribution is above the acceptable intake level recommended by the EPA (RfD of 0.06 mg/kg-day). The remaining portion of the exposure distribution falls into the range of the NOAEL for dental fluorosis. Modeling long-term adult exposure to fluoride could associate less than 1 percent of the predicted exposure level with the development of skeletal fluorosis in this age group.

The entire exposure distribution for molybdenum (Figure 6.7), is above the EPA RfD (RfD of 0.005 mg/kg-day). About 30 percent of the estimated intake falls above the threshold level of mild toxicity, which could manifest as copper deficiency. Gout could result from increased production of uric acid.

The entire exposure distribution for uranium falls within the NOAEL range (Figure 6.8). However, almost 90 percent of the exposure distribution falls above the EPA acceptable intake level (RfD of 0.003 mg/kg-day). This apparent discrepancy occurs largely because the toxicological data base is incomplete.



U BACKGROUND INTAKE LEVELS FROM DRINKING WATER

▲ NUTRITIONAL REQUIREMENT

▲ NRC RECOMMENDED LIMIT FOR DIETARY INTAKE

HYPERTENSION IN HUMANS

NOTE: HYPERTENSION WOULD BE ASSOCIATED WITH THE MAJORITY OF PREDICTED EXPOSURES.

FIGURE 6.3
HEALTH EFFECTS OF POTENTIAL SODIUM EXPOSURE RANGES FOR CHILDREN
SALT LAKE CITY, UTAH, SITE

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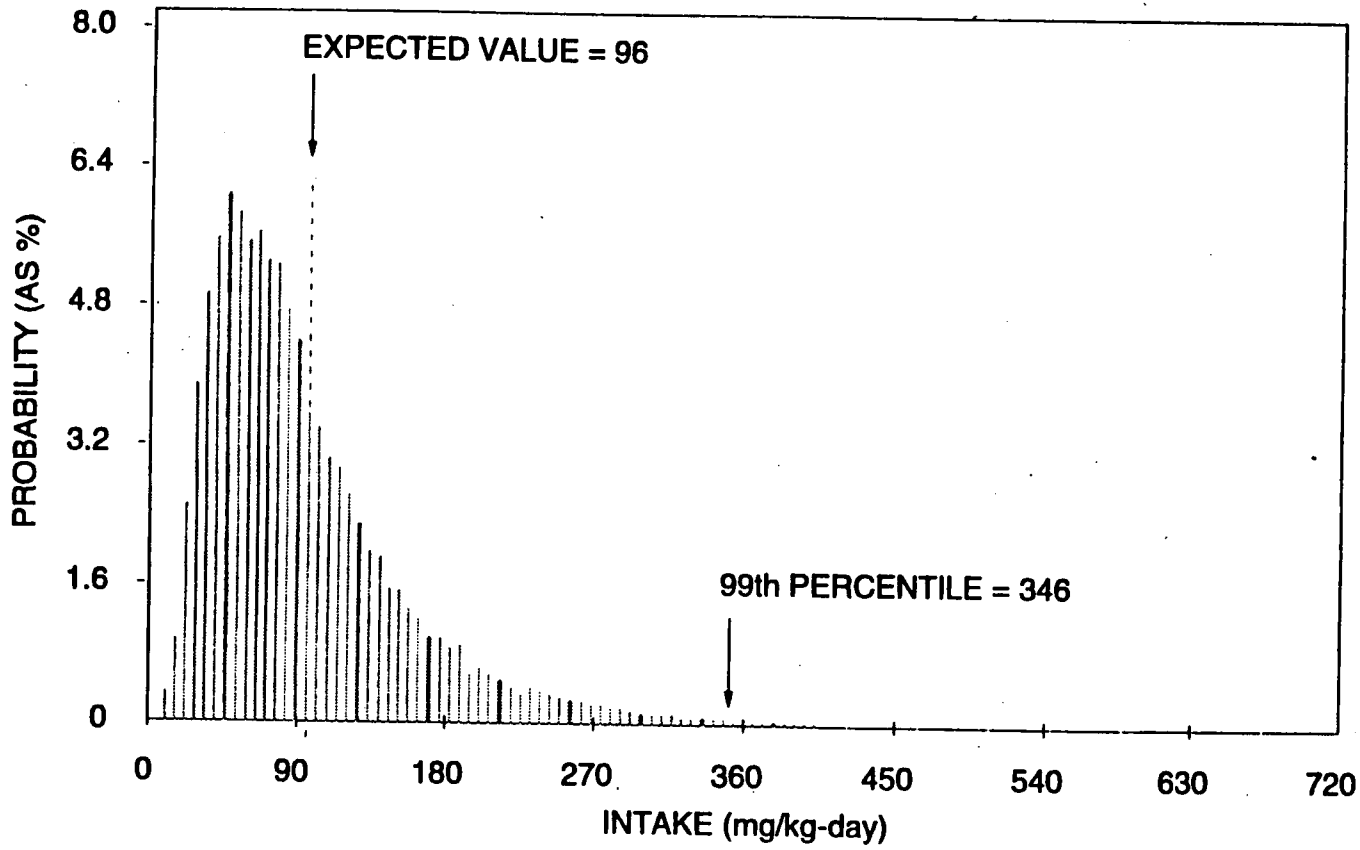

INTAKE FROM DRINKING WATER

RECOMMENDED LIMIT FROM DRINKING WATER

DIETARY INTAKE LEVELS

HYPERTENSION IN HUMANS

NOTE: HYPERTENSION WOULD RESULT FROM THE MAJORITY OF PREDICTED EXPOSURES.

FIGURE 6.4
HEALTH EFFECTS OF POTENTIAL CHLORIDE EXPOSURE RANGES FOR CHILDREN
SALT LAKE UTAH, SITE

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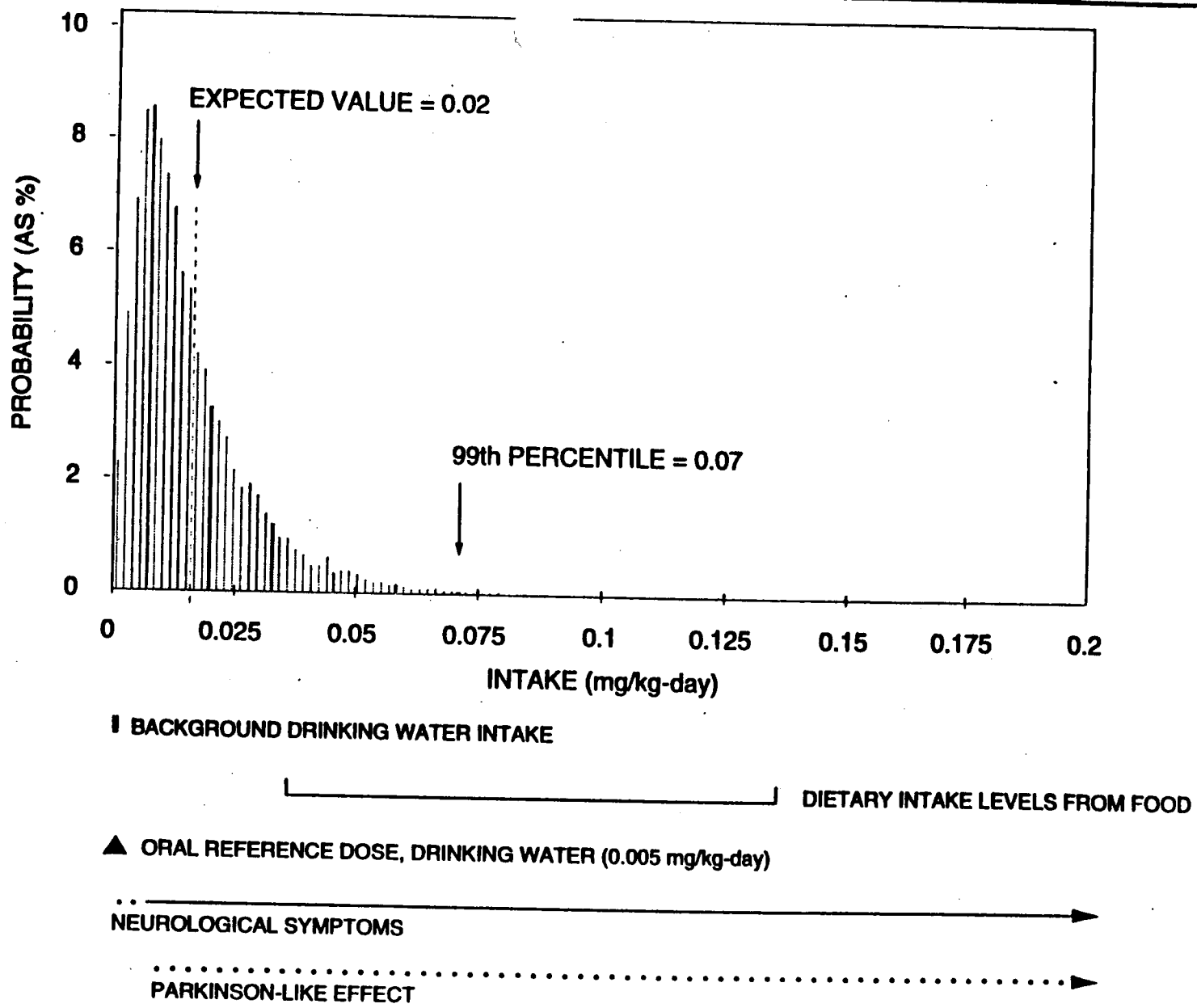

NOTE: NEUROLOGICAL SYMPTOMS WOULD BE ASSOCIATED WITH THE MAJORITY OF PREDICTED EXPOSURES.

FIGURE 6.5
HEALTH EFFECTS OF POTENTIAL MANGANESE EXPOSURE RANGES FOR CHILDREN
SALT LAKE CITY, UTAH, SITE

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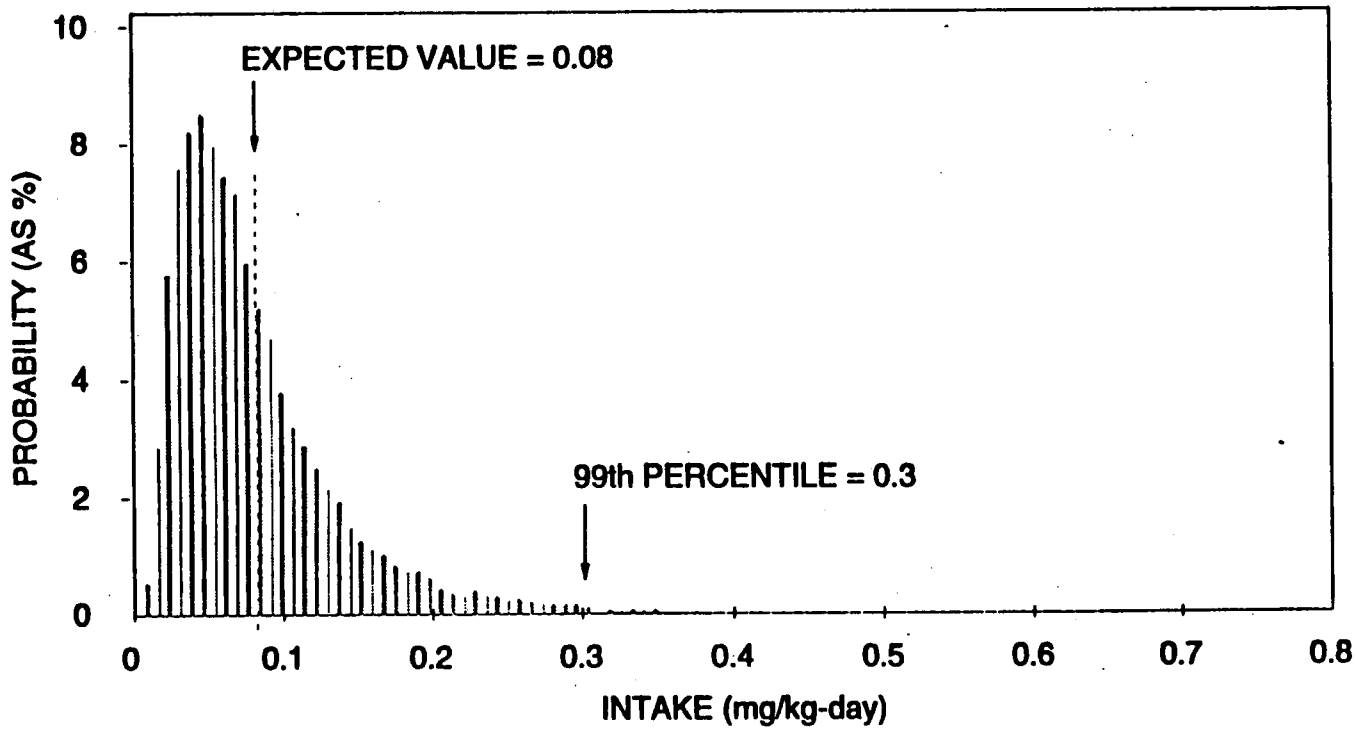


INTAKE LEVELS FROM DRINKING WATER FOR CHILDREN

▲ ORAL REFERENCE DOSE, FOOD AND DRINKING WATER (0.06 mg/kg-day)

NO OBSERVABLE EFFECT LEVEL FOR DENTAL FLUOROSIS IN CHILDREN

DENTAL MOTTLING AND CHANGES IN TOOTH STRUCTURE IN CHILDREN

INCREASING DENTAL FLUOROSIS

NO OBSERVABLE EFFECT LEVEL FOR SKELETAL FLUOROSIS IN ADULTS

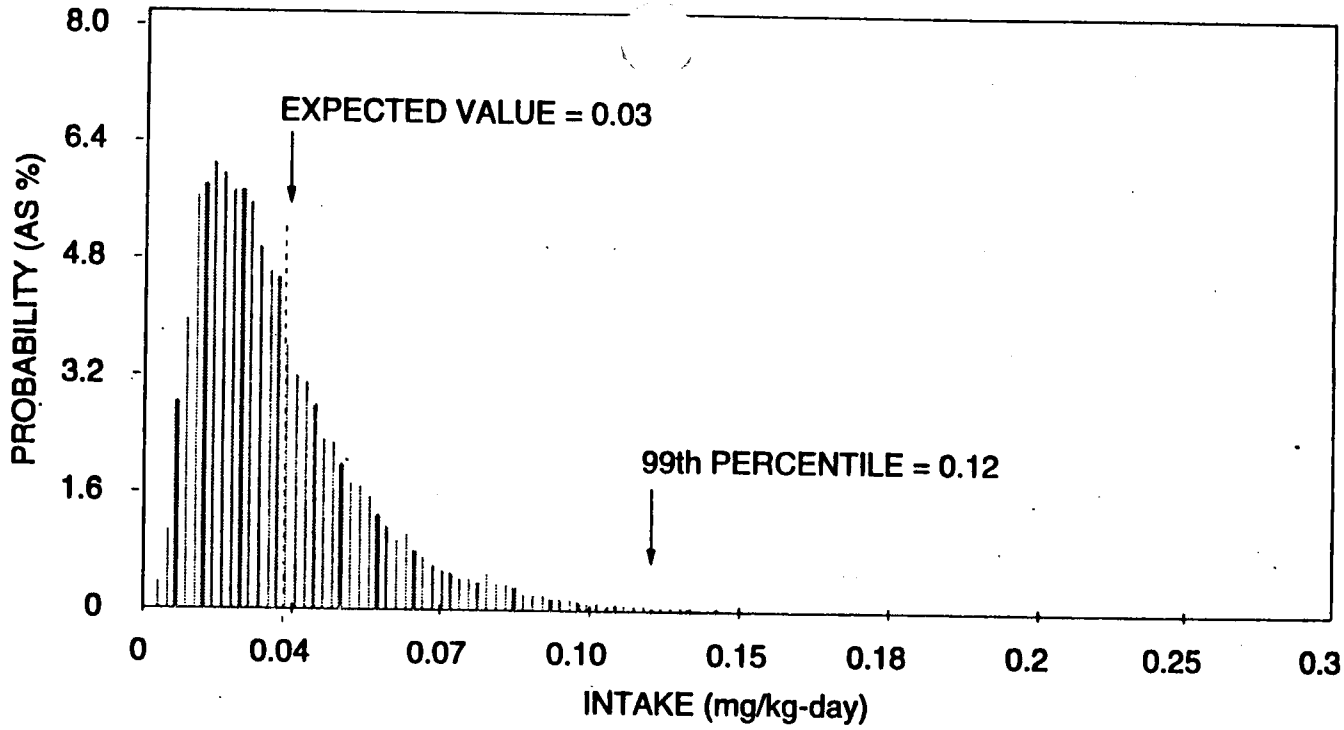
CRIPPLING SKELETAL FLUOROSIS IN ADULTS

NOTE: 90% OF THE EXPOSURES IN CHILDREN WOULD BE ASSOCIATED WITH DENTAL FLUOROSIS OF DIFFERENT DEGREES OF SEVERITY.

FIGURE 6.6

HEALTH EFFECTS OF POTENTIAL FLUORIDE EXPOSURE RANGES FOR CHILDREN

SALT LAK[illegible]Y, UTAH, SITE



U NUTRITIONAL INTAKE LEVELS

U DIETARY INTAKE LEVELS

▲ ORAL REFERENCE DOSE (0.005 mg/kg-day)

NO OBSERVED EFFECT LEVEL

MILD TOXICITY (INCREASED COPPER EXCRETION AND URIC ACID SYNTHESIS - - - - - - → GOUT)

NOTE: 30% OF THE PREDICTED EXPOSURES IN CHILDREN WOULD BE ASSOCIATED WITH MILD TOXICITY.

FIGURE 6.7
HEALTH EFFECTS OF POTENTIAL MOLYBDENUM EXPOSURE RANGES FOR CHILDREN
SALT LAKE CITY, UTAH, SITE

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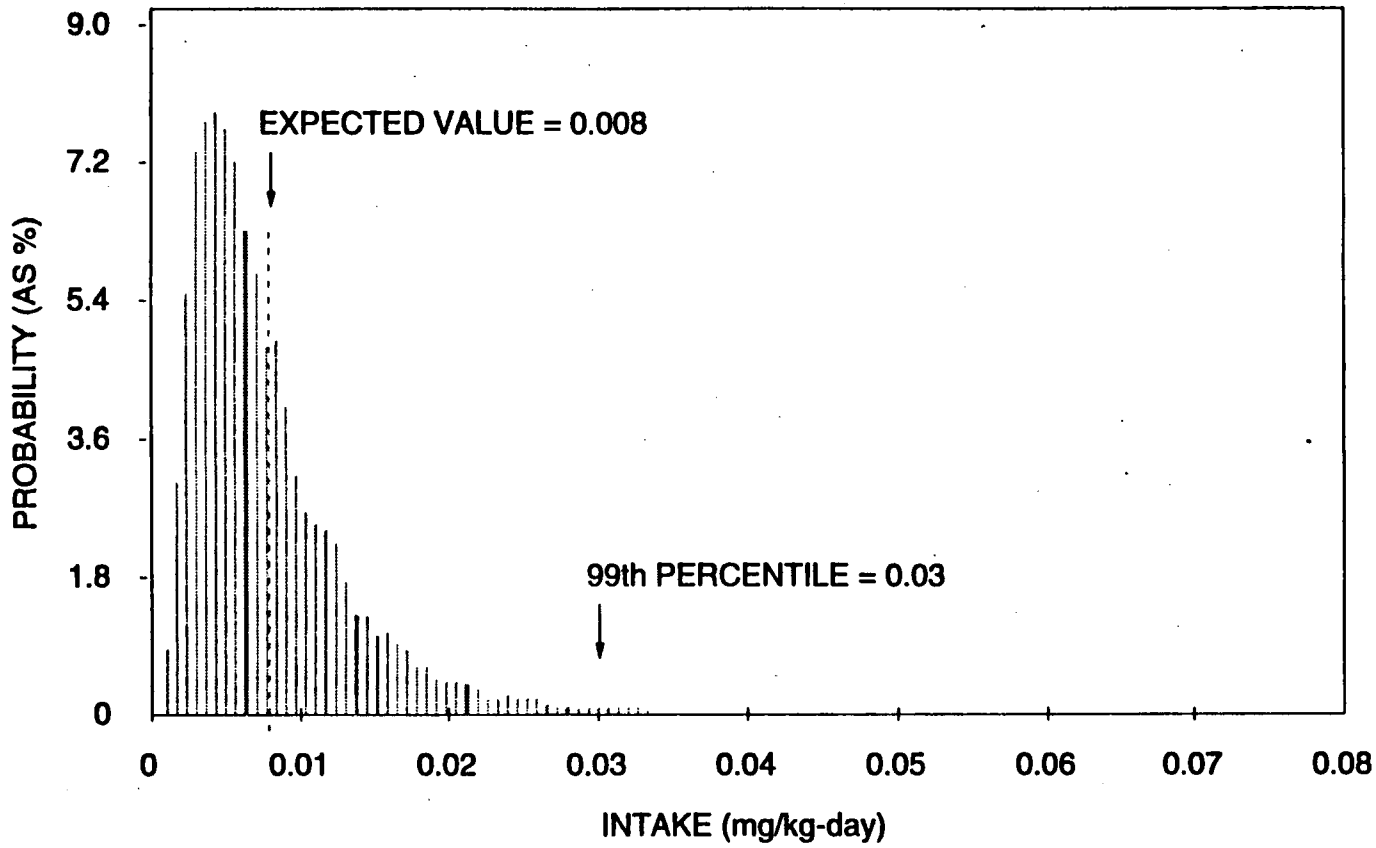


▲ ORAL REFERENCE DOSE (0.003 mg/kg-day)

NO OBSERVED EFFECTS IN EITHER MICE OR RATS
(SUFFICIENT HUMAN DATA NOT AVAILABLE)

NOTE: NO OBSERVED ADVERSE HEALTH EFFECTS WOULD BE ASSOCIATED WITH THE PREDICTED RANGE OF EXPOSURES.

FIGURE 6.8
HEALTH EFFECTS OF POTENTIAL URANIUM EXPOSURE RANGES FOR CHILDREN
SALT LAKE C[illegible] UTAH, SITE

EPA takes this uncertainty into account by lowering the acceptable intake levels (RfDs). Although these low intake levels have not been associated with adverse health effects in humans or test animals, it is important that most of the exposure distribution falls above this RfD criterion.

Diarrhea-induced dehydration may lead to increased concentration of the contaminants in the kidney, enhancing the predicted toxicity from chemical exposures to magnesium, sodium, and most nephrotoxic metals.

The potential exposure contribution from other pathways, including produce ingestion, could not be estimated with current data. The UMTRA Project is conducting additional studies and the results will be used to better characterize these pathways. Although drinking water ingestion is believed to result in the greatest exposure and therefore toxicity, these other pathways may contribute considerably to overall exposure.

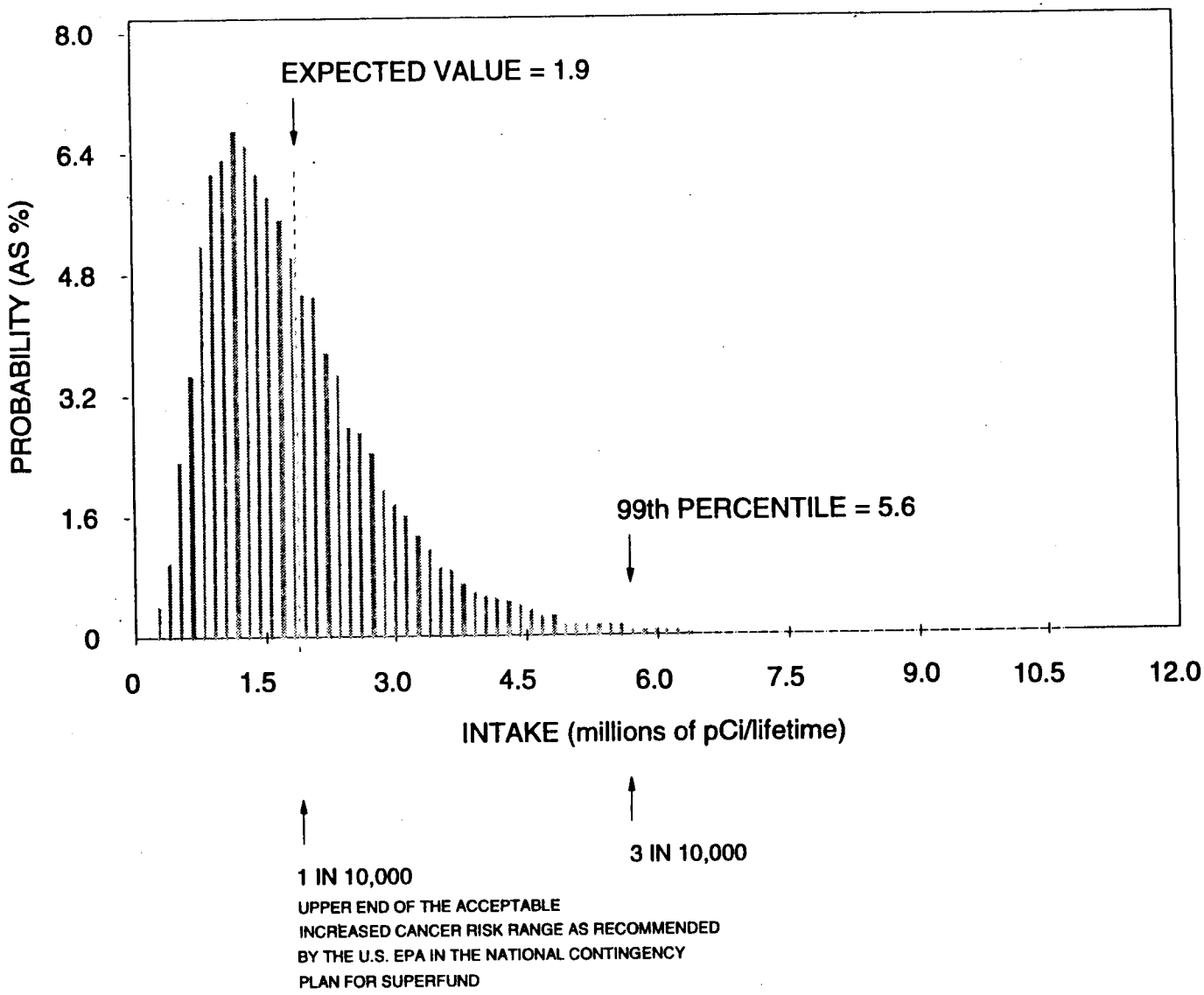
6.2 POTENTIAL CARCINOGENIC HEALTH EFFECTS

All uranium isotopes are radioactive and, as such, are considered carcinogens. Figure 6.9 shows the exposure distribution for uranium-238 and uranium-234 intake and the associated potential lifetime carcinogenic risk. These estimates are based on the cancer slope factor developed by the EPA; however, natural uranium has not been demonstrated to cause cancer in humans or animals following ingestion.

The average predicted exposure to radioactive uranium is associated with an excess lifetime cancer risk of 1 in 10,000 (0.01 percent), which is the maximum recommended by the EPA in its National Contingency Plan for Superfund sites. The distribution presented here is thought to be conservative because it is based on a cumulative, 30-year exposure duration. As previously discussed, this exposure duration is probably appropriate; however, ground water concentrations may decline over this time.

Uranium and radium-226 are the only radionuclides consistently measured above background levels in the contaminated ground water of the unconfined aquifer. However, because uranium decays to radioactive progeny, the entire longer-lived radioactive progeny of the uranium decay series (radium-226, lead-210, polonium-210, and thorium-230) was evaluated for carcinogenic risk (Table 6.1).

Any excess lifetime cancer risks associated with radionuclides other than uranium are within the NCP-acceptable range of 1 in 10,000 and 1 in 1,000,000.



NOTE: THE AVERAGE PREDICTED EXPOSURE CORRESPONDS TO AN INCREASED CANCER RATE OF 0.01%.

FIGURE 6.9
INCREASED LIFETIME CANCER RISK FROM URANIUM-234 AND URANIUM-238 EXPOSURE RANGES
SALT LAKE Y, UTAH, SITE

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Table 6.1 Carcinogenic risk for ground water consumption pathway, Salt Lake City, Utah, site

Radionuclides	Exposure point concentration[a] (pCi/L)	Intake[b] (pCi/lifetime)	Ingestion SF $(pCi)^{-1}$	Lifetime risk
Radium-226	1.1	23,100	2.96E-10	7E-06
Lead-210	1.4	29,400	1.01E-09	3E-05
Polonium-210	0.2	4,200	3.26E-10	1E-06
Thorium-230	0.6	12,600	3.75E-11	5E-07
Total				4E-05

[a]Highest observed concentration; unfiltered ground water samples collected in October 1992.

Note: Intake is calculated from equation (2) in Section 4.4.
1. Ingestion rate: 2 liters/day.
2. Exposure frequency: 350 days/year.
3. Exposure duration: 30 years.

6.3 LIMITS OF THIS RISK EVALUATION

The following potential limitations should be kept in mind when interpreting this risk evaluation.

- This risk assessment evaluates only risks related to ground water contaminated with inorganics. Potential contamination from organic constituents has not been addressed.

- Populations with potentially increased sensitivity, such as the elderly or individuals with preexisting diseases, were not specifically addressed on the toxicity ranges presented on the graphs. Expected sensitivities in certain groups were discussed in the text to the extent possible.

- Some individuals may be more sensitive to the toxic effects of certain constituents for reasons that have not been determined. Therefore, adverse health effects may occur in sensitive individuals at lower exposure levels.

- Available data on potential adverse health effects may not always be sufficient to accurately determine all health effects because human data are insufficient or exposure ranges differed from exposures expected at this site.

- Although the areal extent of ground water contamination and its movement have been evaluated hydrologically and geochemically, it is possible that the monitoring locations sampled were not in the most contaminated portion of the ground water. Additionally, concentrations may increase or decrease substantially as the contaminated ground water moves.

- The risk evaluation results presented in this document are based on filtered (0.45 μm) ground water samples. Therefore, the potential loss of certain ground water constituents as a consequence of filtration is associated with a source of uncertainties. For example, if concentrations of iron and lead measured in unfiltered ground water samples from monitor well 131 represent true values, ingesting this water could cause toxic effects. Because a high degree of uncertainty is associated with these results, they could not be used in this risk evaluation. Therefore, iron and lead should continue to be monitored in unfiltered ground water samples to verify these data.

- Only the drinking water exposure pathway was considered in depth, although other pathways were screened to determine their contribution. However, the incremental contribution from the ground water-irrigated produce-ingestion pathway could not be estimated here. Therefore, the additivity of exposure from other pathways should be considered.

- Changes in land use at the Vitro site (e.g., pumping from the confined aquifer) may affect current and future ground water conditions.

The evaluation presented here compensated for these limitations wherever possible by presenting toxicity ranges and probabilistic exposure assessments rather than point estimates, incorporating as much variability as could be reasonably defined. The impact of these potential limitations is discussed in Section 8.2.

7.0 ECOLOGICAL AND LIVESTOCK RISK EVALUATION

This section assesses the potential for site-related contaminants to adversely affect the existing biological communities, livestock grazing, and potential agricultural practices in the site area. The EPA currently has no guidance for quantifying potential ecological impacts of hazardous constituents; however, the EPA has developed a qualitative approach for ecological risk evaluations (EPA, 1989b). As part of this qualitative approach, the EPA recommends conducting ecological assessments in a phased approach to ensure the most effective use of resources while all necessary work is conducted (EPA, 1992b).

This approach takes place in four phases: identifying potentially exposed habitats (phase 1), collecting chemistry data (phase 2), collecting biological samples (phase 3), and conducting toxicity testing (phase 4). If the initial inspection of the habitats or the analysis of media samples indicates little or no potential for an ecological risk, the assessment probably will be complete. If early phases of the assessment indicate the contaminants may be adversely affecting ecological receptors, a higher level of analysis may be warranted.

The ecological risk assessment at the Salt Lake City site consists of the first two phases of the EPA's approach. Habitats may have been impacted (phase 1), and water chemistry and sediment data have been collected (phase 2). Data from the first two phases of ecological assessment were used to prepare this baseline risk assessment. Thus, this qualitative approach provides a screening level assessment of the risks associated with potential exposure to contaminated media at the site.

Although determining the effects of a contaminant on the ecosystem may be difficult, sampling environmental media such as surface water can help assess potential ecological risk. The following sections identify areas of contamination and their potential pathways into the aquatic and terrestrial ecosystem at the Salt Lake City site, the potential ecological receptors at the site, the contaminants of potential concern, and how these potential contaminants of concern threaten ecological resources, livestock, and agricultural crops.

7.1 EXPOSURE PATHWAYS

The cleanup of surface contamination at the Vitro site included soil excavation from 5 to 35 ft (2 to 11 m) depending on the depth of contamination. The average depth of excavation at the site was 13 ft (4 m). Clean fill was placed in all excavated areas and the ground was recontoured and revegetated (DOE, 1994b).

Surface water bodies at and near the site consist of the South Vitro Ditch, Mill Creek along the northern border, a wetland to the east, and the Jordan River to the west (Figure 2.2). Ground water in the shallow unconfined aquifer beneath the site is contaminated as a result of operations at the former uranium processing site. The ground water table ranges from 5 to 15 ft (1.5 to 4.6 m) below the ground surface. The extent of ground water contamination within this aquifer is summarized in Section 3.0.

The surface water, sediments, and shallow unconfined aquifer represent potential contaminant exposure pathways into the aquatic and terrestrial biological communities at the site. A limited number of surface water and sediment locations were sampled at and near the site to assess these potential pathways.

Contaminated ground water in the unconfined shallow aquifer could enter the ecosystem via plant root uptake or discharge into surface water bodies. There is evidence that the contaminated ground water from the shallow unconfined aquifer is entering the clean fill placed in the excavated area. In 1992, samples were taken from nine boreholes from the native soil material at the interface of the fill material and native soil. These samples were taken from 8.5 to 16 ft (2.6 to 4.9 m) below land surface and averaged 12 ft (3.7 m) below land surface. The water depth of wells in the shallow unconfined aquifer ranged from 5 to 13 ft (1.5 to 4.0 m) and averaged 7 ft (2 m) (DOE, 1993). This indicates that water from the shallow unconfined aquifer has, on the average, moved 4 ft (1.2 m) into the fill material during the 5-year period since the fill was placed at the site in 1987. Given that both the soil beneath the fill and the shallow aquifer are contaminated, the contaminants could enter the ecosystem from plants extracting contaminants from both these sources. These potential pathways will be assessed in this ecological risk assessment.

The unconfined shallow aquifer discharges into surface water bodies near the site in areas such as Mill Creek and the Jordan River (DOE, 1993). This potential exposure pathway to the aquatic and terrestrial biological communities will also be addressed in this assessment.

A potential exposure pathway that does not now exist at the site but could in the future is the establishment of a well in a contaminated aquifer to create a pond and/or irrigation. Contaminated ground water in a pond could affect wildlife that could drink the water and aquatic organisms (including fish) that could live in the pond. Irrigating with contaminated ground water could lead to the ingestion of contaminants by the human population and wildlife. For this assessment, such a well is assumed to be in the most contaminated portion of the unconfined aquifer.

7.2 ECOLOGICAL RECEPTORS

This section describes the terrestrial and aquatic resources present at and near the site, based on information collected during reconnaissance-level surveys conducted at the site and other (published) studies.

7.2.1 Terrestrial resources

The areas that were backfilled after the completion of surface cleanup were revegetated with a mixture of grass and herbaceous species. Most of the site consists of mowed fields; one area is used as a golf driving range.

The South Vitro Ditch traverses the site and consists of a channel about 5 ft (1.5 m) deep and bordered by a dense growth of woody and herbaceous riparian and wetland plant species. Water flows north on site for about 1500 ft (460 m) before it goes underground (below the site) and empties into Mill Creek near the northern border of the site. Willow and cottonwood are the common woody species while reed canary grass, goldenrod, and cattail are the common herbaceous species. A submerged aquatic plant of undetermined species is common (TAC, 1993). Wildlife was not observed along this ditch although evidence of muskrat has been observed.

Mill Creek runs north of the site and empties into the Jordan River 0.25 mi (0.40 km) west of the site. The creek has been channelized and is bordered by industrial facilities in the site area. In some areas, the banks of this creek are covered with woody plant species such as willow, Russian olive, and Chinese elm. In other areas, the vegetation is more open with grass such as reed canary grass being common.

Near the site, the Jordan River is bordered by a thin strip of riparian vegetation that is typically 10 to 50 ft (3 to 15 m) wide. Moving away from the river, the riparian zone gives way to buildings, parking lots, lawns, and disturbed ground. The riparian zone is dominated by a dense growth of sapling-size trees, with cottonwood, Russian olive, willows, and salt cedar most common. Reed canary grass is common while the most common herbaceous species observed are goldenrod, thistle, teasel, and burdock. Giant reed and cattail were noted in some areas.

Mallard and domestic geese were observed along both Mill Creek and the Jordan River. Other bird species recorded were the red-winged blackbird, starling, house sparrow, magpie, flicker, and red-tailed hawk. Beaver cuttings were common along the river and one muskrat was observed (TAC, 1993).

Because a marshy area east of the site and near the interstate highway was considered out of the potential zone of influence of the contaminated ground water, this area was not inspected or sampled.

7.2.2 Aquatic resources

The results of a fisheries study from 1988 through 1991 along the Jordan River in the Mill Creek area indicate 24 species of fish live in the river; carp, Utah sucker, and fathead minnow are the most abundant. The most abundant game species are walleye, white bass, and green sunfish. The study showed no discernible difference in fish abundance, distribution, or reproductive success at sampling

stations above and below the confluence of Mill Creek. Reproduction of game fish is low in this section of the Jordan River because spawning habitat is limited. The higher ammonia concentrations in the river below Mill Creek were probably caused by water discharged from the CVWRF sewage disposal facility along Mill Creek. These increased ammonia concentrations do not impact the fish in the Jordan River; the principal factor limiting fish reproduction in the river appears to be the lack of appropriate habitat (Filbert and Holden, 1992).

Chironomidae and Oligochaeta were the dominant benthic taxa collected in the Jordan River both upriver and downriver of Mill Creek. The dominance of these taxa is typical for water bodies such as the Jordan River that have a sandy and silty substrate, relatively warm temperatures, and low water velocities (Filbert and Holden, 1992). During sediment sampling in 1993, the largest number of invertebrates were observed at sample site 185 (Figure 2.2); a few Ephemopteran, Tricopteran larva were noted with a large number of limpets and a few leaches (TAC, 1993).

No fish or invertebrates were observed during surface water and sediment sampling along Mill Creek and the South Vitro Ditch.

7.3 CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN AND ECOLOGICAL RISK

7.3.1 Surface water and sediment sampling sites and results

Surface water and sediment samples were collected in 1993 from four locations along the Jordan River, and three along Mill Creek (Figure 2.2). In addition, sediment samples were collected at locations 186 and 187 along the South Vitro Ditch.

As indicated in Section 3.5, site-related contaminants do not appear to be affecting the Jordan River. Surface water samples from Mill Creek were analyzed for 9 constituents in 1993 (Table 7.1). This screening analysis indicates site-related contaminants in the surface water do not present ecological risk. However this cannot be definitely determined by only one set of samples because seasonal flows and other factors could change water quality significantly.

Sediment samples were collected at all surface water locations in 1993 (Tables 7.2 and 7.3). As with surface water, site-related contaminants do not appear to have affected the Jordan River sediment (Section 3.6). The analysis of sediment samples from Mill Creek in 1993 indicates the constituent concentrations do not increase at the downstream location (sample site 182) and there are no elevated site-related contaminants in the sediment of Mill Creek (Table 7.2).

Table 7.1 Constituents measured in unfiltered surface water in 1993 in Mill Creek, Salt Lake City, Utah, site

	Mill Creek			Aquatic life water quality value	
	Upstream of site	West of railroad tracks	Downstream from sewage outfall		
Constituent	180	181	182	Acute value	Chronic value
Calcium	104	113	85	NA	NA
Chloride	66	67	197	860[a]	230[a]
Magnesium	36	39	35	NA	NA
Molybdenum	<0.01	<0.01	<0.01	NA	50 (0.79)[b]
Selenium	<0.005	<0.005	<0.005	0.02[c]	0.005[c]
Silver	<0.01	<0.01	<0.01	0.01[a]	NA
Sodium	35	39	152	NA	NA
Sulfate	173	173	141	NA	NA
Strontium	1	1	0.78	NA	NA
Uranium	0.002	0.002	0.004	11[c]	7[c]

[a] From EPA (1991), chronic Federal Water Quality Criteria for the protection of freshwater aquatic life; based on unfiltered samples.

[b] No state or federal water quality criteria available. Value presented is the current molybdenum criterion recommended by the U.S. Fish and Wildlife Service for protection of aquatic organisms except for newly fertilized rainbow trout eggs, which are sensitive to molybdenum concentrations above 0.79 mg/L (Eisler, 1989).

[c] From water hardness chronic criteria, state of Colorado (CDH, 1991). Criteria calculated using total hardness of 403 mg/L; based on filtered samples.

NA – criteria not available.
ND – not detected.

Note: Concentrations in milligrams per liter.

Table 7.2 Constituents measured in 1993 in the sediment in Mill Creek, Salt Lake City, Utah, site

Constituent	Mill Creek			Guidelines for potential effects[a]	
	Upstream of site	West of railroad tracks	Downstream from sewage outfall	Lowest effect level	Medium effect level
	180	181	182		
Calcium	76100	64500	8810	NA	NA
Chloride	110	807	165	NA	NA
Magnesium	11000	10900	13400	NA	NA
Molybdenum	<4.6	<4.2	<4.1	NA	NA
Selenium	<2.3	<2.1	<2.1	NA	NA
Silver	<4.6	<4.2	<4.1	1	3.7
Sodium	908	857	1240	NA	NA
Strontium	190	153	83	NA	NA
Sulfate	60	184	67	NA	NA
Uranium	1.3	1.4	1.2	NA	NA

[a]From Long and Morgan (1990).

NA - guideline not available.
ND - not detected.

Note: All concentrations in milligrams per kilogram.

Table 7.3 Constituents measured in 1993 in the sediment in South Vitro Ditch, Salt Lake City, Utah, site

Constituent	South Vitro Ditch		Guidelines for potential effects[a]	
	South end 186	North end 187	Lowest effect level	Medium effect level
Calcium	69800	81700	NA	NA
Chloride	50	130	NA	NA
Magnesium	3710	16500	NA	NA
Molybdenum[b]	6.6	236	NA	NA
Silver	<2.7	<6.4	1	3.7
Selenium	<1.4	<3.2	NA	NA
Sodium	718	1600	NA	NA
Strontium	79	227	NA	NA
Sulfate	99	247	NA	NA
Uranium	3.9	4.8	NA	NA

[a] From Long and Morgan (1990).
[b] Observed range of molybdenum concentrations in samples of soil from the western United States is less than 3 to 7 mg/kg (USGS, 1984).

NA - guideline not available.

Note: All concentrations in milligrams per kilogram.

Sediment samples from the South Vitro Ditch had a high concentration of molybdenum (236 mg/kg) at the north end (sample site 187) and a lower concentration at the south end (6.6 mg/kg) (sample site 186) relative to levels in Mill Creek and the Jordan River (Table 7.3). The molybdenum level at location 187 was higher than the range of molybdenum concentrations found in soils in the western United States (less than 3 to a maximum of 7 mg/kg) (USGS, 1984 and the suggested maximum acceptable concentrations of 37 mg/kg for soils at UMTRA Project sites (JEG, 1986).

Molybdenum in the South Vitro Ditch sediment could enter the biological communities via uptake by aquatic benthic invertebrates and/or plants growing in and near the zone of molybdenum contamination. Molybdenum is absorbed by plants primarily in the water soluble form (Kubota et al., 1961). The amount of molybdenum in soils or sediments that is available to plants varies widely among plant species and soil chemistry. The pH, percent organic matter, water content, and concentrations of elements such as iron, phosphate, and sulfate can affect the availability of molybdenum to plants (Davies, 1956; Kubota et al., 1961). For the South Vitro Ditch, a relatively high concentration of molybdenum is assumed to be available to plants because higher availability of this element has been documented for waterlogged soils. This availability occurs as inundation produces reducing conditions that release molybdenum from iron molybdate (Jarrell et al., 1980). The concentrations of molybdenum in plants growing in and along the South Vitro Ditch were not measured. The amount of molybdenum in the plants at the north end of this ditch was estimated by assuming a transfer coefficient from dry soil to plants of 0.12 (NRC, 1977). This coefficient may underestimate the transfer of molybdenum to plants because, as stated above, more molybdenum may be transferred to plants from waterlogged soil than dry soil. The estimated concentration of molybdenum in plants along the ditch is 28 mg/kg, using the transfer coefficient of 0.12 (DOE, 1995a).

According to Jarrell et al. (1980), molybdenum has never been shown to reach toxic concentrations for field-grown crops. However, it is known to be phytotoxic to some agricultural plants at concentrations of 2 to 10 mg/kg (Kabata-Pendias and Pendias, 1992). If the molybdenum concentration in the plants along the South Vitro Ditch is 28 mg/kg, plant species that are sensitive to molybdenum toxicity may have been negatively impacted. However, it could not be determined with existing data whether plant species growing at the Vitro site could be harmed by this level of molybdenum.

Molybdenum has been shown to be toxic to certain animal species; ruminants such as cattle and sheep are the most sensitive. Generally, 2 to 5 mg/kg of molybdenum in vegetation represents the upper level of tolerance for these animals (Erdman et al., 1978). The potential impact of molybdenum on cattle and sheep is discussed in more detail in Section 7.4. Birds and mammals are comparatively tolerant to a high dietary intake of molybdenum (Eisler, 1989). For example, mule deer tolerate 10 times more molybdenum in their diet than cattle (Jarrell et al., 1980). The molybdenum concentrations in the sediments at the north end of the South Vitro Ditch could pose a potential ecological risk to terrestrial plant and animal communities in the area directly adjacent to the

contaminated sediments; however, the extent of the elevated molybdenum contamination along the South Vitro Ditch is not known.

7.3.2 Ecological risk associated with plant root transport of contaminants

Plant root transport of contaminants to the surface could occur if roots grew into the contaminated unconfined aquifer. Samples of the native material just below the clean fill were collected from nine locations at the site (Figure 2.2). Twenty-four constituents were measured in this material; the high concentrations tended to be in the north, east, and south ends of the site; the lowest concentrations were along the western boundary (sample locations 573, 577, and 578) (Table 7.4). Data regarding soil concentrations that may be phytotoxic are not available for 9 of these constituents. The remaining 15 constituents were compared to soil concentrations screening benchmarks; arsenic, chromium, cobalt, manganese, molybdenum, vanadium, and zinc levels exceeded the benchmarks (Table 7.5). These concentrations were generally found at the center (location 575) and south end (location 572) of the site. The minimum depth of this contaminated material at the 9 boreholes is 8.5 ft (2.6 m) and the average depth is 12 ft (3.7 m).

The species composition of the grass/herb-dominated plant community in the site area is not known but these plants probably have not grown through the fill material into the underlying material for the following reasons:

- Although some grass and herbaceous plant species can send roots down 4 to 6 ft (1 to 2 m) (such as crested wheatgrass and Russian thistle) (Anderson, et al., 1987; Reynolds, 1990), the contaminated material under the fill material is believed to be beyond the reach of most grass and herbaceous plant species.
- Plants growing in the site area can reach water at shallower depths, both from the unconfined aquifer (no deeper than 5 ft [2 m] from the surface) and from irrigation water for the golf driving range.

Because the woody plants and other species growing along the South Vitro Ditch probably obtain water from the ditch, they do not need very deep roots. Therefore, the contamination in the material below the clean fill at the site will not affect the ecosystem.

The unconfined aquifer occurs within 5 ft (2 m) or less of the surface in some areas of the site. This water may be utilized by some plants growing in the grass/herb plant community. The contaminants in this aquifer are potentially toxic to the plants themselves (phytotoxicity) and may move up the food chain via herbivores feeding on the plants. The concentrations of contaminants of potential concern were not measured in plants growing on the site. To determine if the contaminants of potential concern could be phytotoxic, the concentrations of these constituents in the unconfined aquifer were compared to screening

Table 7.4 Constituents detected in the sediments of the shallow unconfined aquifer at the Salt Lake City, Utah, site

	Sample location								
Constituent	0571	0572	0573	0574	0575	0576	0577	0578	0579
Aluminum	17300	11300	11800	5260	12200	17400	3880	8600	7720
Arsenic	14[a]	25[a]	6	32[a]	7	30[a]	5	10[a]	12[a]
Barium	121	144	150	114	218	143	42	90	105
Beryllium	0.85	0.51	0.54	ND	0.56	0.83	ND	ND	ND
Cadmium	0.57	0.40	0.72	0.51	0.75	0.80	ND	0.55	0.57
Calcium	64300	57300	50800	18700	64200	63100	20000	39000	34600
Chloride	247	52	109	49	232	1010	40	171	42
Chromium	21[a]	13[a]	14[a]	10[a]	13[a]	20[a]	5[a]	12[a]	11[a]
Cobalt	9	7	6	5	26[a]	9	6	6	8
Copper	48	49	33	21	39	46	16	28	37
Iron	NM	15400	15300	11600	18200	20700	8130	4600	13500
Lead	26	29	28	17	26	32	7	17	27
Magnesium	18000	18800	14200	8580	18100	16100	6530	13200	14400
Manganese	489	340	305	276	607[a]	495	182	195	228
Molybdenum	ND	8[a]	ND	4[a]	9[a]	2[a]	ND	ND	12[a]
Nickel	19	13	11	6	19	18	7	12	10
Potassium	5760	4070	3950	1340	4900	5980	1370	2300	2290
Silver	1.7	1.3	1.2	NM	2.0[a]	1.7	ND	ND	ND
Sodium	NM	870	501	257	696	2280	159	598	252
Strontium	189	148	111	164	748	149	54	103	68
Sulfate	319	429	150	428	4020	1480	1410	909	834
Uranium	3	3	2	4	10[a]	2	4	2	3
Vanadium	34[a]	28[a]	26[a]	32[a]	34[a]	36[a]	16[a]	22[a]	24[a]
Zinc	96[a]	68[a]	65	36	75[a]	86[a]	34	60[a]	69[a]

[a] At or above the screening benchmark.

ND – not detected.
NM – not measured.

Note: All concentrations in milligrams per kilogram. See Figure 2.2 for location of sample sites.

Ref: DOE (1993); Will and Suter (1994).

Table 7.5 Comparison of deep soil concentration of contaminants of potential concern to screening benchmarks for terrestrial plants

Contaminants of potential concern	Deep soil concentrations[a] (mg/kg)		Screening benchmarks for terrestrial plants[b] (mg/kg)
	Range	Mean	
Arsenic	5-32	16	10
Barium	42-218	125	500
Beryllium	ND-0.85	0.66	10
Cadmium	ND-0.80	0.54	3
Chromium	12-21	13	1
Cobalt	5-26	9	20
Copper	16-49	35	100
Lead	7-32	23	50
Manganese	182-607	346	500
Molybdenum	ND-12	4	2
Nickel	6-19	13	30
Silver	ND-2.0	1.6	2
Uranium	2-10	4	5
Vanadium	16-36	28	2
Zinc	36-96	65	50

[a] Samples collected from nine locations 8 to 16 ft (2 to 5 m) below land surface.
[b] From Will and Suter (1994).

ND – not detected.

Ref.: DOE (1993).

benchmarks for terrestrial plants (Table 7.6). These benchmarks represent concentrations where potential negative effects to some plant species may first become evident. Plant uptake and response to the contaminants varies widely among plant species. Other factors, such as soil characteristics and water chemistry, also can cause wide variations in plant uptake of specific constituents. This analysis was performed to provide an order-of-magnitude estimate of the potential phytotoxicity of these contaminants.

The results of this analysis indicate estimated concentrations of molybdenum slightly exceed the plant screening benchmarks (Table 7.6). Although molybdenum concentrations were not measured in the vegetation at the site, this analysis indicates that molybdenum concentrations in the shallow unconfined aquifer beneath the site may have a slight negative effect on molybdenum-sensitive plants.

As indicated in Section 7.3.1, terrestrial wildlife species are resistant to molybdenum's toxic effects. Any slight impact of molybdenum to terrestrial plants would likely have no impact on wildlife that feed on these plants.

7.3.3 Ecological risk associated with stock ponds and irrigation water

A pond filled with contaminated ground water from the unconfined aquifer may create another hypothetical pathway into the aquatic and terrestrial ecosystem. Fourteen constituents exceed background concentrations in the shallow unconfined aquifer beneath the site (Table 7.7). These concentrations were compared to aquatic life water quality criteria; chloride, iron, and silver levels exceeded these values.

Chloride. The maximum concentration of chloride is 2830 mg/L, much higher than the maximum background level (74 mg/L) as well as the chronic (230 mg/L) and acute criteria (860 mg/L) considered protective of aquatic life (EPA, 1991). Data are not available on the nature and severity of the effects of elevated chloride on aquatic and terrestrial ecological systems.

Iron. The maximum concentration of iron is 6.5 mg/L, which is elevated above the maximum background level of 0.25 mg/L and the chronic Federal Water Quality Criteria of 1.0 mg/L. Data are not available on the severity of the effects of elevated iron on the terrestrial and aquatic ecosystems.

Silver. Other than a concentration of 0.019 mg/L of silver in well 008 in 1991, silver was not detected in monitor wells at the site until October 1992, when it was detected in seven of 10 wells sampled. Concentrations in the seven wells were 1 order of magnitude above the acute toxicity criterion for freshwater (0.0018 mg/L) and 2 orders of magnitude greater than the chronic aquatic life criterion of 0.00012 mg/L. Because the detection limit for silver was 0.01 mg/L, silver levels may have exceeded the aquatic life value at wells where silver was reported as undetected. Therefore, using ground water from the unconfined aquifer as a source for a pond could cause acute and chronic effects

Table 7.6 Comparison of contaminant levels in the unconfined shallow aquifer to screening benchmarks for terrestrial plants

Contaminants of potential concern	Maximum concentration in unconfined shallow aquifer	Screening benchmarks for terrestrial plants[a]
Barium	0.61	NA
Calcium	426	NA
Chloride	2830	NA
Copper	0.01	0.03
Fluoride	2.7	5
Iron	6.5	10
Magnesium	900	NA
Manganese	0.63	4
Molybdenum	0.94	0.5
Potassium	228	NA
Silver	0.041	0.1
Sodium	3160	NA
Strontium	4.4	NA
Sulfate	5560	NA
Uranium	0.27	40

[a] From Will and Suter, 1994.

NA – not available.

Note: Concentrations in milligrams per liter.

Table 7.7 Comparison of contaminant concentrations in the shallow unconfined aquifer to water quality criteria, Salt Lake City, Utah, site

Constituent	Maximum observed concentration	Aquatic life water quality value	Water concentrations protective of livestock[a]	Concentration in irrigation water protective of plants[a]
Barium	0.61	NA	NA	NA
Calcium	4.26	NA	NA	NA
Chloride	2830	230[b]	c	NA
Fluoride	2.7	NA	2.0	1.0
Iron	6.5	1.0[d]	c	5.0
Magnesium	900	NA	c	NA
Manganese	0.63	1.5[e]	NA	0.2
Molybdenum	0.94	50 (0.79)[f]	NA	0.01
Potassium	228	NA	NA	NA
Silver	0.041	0.00012[a]	NA	NA
Sodium	3160	NA	NA	NA
Strontium	44	NA	NA	NA
Sulfate	5560	NA	1000[g]	NA
Uranium	0.27	8.43[h]	NA	NA
Vanadium	0.071	NA	0.1	0.1

[a] From EPA (1973) unless specified otherwise. Irrigation water values shown are for water used continuously on all soils.
[b] From EPA (1991), chronic Federal Water Quality Criteria for the protection of freshwater aquatic life.
[c] Determination of concentration protective of livestock not deemed necessary (EPA, 1973).
[d] From UDEQ (1992); numeric chronic criteria for aquatic life based on a 4-day average concentration. Criteria should not be exceeded more than once every 3 years on the average.
[e] From EPA (1986). Value presented is the lower end of the tolerance range for aquatic life.
[f] Value from Eisler (1989).
[g] From Church (1984).
[h] From water hardness chronic criteria (CDH, 1991).

NA – not available.

on aquatic invertebrates and fish. Negative effects could also be expected for some aquatic plants. For example, some algae had a 96-hour effective concentration (EC) EC-50 of 0.0026 mg/L; effects to vascular plants are unlikely because they had EC-50s ranging from 0.27 to 7.5 mg/L of silver (EPA, 1987).

Bioconcentration factors (BCF) for silver in freshwater fish ranged from 11 to 150 while mean BCFs for freshwater invertebrates were 37 to 84 (EPA, 1987). This indicates that silver could be transported up the food chain and enter the terrestrial environment in a pond using water from the unconfined aquifer.
Another hypothetical pathway is irrigation with contaminated ground water from the unconfined aquifer. The criteria protective of plants (EPA, 1973) were compared to the maximum concentrations for the contaminants of potential concern (Table 7.7). Such criteria exist for 5 of the 15 contaminants of potential concern listed in Table 7.7; fluoride, iron, manganese, and molybdenum exceed these criteria. Excessive fluoride levels in irrigation water can reduce plant yield and the germination. It has also been found that cattle can accumulate relatively high levels of fluoride in their bones (over 2000 mg/kg of bone) if they graze on forage high in fluoride. Iron in irrigation water is not likely to result in plant toxicity. However, iron can decrease the availability of essential elements such as phosphorous and molybdenum. Manganese levels of a few tenths to a few milligrams per liter can be toxic to some crops although this toxicity can be reduced by increasing the pH. Molybdenum concentrations in the unconfined aquifer (maximum concentration of 0.94 mg/L) would not be toxic to irrigated plants. The potential negative effect could be on livestock that fed on the forage irrigated with water from this aquifer.

7.4 POTENTIAL IMPACTS TO LIVESTOCK

Livestock do not graze within the site boundary. However, cattle graze just south of the site and horses are kept west of the site. There are no plans to allow grazing at the site but livestock could be kept within the site boundary in the future.

The constituent concentrations in the surface water do not threaten livestock. However, molybdenum concentrations may be elevated in plants along part of South Vitro Ditch as a result of contaminated sediments and elsewhere at the site as a result of contaminated ground water in the shallow unconfined aquifer. Molybdenum concentration in plants were not measured at the site. However, the estimated molybdenum concentration in plants growing at the north end of the South Vitro Ditch is 28 mg/kg, based on literature values (DOE, 1995a). The concentration of molybdenum in plants that may be rooted in the shallow unconfined aquifer was not estimated. The estimated concentration in the ditch exceeds the limits (2 to 5 mg/kg) of molybdenum in forage that can be tolerated by cattle (Erdman et al., 1978). The negative effects of molybdenum can be offset if the ratio of copper to molybdenum is at least 2 to 1 (Erdman et al., 1978). However, the copper-to-molybdenum ratio at the site is unknown at present. Therefore, it cannot be determined with existing data whether molybdenum levels could affect cattle or sheep if they were grazing in the site area in the future.

A hypothetical pathway for contaminants from the unconfined aquifer to enter the environment would be the construction of a pond which uses this water. Values that are considered protective of livestock water supplies are available for 3 of the 15 constituents that exceed background concentrations in the unconfined aquifer (Table 7.7). Fluoride and sulfate exceed these values. Cattle drinking water with as little as 2 mg/L fluoride suffer from tooth mottling, but a much larger increase in fluoride concentrations is required before other harmful effects are observed (EPA, 1973). Sulfate concentrations are highly elevated in the unconfined aquifer and consuming this water could result in diarrhea (Church, 1984).

7.5 UNCERTAINTIES OF THE ECOLOGICAL RISK ASSESSMENT

The qualitative evaluation of potential ecological risks presented here is a screening-level assessment of the risks associated with potential exposure of plants and animals to contaminated ground water, surface water, and sediment at the Salt Lake City site. Sources of uncertainty in any ecological assessment arise from the monitoring data, exposure assessments, toxicological information, and inherent complexity of the ecosystem. In addition, methods of predicting nonchemical stresses (e.g., drought), biotic interactions, behavior patterns, biological variability (i.e., differences in physical conditions, nutrient availability), and resiliency and recovery capacities often are unavailable. The Salt Lake City ecological risk assessment includes the following general limitations:

- Only a small amount of ecological data were collected during this screening.
- General literature values were used in many cases because little is known about site-specific intake rates for wildlife and the amounts of contaminants taken up by plants.
- Ecotoxicological reference data are limited.
- Considerable uncertainty is associated with the toxicity of multiple contaminants.

7.6 SUMMARY

Surface water sampling from the Jordan River indicates that these waters are not contaminated as a result of uranium processing at the Salt Lake City site. As discussed in Section 3.6, Mill Creek may be receiving a small amount of uranium from the site. However, this conclusion is based on limited sampling.
Site-related contaminants were identified in sediment samples from these water bodies only in the South Vitro Ditch, where a high molybdenum concentration was encountered at one location. The molybdenum contamination in these sediments has a potential to affect the aquatic organisms in the ditch and the wetland plants adjacent to the ditch. However, it cannot be determined with existing data whether these levels of molybdenum could harm plant species growing on the site.

After tailings cleanup, an average of 12 ft (4 m) of clean fill was deposited on the site. Concentrations of arsenic, chromium, cobalt, manganese, molybdenum, and zinc in the native material below this clean fill are at levels above screening benchmarks for terrestrial plants. However, it is believed that few if any plants are sending roots into this material because of its depth and the availability of water at shallower depths.

Plants may be sending roots into the shallow unconfined aquifer because this water is available at a depth of 5 ft (2 m) or less in some locations. The concentrations of constituents in the contaminated alluvial aquifer were compared with screening benchmarks for terrestrial plants, and molybdenum was the only constituent to exceed these benchmarks. This constituent was just above the benchmark, indicating only slight effects, if any, would be seen in the vegetation.

A hypothetical pathway to ecological receptors considered was a pond filled with contaminated water from the unconfined aquifer. It was determined that concentrations of chloride, iron, and silver would exceed the chronic federal water quality criteria for protection of aquatic life, while chloride and silver would also exceed the acute federal water quality criteria.

Water from the unconfined aquifer has concentrations of fluoride, iron, manganese, and molybdenum that are not suitable for livestock. Livestock do not graze on the site and there are no future plans for irrigation. Using water from the unconfined aquifer in a pond would likely result in water high in fluoride and sulfate which could have deleterious effects on livestock.

8.0 INTERPRETATION AND RECOMMENDATIONS

8.1 RISK SUMMARY

The UMTRCA requires the UMTRA Project to protect public health and the environment from radiological and nonradiological hazards associated with the uranium mill sites. This baseline risk assessment was conducted for the contaminated ground water at the former Salt Lake City uranium processing site to evaluate the presence of these hazards. This risk assessment is conservative in the sense that it evaluates the residential exposure scenario associated with the highest exposure level from drinking the water from the most contaminated wells on the site. Because contaminated ground water is not currently used by area residents, human health is not at risk. This situation will continue if land and water use at the site remain the same. Changes of land use may or may not create future risks. When specific land uses are determined for the site, these uses should be evaluated to identify potential health and environmental risks from the contaminated ground water.

Health risks could be associated with potential future use of contaminated ground water from the unconfined (shallow) aquifer. However, the likelihood of such use is considered low because the natural quality of the water from this aquifer is considered poor in the site area (Minor, 1995; USGS, 1984; DNR, 1971) due to naturally high levels of total dissolved solids. If background ground water in the shallow aquifer near the site were used as drinking water, ambient levels of arsenic could result in an increased skin cancer risk of about 1 in 1000 (DOE, 1995a). This risk level would exceed the EPA's Superfund National Contingency Plan (NCP) guidance by a factor of 10. Note, however, that in the future residential scenario, only the people who drilled a well in the most contaminated portion of the aquifer (a fraction of the site) could experience the health problems discussed below. Drinking the water from a future well drilled further off the site could be associated with risks lower than estimated here. Furthermore, the ground water contaminant concentrations will decline over time.

The risks associated with future ground water use of the unconfined aquifer for drinking purposes are unacceptable for sulfate, magnesium, fluoride, manganese, molybdenum, sodium, and chloride. The sulfate in this water is potentially in the severe toxicity range, particularly for infants following short-term exposure. Sulfate levels are associated with severe diarrhea, which could lead to dehydration. The effect is reversible and diarrhea would terminate after the substitution of water low in sulfate for contaminated water.

Although the sulfate toxicity could preclude chronic exposures, the effects from long-term exposures to contaminants other than sulfate are also discussed. The magnesium concentration in the contaminated ground water could enhance the severity of sulfate-induced diarrhea, and could depress the central nervous system, especially if the kidney function was impaired for other reasons. The fluoride levels could result in dental fluorosis in children. The manganese and molybdenum concentrations could be associated with the development of mild neurological

symptoms and copper deficiency, respectively. Finally, the sodium chloride level could result in hypertension in sensitive people. Diarrhea-induced dehydration may enhance the toxicity of other contaminants, especially magnesium, manganese, and molybdenum.

In addition to human health risks, the concentrations of molybdenum, fluoride, manganese, and iron may limit the potential use of ground water for irrigating crops and pasture. Sulfate, fluoride, and molybdenum concentrations preclude watering livestock with contaminated ground water. Concentrations of chloride and iron in the contaminated ground water are toxic to many aquatic organisms, precluding its use in a stock pond.

Moreover, high molybdenum concentrations in the South Vitro Ditch sediments may have toxic effects on the aquatic organisms within the ditch and the wetland plants adjacent to the ditch.

8.2 LIMITATIONS OF THIS RISK ASSESSMENT

The following limitations to this evaluation of health and environmental risks should be noted:

- Uncertainties regarding potential future contamination of the confined aquifer.
- Uncertainties from ongoing site development.
- Uncertainties arising from the use of filtered versus unfiltered water samples. In general, the results presented in this document are based on filtered (0.45 μm) water samples. The effect of filtration differs for different elements. Constituents in suspension may be lost with filtration, but can still produce toxic effects if ingested and broken down in the acidic environment of the stomach. If concentrations of iron and lead measured in the unfiltered ground water sample from monitor well 131 represent true values, ingesting this water would be associated with toxic effects from the levels of these elements. Because a high degree of uncertainty (see Section 3.0) is associated with these results, they could not be used in this risk evaluation.
- Contaminant toxicities vary from person to person. Presenting probability distributions (for potential exposure) and exposure ranges that can produce toxic effects emphasizes these variabilities. However, it is not possible to account for all sources of variability and still present useful and meaningful analyses.
- Specific subpopulations known to be more sensitive to toxicity of given constituents are noted. Exposure ranges and distributions for expected toxic effects enhance understanding of the potential for toxicity occurrence.

- Standardized reference values from regulatory agencies and literature values are used to determine toxic effects in humans. However, some data obtained from laboratory animal testing at exposure doses different from those expected at the site were used to determine toxicity. The relationship between dose and response is not always linear, and humans do not always exhibit the same responses as animals. Additionally, data used to determine toxicity generally are based on exposure to only the constituent of concern. In reality, exposures generally occur simultaneously to multiple constituents. The interactive effects of multiple constituents and the impact of these interactions on expected toxicity generally cannot be accurately assessed from existing data.

- Considerable effort went into determining the areal extent of contaminated ground water and its movement, and placing monitor wells in locations that capture maximal contamination. Variability in physical systems and models used to determine contaminant plume migration could still result in well placements that do not measure the highest contaminant concentrations or determine the fullest extent of plume impact. On the other hand, because the major source of contamination (the tailings and contaminated soils) at the Vitro site has been removed, the assumption of a constant source used in this risk assessment may lead to an overestimation of risks. Because the contaminant concentrations could be higher or lower than those used in the analysis, the net effect of these uncertainties on future risk estimates cannot be predicted at this time.

- Variability can be introduced through sampling and analytical processes. However, the data at UMTRA Project sites have been collected over many years and subjected to rigorous quality assurance procedures to minimize this source of variability. Testing multiple samples introduces high confidence in the reliability and validity of the collected data.

- Due to insufficient data, the incremental contribution from the ground water-irrigated produce ingestion pathway could not be estimated in this risk assessment. Therefore, the possibility of exposure from this pathway may need to be evaluated.

- The limitations for the Salt Lake City ecological risk assessment include limited amounts of ecological data collected during this screening, little knowledge about site-specific intake rates for wildlife or amounts of contaminants taken up by plants, limited ecotoxicological reference data, and considerable uncertainty associated with the toxicity of mixed contaminants.

Presenting ranges of toxic effects, probable exposure distributions, summaries of available data on health effects and interactions, and outlines of potential limitations ensures a reasonable interpretation of potential health risks associated with ground water contamination at this site. This assessment describes

contamination and risk as accurately as possible, based on available data, and conveys areas of uncertainties.

8.3 GROUND WATER CRITERIA

In 1983, the EPA established health and environmental protection standards for the UMTRA Project (40 CFR Part 192). The standards were revised and the final rule was published on 11 January 1995 (60 FR 2854 (1995)). The ground water standards consist of ground water protection standards to evaluate disposal cell performance and ground water cleanup standards for existing contamination at processing sites. Concentration limits for constituents at the site are summarized in Table 8.1. Maximum concentration limits (MCL) are not established for every contaminant; for contaminants without MCLs, background levels must be met. The standards also allow for supplemental standards or alternate concentration limits, where appropriate.

In general, EPA ground water standards are sufficient to protect human health and the environment. However, some risk assessments may identify site-specific factors that suggest these standards are not appropriate. When standards are too restrictive as, for example, when there may be no potential for exposure, a less restrictive alternate concentrate limit may be sought.

While these ground water protection and cleanup standards apply specifically to the UMTRA Project, the EPA has also published drinking water health advisory (EPA, 1993) levels for long- and short-term exposures to contaminants in ground water (Table 8.1).

The following contaminant concentrations in contaminated wells in the unconfined aquifer have consistently exceeded the EPA ground water standards and/or the EPA health advisory levels: antimony, arsenic, molybdenum, selenium, and uranium. Arsenic exceeded its MCL, and antimony exceeded its health advisory level in background well 007.

8.4 RISK MITIGATION MEASURES

Use of the contaminated ground water from the shallow, unconfined aquifer below the Salt Lake City former uranium processing site could cause health problems. Although the former processing site is in an urban area, adjacent to local residences, water from the unconfined aquifer is not known to be used for any purpose. Although drilling a shallow well does not require a permit, the county may withhold a water supply approval if samples from the well do not meet the quality requirements of the State of Utah Public Drinking Water Regulations (SLCC, 1981; Minor 1995). However, the standards and regulations applicable to uses other than domestic purposes are not clear. Note, however, that contaminated ground water expresses itself in the South Vitro Ditch, creating possible exposure pathways to environmental receptors.

Table 8.1 Concentration limits of constituents

Constituent	EPA MCL for UMTRA (mg/L)	Health advisories 10-kg child, 10-day[a] (mg/L)	Health advisories 70-kg adult, lifetime[a] (mg/L)
Chemical (inorganic)			
Antimony	NA	0.01[b,c]	0.003[b,c]
Arsenic	0.05[B,C]	NA	NA
Barium	1.0	NA	2
Boron[d]	NA	0.9	0.6
Cadmium	0.01	0.04	0.005
Chromium	0.05	1.0	0.1
Lead	0.05	NA	0.015[e]
Mercury	0.002	NA	0.002
Molybdenum	0.1[C]	0.04[c]	0.04[c]
Nickel	NA	1.0	0.1
Nitrate (as NO_3^-)	44[F]	44[g]	NA
Selenium	0.01[C]	NA	NA
Silver	0.05	0.2	0.1
Strontium	NA	25.0	17
Thallium	NA	0.007	0.0004
Zinc	NA	6.0	2
Radionuclide			
Radium-226/-228	5 pCi/L	NA	NA
Uranium (U-234/-238)	30 pCi/L[c] (0.044 mg/L)	0.03 mg/L[c,h,i]	0.1 mg/L[c,h]

[a]Drinking Water Regulations and Health Advisories (1995). Office of Water, U.S. Environmental Protection Agency, Washington, D.C.
[b]Exceeded in background well samples.
[c]Exceeded in contaminated well samples.
[d]Not monitored from 1990 to 1994.
[e]Action level.
[f]Equals 10 mg/L nitrate as nitrogen.
[g]Under review.
[h]Proposed value under review; revision expected in 1995.
[i]Longer-term health advisory.

NA - not available.

State of Utah

The state of Utah requires that permits for new ground water wells must be obtained from the state engineer's office. The Salt Lake City/County Health Department regulation #11, Individual Water Systems, requires that an effective geologic seal exist between the ground surface and the water bearing aquifer and that the annular space between the drilled hole and the well casing be grouted at least 100 ft (30 m) below surface, or into an effective geologic seal. The regulations also require that water supply wells be isolated from concentrated sources of pollution for a distance of at least 100 ft (30 m). The county health department approves of water use from the shallow aquifer wells (aquifer above the confined aquifer) based on whether or not samples are potable (Minor, 1995).

The permits ensure that wells are constructed properly and that the quantity of water withdrawn is acceptable. The state engineer's office also has the authority to order repairs, capping, or plugging for any well to prevent ground water pollution or contamination. This office also has the authority to bring suit to prevent ground water pollution.

The state of Utah established a precedent when it restricted withdrawal of ground water. The state engineers' office has developed a Salt Lake Valley Ground Water Management Plan that uses the state engineer's authority to restrict new withdrawals of ground water to protect ground water quality.

Surface water in the state of Utah is classified by permissible uses (for example, drinking, swimming, or boating). If a permitted point source threatens the classification of a surface water body, a National Pollutant Discharge Elimination System permit would be enforced, the discharge would be cleaned up, and the classification would be maintained. If adequate information on a surface water body is not available when a classification is assigned, or if new information becomes available, the Water Quality Board may reclassify a surface water body. However, classification is considered a permanent (not temporary) water quality assessment. Ideally, ground water classification is upgraded over time, rather than downgraded due to degradation from human activities and pollution (Wham, 1994).

Salt Lake City/Salt Lake County

South Salt Lake City's environmental and health programs are administered through combined city and county agencies. The Bureau of Water Quality and Hazardous Waste for Salt Lake City and Salt Lake County has the authority to assist the state departments of environmental quality and health in notifying residents about health hazards. In the past, residents were notified through posted health warnings, press conferences, and press releases (Minor, 1994; Wham, 1994).

8.5 RESULTS OF THE DECEMBER 1994 SAMPLING ROUND

After this risk assessment was prepared, validated data were obtained from the December 1994 sampling round. Samples of ground water were analyzed as part of the routine ground water monitoring of the site. Surface water and sediment samples were collected and analyzed in response to data gaps identified during the preparation of this risk assessment. This section briefly discusses the results of that sampling event; however, in many cases, these are the first samples taken for specific locations and media. As such, additional sampling will be required in some cases to confirm the findings.

Ground Water

December 1994 ground water sampling results (Table 8.2) were generally within the range of previous analytical results, although previously observed maximum values for iron, potassium, and molybdenum were exceeded by about a factor of 2 or less. The higher levels of iron (13.9 mg/L versus a previous maximum of 6.5 mg/L) and potassium (308 mg/L versus a previous maximum of 228 mg/L) are still below thresholds for toxicity in humans and livestock and therefore not a toxicological issue (DOE, 1995a). The higher molybdenum concentration in a filtered sample from well 131 (1.4 mg/L versus a previous maximum of 0.94 mg/L) is still in the range of mild toxicity to humans, as discussed in Section 6.1. The higher molybdenum value does not change the assessment of ecological risks from ground water discussed in Sections 7.3.2 through 7.4.

Vanadium, not previously identified as a contaminant of concern, was detected in ground water during the December 1994 sampling. The results indicate that this constituent needs to be monitored for in plume wells as well as in background to verify these data and to determine their relation, if any, to the site.

Analyses of arsenic in an upgradient monitoring well (006) further demonstrate the presence of arsenic as both dissolved and suspended forms in background ground water near the site. In addition, the occurrence of copper, iron, and lead as suspended particulates in unfiltered samples from this well indicates that these constituents are present in background.

Surface water results

A second screen sampling of surface water in Mill Creek at locations upstream and downstream of the site confirmed previous results, including uranium at higher levels downstream than upstream of the site (Table 8.3). In addition, the new data indicate higher levels of arsenic, molybdenum, and silver at the downstream location. These data indicate the need for further sampling to determine whether these increases are site related, related to discharge of treated sewage from the CVWRF, or whether they come from some other source.

Table 8.2 Summary of December 1994 ground water quality data, filtered samples (unless otherwise specified), unconfined aquifer, Salt Lake City, Utah, site[a]

	Monitor well location							
	0006		0007		0008		0130	
Parameter	F	U	F	U	F	U	F	U
Aluminum	<0.05	25.0	<0.05	0.24	<0.05	3.88	<0.05	<0.05
Ammonium[b]	NA	55.6	NA	9.58	NA	11.0	NA	18.0
Arsenic	0.080	0.150	0.034	0.03	0.017	0.016	0.085	0.077
Barium[b]	0.15	0.57	0.12	0.13	0.23	0.41	0.35	0.34
Calcium[b]	75.9	NA	12.6	NA	91.8	NA	52.9	NA
Chloride[b]	NA	342	NA	69.0	NA	925	NA	296
Chromium	<0.01	0.03	<0.01	<0.01	<0.01	0.02	<0.01	<0.01
Copper	<0.02	0.22	<0.02	<0.02	<0.02	0.03	<0.02	<0.02
Fluoride[b]	NA	0.38	NA	0.71	NA	0.55	NA	0.63
Iron[b]	0.21	47.5	0.06	0.90	0.90	13.9	2.27	2.26
Lead	<0.003	0.550	<0.003	0.003	<0.003	<0.003	<0.003	<0.003
Magnesium[b]	68.0	NA	37.0	NA	151	NA	101	NA
Manganese[b]	0.53	NA	0.03	NA	0.11	NA	0.20	NA
Molybdenum[b]	<0.01	NA	<0.01	NA	<0.01	NA	0.19	NA
Potassium[b]	58.5	NA	35.2	NA	52.5	NA	67.6	NA
Radium-226[b,c]	0.3	NA	0.3	NA	1.0	NA	0.7	NA
Silica	NA	162	NA	26.9	NA	46.7	NA	30.8
Silver[b]	<0.0002	NA	<0.0002	NA	<0.0002	NA	<0.0002	NA
Sodium[b]	230	NA	130	NA	380	NA	270	NA
Strontium[b]	0.80	NA	0.22	NA	1.42	NA	0.57	NA
Sulfate[b]	NA	56	NA	4.7	NA	2020	NA	214
TDS	1220		565		5350		1470	
Uranium[b]	0.003	NA	<0.001	NA	0.005	NA	0.002	NA
Vanadium	ND		ND		ND		ND	

Table 8.2 Summary of December 1994 ground water quality data, filtered samples (unless otherwise specified), unconfined aquifer, Salt Lake City, Utah, site[a] (Concluded)

	Monitor well location									
	0131		0132		0133		0134		0136[d]	
Parameter	F	U	F	U	F	U	F	U	F	U
Aluminum	<0.05	<0.05	<0.05	0.93	<0.05	0.08	<0.05	<0.05	<0.05	0.12
Ammonium[b]	NA	0.45	NA	15.3	NA	8.56	NA	8.66	NA	4.56
Arsenic	0.145	0.14	0.105	0.100	0.090	0.088	0.048	0.057	0.012	0.015
Barium[b]	<0.10	<0.10	0.20	0.20	0.22	0.22	0.55	0.54	<0.10	<0.10
Calcium[b]	71.3	NA	56.3	NA	85.9	NA	171	NA	156	NA
Chloride[b]	NA	745	NA	223	NA	373	NA	136	NA	2760
Chromium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper	0.04	0.04	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Fluoride[b]	NA	1.37	NA	0.77	NA	1.00	NA	0.64	NA	1.72
Iron[b]	0.07	0.05	2.17	3.73	3.57	3.63	2.56	2.42	2.09	2.22
Lead	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.03
Magnesium[b]	224	NA	58.6	NA	124	NA	116	NA	907	NA
Manganese[b]	0.51	NA	0.24	NA	0.51	NA	0.23	NA	0.18	NA
Molybdenum[b]	1.39	NA	0.72	NA	0.02	NA	0.02	NA	0.07	NA
Potassium[b]	91.3	NA	58.0	NA	77.9	NA	39.0	NA	308	NA
Radium-226[b,c]	0.4	NA	0.4	NA	0.8	NA	0.8	NA	0.4	NA
Silica	NA	25.7	NA	36.1	NA	30.3	NA	23.5	NA	30.5
Silver[b]	0.0002	NA	<0.0002	NA	<0.0002	NA	<0.0002	NA	0.0021	NA
Sodium[b]	580	NA	320	NA	280	NA	140	NA	2790	NA
Strontium[b]	1.46	NA	0.70	NA	1.08	NA	2.05	NA	4.09	NA
Sulfate[b]	NA	706	NA	297	NA	292	NA	829	NA	4750
TDS	2990		1330		1640		1480		12700	
Uranium[b]	0.067	NA	0.001	NA	0.101	NA	0.049	NA	0.057	NA
Vanadium	0.03		ND		ND		ND		ND	

[a] All contaminant concentrations are in mg/L, except as noted.
[b] Contaminant of potential concern.
[c] Units are pCi/L.
[d] Former well 135.

NA – not analyzed.
TDS – total dissolved solids.
F – filtered sample.
U – unfiltered sample.

Table 8.3 Summary of Mill Creek surface water quality data, December 1994, Salt Lake City, Utah, site

Parameter	Upstream location 180 Filtered	Upstream location 180 Unfiltered	Downstream Location 182 Filtered	Downstream Location 182 Unfiltered
Inorganic constituents				
Alkalinity as $CaCO_3$	NA	225	NA	244
Aluminum	0.05	0.13	<0.05	<0.05
Ammonium	NA	0.26	NA	0.79
Arsenic	<0.005	<0.005	0.006	0.006
Barium	<0.10	<0.10	<0.10	<0.10
Calcium	116	NA	93	NA
Chloride	NA	122	NA	279
Chromium	<0.01	<0.01	<0.01	<0.01
Copper	<0.02	<0.02	<0.02	0.02
Fluoride	NA	0.22	NA	0.63
Iron	<0.03	0.26	0.04	0.10
Lead	<0.003	<0.003	<0.003	<0.02
Magnesium	39	NA	42	NA
Manganese	0.02	0.02	0.03	0.03
Molybdenum	<0.01	<0.01	0.01	0.02
pH	NA	7.94	NA	6.92
Potassium	4.0	NA	20.7	NA
Silica	21	20	23	22
Silver	<0.0002	<0.0002	0.0002	0.0005
Sodium	71	NA	180	NA
Strontium	1.1	1.1	0.94	0.92
Sulfate	NA	138	NA	133
Total dissolved solids	729	NA	960	NA
Uranium	0.001	0.002	0.007	0.007
Vanadium	<0.01	<0.01	<0.01	<0.01
Radionuclide				
Radium-226	0.1	0.1	0.0	0.1

Notes: 1. Inorganic constituent concentrations in milligrams per liter, except for pH (standard units). Radionuclide radium-226 in picocuries per liter.
2. < indicates less than the given method detection limit.

NA – not analyzed.

Surface water in South Vitro Ditch and Vitro Ditch was sampled for the first time in December 1994. The results indicate the presence above the detection limit of dissolved species of uranium and molybdenum (Table 8.4). These constituents are known to be present in contaminated ground water at the site, and their occurrence suggests that these surface water bodies are receiving contaminated ground water. In addition, dissolved vanadium is present in South Vitro Ditch.

A first-time screening of Vitro Ditch in the marshy area east of the site indicates the presence of arsenic, barium, copper, iron, lead, and silver as suspended particulates in surface water at that location. These constituents were also found in surface water at the confluence of Vitro and South Vitro Ditches (location 187, Table 8.4). It is reasonable to suggest that these constituents are not site-related considering that these elements occur naturally in copper deposits within the drainage basin of the Salt Lake Valley and that several of these constituents are also found (as suspended particulates) in shallow ground water from upgradient monitoring well 006.

8.6 RECOMMENDATIONS

The shallow ground water under the site is not considered potable. Current restrictions on using ground water from the shallow aquifer for drinking should be maintained until the water quality improves.

Monitoring water levels of both the unconfined and the confined aquifers is recommended. It is not possible at this time to model and evaluate the potential drawdown effects to the confined aquifer due to pumping of the proposed municipal well. Therefore, if the municipal well is to be used, the drawdown effects should be evaluated at that time.

The off-site extent and depth of ground water contamination in the unconfined aquifer should be identified during future characterization and remedial planning activities by installing monitor wells downgradient (to the west, northwest, and north). Better characterization of background ground water and surface water quality and surface water and sediment contamination may also be part of this future field work. One possible focus of this effort is the molybdenum in South Vitro Ditch sediments and possibly in nearby vegetation. Ground water monitoring in the unconfined aquifer should continue. Future field plans will describe the sampling locations, analytes, and frequencies.

Table 8.4 Summary of Vitro Ditch and South Vitro Ditch surface water quality data, December 1994, Salt Lake City, Utah, site

	South Vitro Ditch (on site)				Vitro Ditch (east of site)	
	South end Location 186		North end at confluence with Vitro Ditch Location 187		Location 191	
Parameter	Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
Inorganic Constituents						
Alkalinity as $CaCO_3$	NA	296	NA	267	NA	85
Aluminum	<0.05	0.12	<0.05	0.71	<0.05	1.68
Ammonium	NA	0.61	NA	0.63	NA	0.31
Arsenic	0.026	0.028	0.017	0.022	<0.005	0.008
Barium	<0.10	<0.10	<0.10	0.10	0.10	0.11
Calcium	79	NA	93	NA	76	NA
Chloride	NA	240	NA	324	NA	769
Chromium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper	<0.02	<0.02	<0.02	0.03	<0.02	0.03
Fluoride	NA	0.68	NA	0.66	NA	0.35
Iron	<0.03	0.21	<0.03	1.18	0.12	2.11
Lead	<0.003	<0.003	<0.003	0.014	<0.003	0.021
Magnesium	56	NA	63	NA	34	NA
Manganese	0.04	0.04	0.06	0.08	0.15	0.16
Molybdenum	0.12	0.12	0.14	0.13	0.01	0.01
pH	NA	7.53	NA	7.55	NA	7.43
Potassium	22.4	NA	24.7	NA	10.6	NA
Silica	21	22	23	24	7	17
Silver	<0.0002	<0.0002	<0.0002	0.0003	0.0002	0.0004
Sodium	200	NA	250	NA	510	NA
Strontium	0.87	0.84	0.90	0.88	0.61	0.61
Sulfate	NA	179	NA	242	NA	138
Total dissolved solids	1040	NA	1220	NA	1710	NA
Uranium	0.024	0.023	0.037	0.028	0.008	0.008
Vanadium	0.04	0.04	0.03	0.03	<0.01	<0.01
Radionuclide						
Radium-226	0.3	0.3	0.3	0.3	0.1	0.2

Notes:
1. Inorganic constituent concentrations in milligrams per liter, except for pH (standard units). Radionuclide radium-226 in picocuries per liter.
2. NA - not analyzed.
3. < indicates less than the given method detection limit.

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Attachment C

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Hydrogeologic Characterization of the Former Vitro Processing Site Salt Lake City, Utah

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Final

January 1993

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HYDROGEOLOGIC CHARACTERIZATION OF THE FORMER VITRO PROCESSING SITE SALT LAKE CITY, UTAH

FINAL

January 1993

U.S. Department of Energy
UMTRA Project Office
Albuquerque, New Mexico

EXECUTIVE SUMMARY

During fiscal year (FY) 1992, the U.S. Department of Energy (DOE) received Congressional direction to investigate whether contamination from former processing activities is present in groundwater and soils at the former Vitro processing site in Salt Lake City, Utah. A total of $100,000 was appropriated for this activity. The surface of the Vitro site was cleaned up by the state of Utah under the Uranium Mill Tailings Remedial Action (UMTRA) Project during the mid- to late 1980s. The basis for the directive was the desire of the site owners, the Central Valley Water Reclamation Facility (CVWRF), to develop the site. This report, as well as the final Vitro Site Certification Report and the Clive Completion Report (both to be prepared and submitted by the state of Utah), will have to be reviewed and concurred with by the U.S. Nuclear Regulatory Commission (NRC) prior to release of the Vitro site for restricted development.

The groundwater and soil investigation was performed by the Technical Assistance Contractor (TAC) to the DOE UMTRA Project Office during FY92. The investigation at the Vitro site consisted of the installation of monitoring wells and soil borings, aquifer testing, and the collection and analyses of groundwater and soil samples. The results of the investigation are as follows:

- The groundwater regime under the site is generally characterized by two aquifer systems: a near-surface unconfined system and a deeper confined system. Near the Vitro site, groundwater in both aquifers flows to the west-northwest.

- The average linear groundwater velocity in the shallow unconfined aquifer is 4 feet per year (ft/yr) [1.3 meters per year (m/yr)].

- Residual contamination consisting of molybdenum, sulfate, and uranium, most likely derived from the former Vitro tailings, exists in the soils at levels above background underlying the central area of the site.

- Contamination exists in groundwater in the shallow unconfined aquifer as a result of uranium processing activities. The highest concentrations of chloride, sodium, sulfate, and total dissolved solids (TDS) occur at monitor well 135, near the center of the site. The contamination extends off the site to the west-northwest, with the highest concentrations of uranium observed in the northwestern corner of the site and off-site to the west.

- Historically, groundwater on-site and off-site in the shallow unconfined aquifer has had elevated concentrations of chloride, sodium, sulfate, TDS, and uranium. This is consistent with the on-site groundwater quality conditions found during this investigation.

- No contamination associated with the former tailings pile was found in levels exceeding background in groundwater in the deeper confined aquifer system.

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1.0 INTRODUCTION

The former Vitro processing site (Vitro), located in Salt Lake City, Utah, was one of 24 inactive uranium mill sites designated to be cleaned up by the DOE under the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA). Part of UMTRCA requires that the NRC concur that the remedial action conducted at the site complies with the standards proposed by the U.S. Environmental Protection Agency (EPA).

Remedial action at the Vitro site occurred during 1985 to 1987. A total of 2,798,000 cubic yards (yd^3) [2,139,000 cubic meters (m^3)] of tailings were removed from Vitro, and stabilized in a disposal cell located at Clive, Utah. The state of Utah, through a cooperative agreement with the DOE, was the remedial action contractor (RAC) for the project. As the RAC, the state of Utah was responsible for removing the tailings from Vitro and submitting a site certification report to the DOE for NRC concurrence, certifying that the surface is free of contamination. Typically, the DOE requires the UMTRA RAC to submit one comprehensive completion report at project end, detailing all remedial action activities. However, in order to facilitate the early release of the Vitro site for restricted development, the DOE, with NRC concurrence, authorized the state of Utah to submit a separate certification report on Vitro. The state of Utah is also responsible for submitting a completion report for the Clive disposal cell, with as-built drawings and construction records showing that work was completed within NRC regulations. The completion report is to be submitted to the DOE for NRC concurrence. To date, the DOE has not received a copy of the Clive completion report.

The current owners of the Vitro site, the CVWRF, want to develop the vacant southern half of the site, but have been unable to do so because the state has only recently (December 1992) submitted the site certification report for NRC concurrence. The CVWRF, through Congressional channels, solicited support to facilitate the release of the Vitro site. As a result of the CVWRF request, Congress budgeted $100,000 during FY1992 for the DOE to perform a groundwater and soil study at the Vitro site. The purpose of this report is to present the results of the hydrogeologic investigation performed at the Vitro site during FY1992.

2.0 SITE HISTORY

The 128-acre Vitro site (named for an early plant operator, Vitro Chemical Company) is located 4 miles (mi) [6.4 kilometers (km)] south-southwest of the center of Salt Lake City (Figure 2.1). The site is at the northeast corner of the intersection of 3300 South Street and 900 West Street in the City of South Salt Lake. The CVWRF sewage treatment plant is located on adjacent property north of the central portion of the site. The entire site is now owned by the CVWRF Board. The site is bounded on the north by the CVWRF and the channel of Mill Creek, on the east by the Denver and Rio Grande Western Railroad, on the south by 3300 South Street, and on the west by 900 West Street. A 5.4-acre (ac) [2.2-hectare (ha)] industrial area occupies a 225-ft (70-m) wide strip adjacent to the west edge of the south half of the site facing 900 West Street. Another industrial facility is situated adjacent to the southeast corner of the site. The nearest residences to the Vitro site are approximately 300 ft (90 m) away from the southwestern corner, across 3300 South Street.

In 1941, a large smelter was completed on 3300 South Street and 900 West Street in Salt Lake City. For 5 years this smelter was operated by the Calunite Smelter, Inc. 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 with the United States Atomic Energy Commission (AEC). From 1951 to 1964, the Vitro plant processed uranium ores by acid leaching. During this period, the plant processed 1.7 million dry tons (1.5 million metric tons) of ore with an average grade of 0.32 percent uranium oxide (U_3O_8) and produced 4787 tons (4342 metric tons) of U_3O_8 in concentrate. In 1965, the mill was converted to the production of vanadium. Vanadium production ceased in 1968. Approximately 106,000 dry tons (96,000 metric tons) of vanadium-bearing material were processed. The plant was dismantled in 1970.

Clive, Utah, in Tooele County, was selected as the site to which the Vitro tailings would be relocated. The first tailings left the Vitro site for Clive by rail on July 2, 1985. Ninety percent of the tailings were removed in the next 11 months. In December 1986, the state directed the contractor, the Argee Corporation, to terminate work on the project, which was done in March 1987.

To complete the project, the state issued a request for proposals in April 1987 and the Tolboe Construction Company was awarded the contract in June 1987. The remaining 10 percent of the tailings were removed as of November 20, 1987.

A total of 4.3 million tons (3.9 million metric tons), or 2,798,000 yd^3 (2,139,000 m^3), of tailings were removed from the site. In the few months following, the Clive site was stabilized with earth and rock protection.

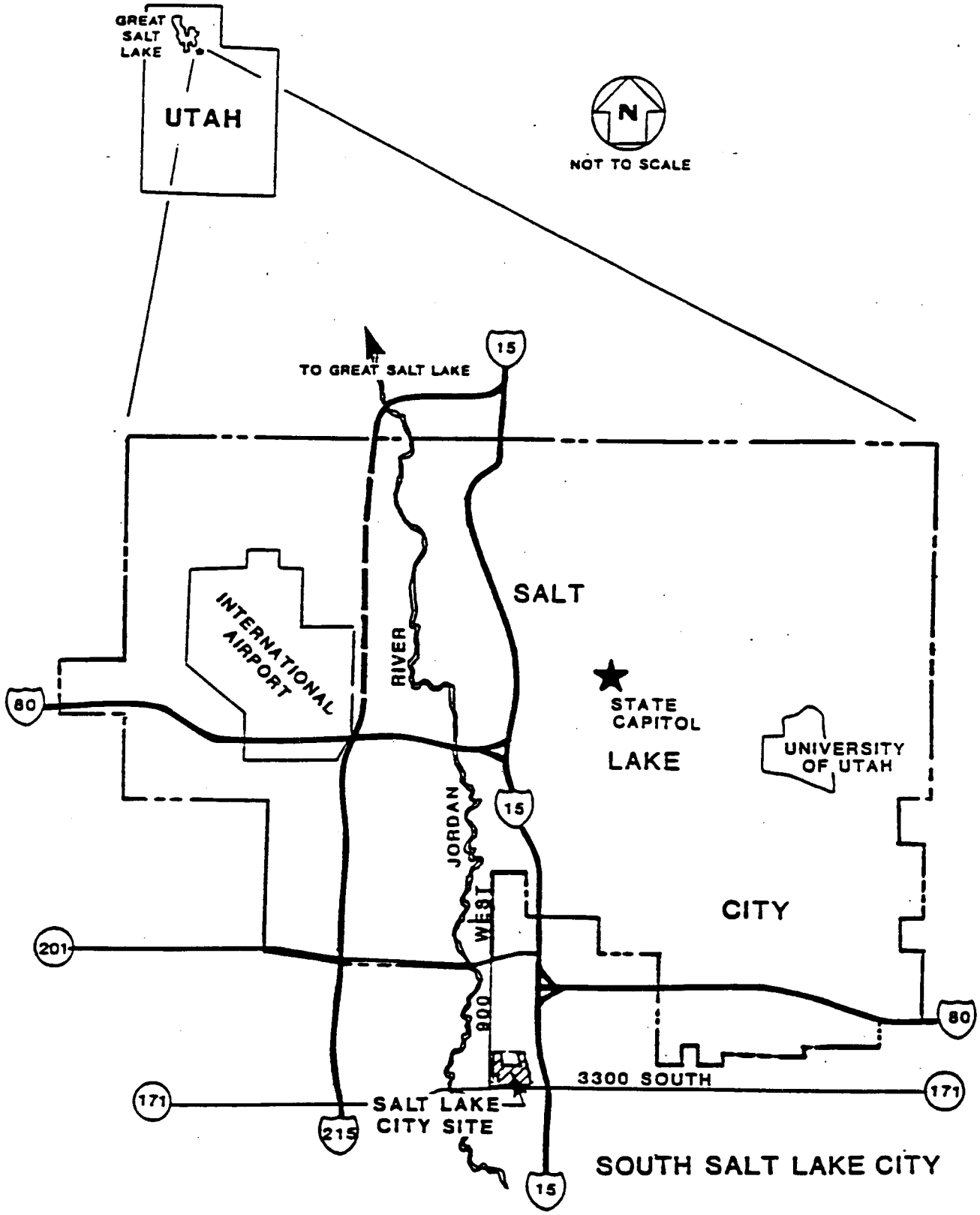


FIGURE 2.1
LOCATION OF THE FORMER VITRO PROCESSING SITE NEAR SALT LAKE CITY, UTAH

3.0 HYDROGEOLOGIC CHARACTERIZATION

The DOE has characterized the hydrogeology, water-quality, and water resources at the Vitro site.

3.1 HYDROGEOLOGIC INVESTIGATIONS

3.1.1 Previous investigations

Hydrogeologic investigations, including subsurface exploration, monitoring well installation, aquifer testing, water level monitoring, and sampling for water quality testing, have been carried out by various investigators at and near the Vitro site and in the Jordan River Valley. These investigators include Hely, Mower, and Harr (1971), Markos and Bush (1982), Dames and Moore (1982), CSU (1982), and the DOE TAC (1983). These investigations are summarized in an Environmental Impact Statement prepared by the DOE (1984).

Exploration boreholes and monitor wells were drilled and installed on and surrounding the site area in the early 1980s. Depths of exploration ranged from 10 to 135 ft (3 to 41 m). For details of boring locations, boring logs, and field sampling procedures refer to DOE, 1984 and CSU, 1982.

Since 1990, the DOE has been conducting groundwater sampling of selected monitor wells and analyzing groundwater samples for major ions, metals, uranium, and radium.

3.1.2 Fiscal year 1992 investigations

Additional hydrogeologic characterization of the shallow unconfined aquifer at the Vitro site was conducted by the TAC during June and July 1992. This hydrogeologic field investigation consisted of the following activities:

- Conducting borehole drilling and lithologic sampling to a maximum depth of 115 ft (35 m) (G-130 and G-135).
- Conducting borehole geophysical logging (natural-gamma, self potential, and resistivity) (G-130 and G-135).
- Installing five 2-inch (in) [5-centimeter (cm)] polyvinyl chloride (PVC) monitor wells (130 through 134); one 6-in (15-cm) PVC pumping test well (135); and three 2-in (5-cm) PVC piezometers surrounding the pump well (136 through 138). The monitor wells and piezometers range in depth from 45 to 49 ft (13.7 to 14.3 m).
- Surveying all new and existing well locations, including ground and casing elevations.

- Measuring groundwater elevations in the new monitor wells at the site.
- Conducting a 24-hour constant discharge aquifer pumping test in the shallow unconfined aquifer (in pumping test well 135).
- Sampling six new monitor wells (130 through 135).
- Field measuring temperature and pH in all groundwater samples.
- Performing laboratory analyses of all groundwater samples for major ions, metals, uranium, and radium.
- Performing sampling and analyses of aquifer sediments at nine locations just beneath the water table and the clean fill material for major ions, trace elements, metals, uranium, and radium (boreholes 571 through 579).

All field and laboratory procedures, and subsequent data analyses and calculations, were performed according to standard operating procedures (SOP) developed for the UMTRA Project (DOE, 1989).

The data were validated according to the UMTRA Project data validation procedure. The activities that make up this procedure are verification that 1) sample chain-of-custody was maintained; 2) the analyses were performed within the applicable holding times; 3) the quality control sample analyses and results meet the specified criteria; and 4) the data pass comparative tests with historical data. The comparison with historical data is not applicable in this case, since no previous data had been obtained for these sampling locations.

Well construction data for all the monitor wells used in this investigation are presented in Table 3.1. The locations of the monitor wells at the site are shown on Figure 3.1. Borehole and monitor well logs are in Attachment 1. Logs of existing boreholes shown in the cross sections are in Attachment 2.

3.2 HYDROGEOLOGY

3.2.1 General setting

The Vitro site is located in the Salt Lake Valley, a large fault block basin drained by the Jordan River. This basin is located between the Wasatch Mountains to the east and the Oquirrh Mountains to the west.

The lithology underlying the Vitro site consists of a thick sequence of Quaternary lacustrine-fluvial deposits with minor alluvial overburden. Unconsolidated lacustrine 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 some lava and cemented layers of sand and gravel (Arnow et al., 1970). Subsequent to the site surface remediation, the upper 4 to 13 ft (1.2 to 3.9 m) have been replaced by clean sandy

Tabe 3.1 We' pletion Information
Salt Lake C, tah, Site
SITE: SLC01 SALT LAKE CITY
REPORT DATE: 01/05/93

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	GROUND ELEVATION (FT MSL)	BOREHOLE DEPTH (FT)	BOREHOLE DIAMETER (INCHES)	CASING ELEVATION (FT MSL)	CASING DEPTH (FT)	CASING DIAMETER (INCHES)	SCREEN BEGINNING DEPTH (FT)	SCREEN LENGTH (FT)	FLOW CODE	FORMATION OF COMPLETION
0001	2717.65	7535.58	4244.82	115.00	2.00	4246.19	115.0	2.0	-	10.0	U	LC
0002	5522.05	6618.50	4237.90	135.00	2.00	4238.89	132.5	2.0	-	10.0	U	LC
0003	6309.28	4434.42	4234.97	125.00	2.00	4246.73	123.8	2.0	-	10.0	C	LC
0007	5541.12	6615.60	4237.86	35.00	3.00	4238.95	31.5	2.0	-	2.0	U	LU
0008	6328.93	4444.33	4234.56	40.00	3.00	-	32.5	3.0	-	2.0	C	LU
0011	4441.90	3214.19	4234.48	31.50	3.00	-	29.3	3.0	-	2.0	D	LU
0015	4414.34	3378.24	4234.37	133.00	6.00	4237.71	123.6	6.0	-	10.0	D	LC
0109	4422.28	3480.60	4236.12	25.00	3.00	-	20.8	2.0	-	2.0	D	LU
0130	4300.60	6389.97	4237.96	45.00	8.25	4240.22	43.8	2.0	31.8	10.0	O	LU
0131	3264.85	6689.24	4237.75	47.00	8.25	4240.01	46.7	2.0	34.7	10.0	U	LU
0132	3273.28	5443.72	4238.29	48.27	8.25	4239.99	48.3	2.0	36.3	10.0	O	LU
0133	3150.88	3891.11	4236.53	47.00	8.25	4238.83	47.0	2.0	35.0	10.0	O	LU
0134	6077.66	3687.18	4236.72	45.00	8.25	4239.50	44.2	2.0	32.2	10.0	D	LU
0135	4223.31	4533.89	4233.83	47.55	14.00	4236.10	47.5	6.0	25.5	20.0	O	LU

FORMATION OF COMPLETION CODE:
LC - LACUSTRINE CONFINED
LU - LACUSTRINE UNCONFINED

FLOW RELATIONSHIP CODE:
U - UPGRADIENT
C - CROSS GRADIENT
D - DOWN GRADIENT
O - ON-SITE

DATA FILE: M:\DART\SLC01\MWI10010.DAT

FIELDS DISPLAYED WITH A DASH INDICATE THE DATA IS UNAVAILABLE

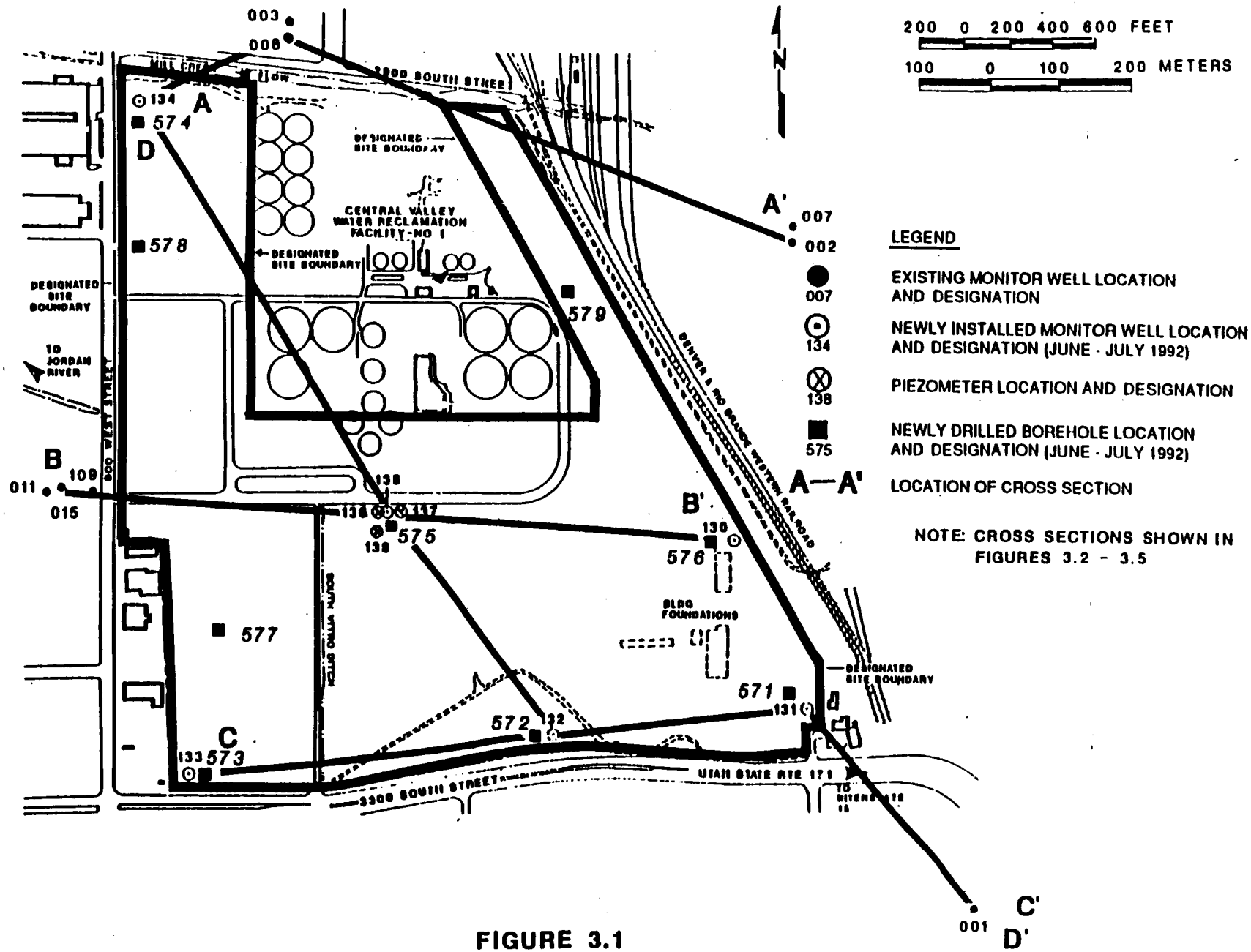


FIGURE 3.1
LOCATION OF MONITOR WELLS, PIEZOMETERS, AND BOREHOLES
SALT LAKE CITY, UTAH SITE

gravel fill material. Geologic cross sections of the Vitro site are shown in Figures 3.2 through 3.5.

Borehole samples from previous investigations indicate that shallow materials consist of unconsolidated silt, clayey-silt, silty-clay, and lenticular sands deposited in a fluvial-lacustrine environment. These sediments are complexly interbedded and correlation between individual boreholes is sometimes difficult.

The geophysical logging performed in boreholes G-130 and G-135 indicates a zone of high electrical conductivity to depths of 30 ft (9 m) and shows a sandy zone below about 50 ft (15 m) (Attachment 3).

A primary feature of the region is the seismically active Wasatch Frontal Fault system just east of the site. Project design studies have indicated that the subsurface sandy deposits may be subject to liquefaction in the event of large earthquakes. The nearest fault to the site is the East Bench Terrace Fault, approximately 2.5 mi (4 km) east of the site (DOE, 1984).

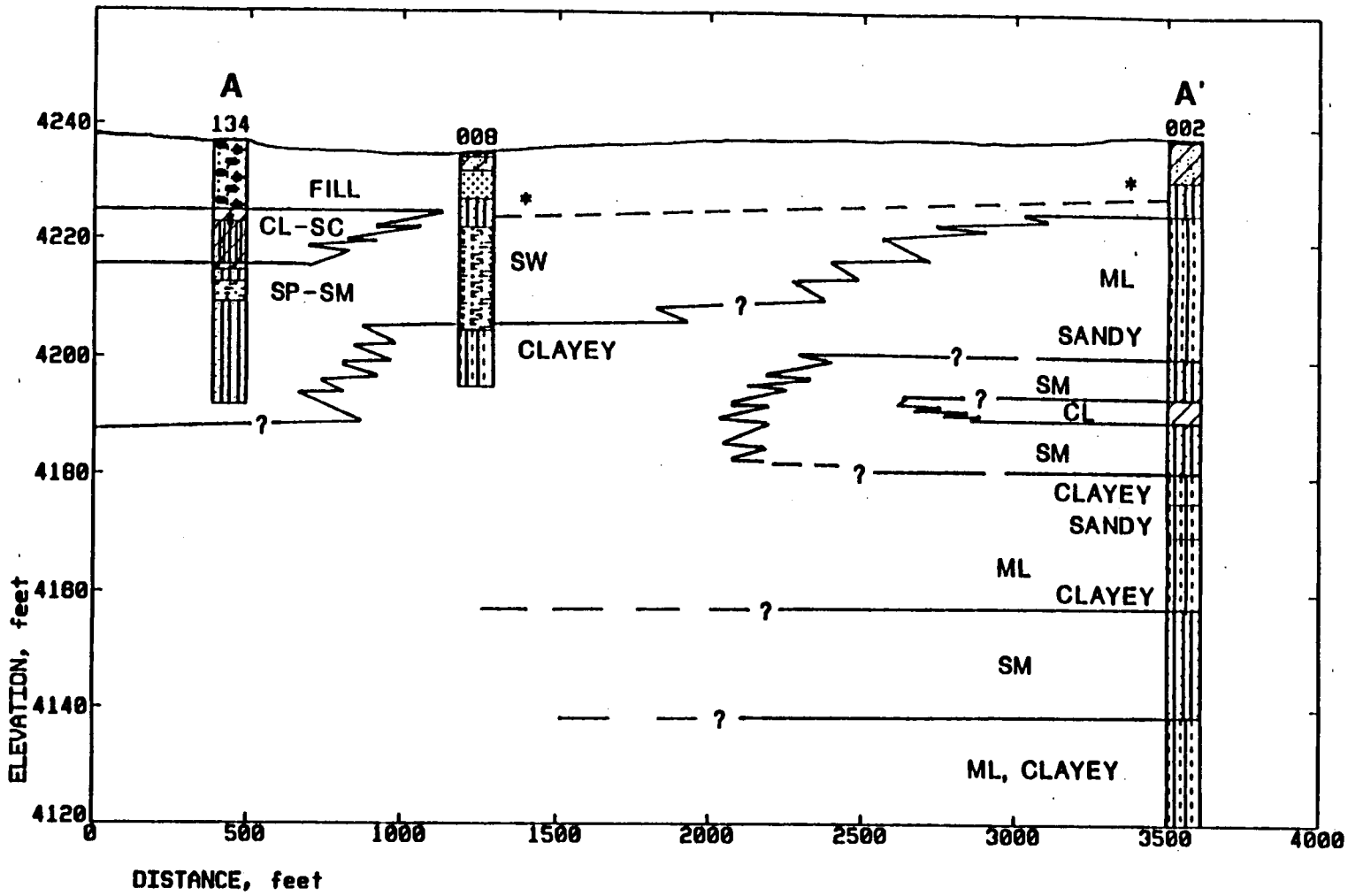
The groundwater regime in the vicinity of the Vitro site is generally characterized by two aquifer systems: a shallow unconfined system and a deeper confined system. The two aquifers are separated by interbedded layers of low-permeability clays and silts. Wells at depths from 70 to 330 ft (20 to 100 m) below the ground surface are under substantial artesian pressure with groundwater flowing from several wells. Near the site, groundwater flow in both aquifers is to the west-northwest, or toward the Great Salt Lake.

3.2.2 Shallow unconfined aquifer

In the vicinity of the former tailings pile, the upper unconfined aquifer is approximately 45 ft (14 m) thick. Groundwater yields from the interbedded strata of this aquifer system vary depending on the lithology of where a well is screened. Results from recent aquifer pumping tests indicate that groundwater yields can range from much less than 1 gallon per minute (gpm) [4 liters per minute (Lpm)] from the silts and clays, to long-term sustained yields of greater than 4 gpm (16 Lpm) from the fine-grained sands and silty sands.

The major sources of recharge to the unconfined aquifer are infiltration of precipitation and upward leakage from the confined aquifer. Groundwater in the unconfined aquifer generally discharges to surface water drainages such as the Jordan River, Mill Creek, and the Great Salt Lake. However, a highway drain below the Denver & Rio Grande Western Railroad overpass of 3300 South Street locally influences groundwater flow in the unconfined aquifer. The groundwater entering the drain is pumped out of a sump into a culvert that discharges into the head of South Vitro Ditch. Groundwater levels in the area indicate that there is a groundwater divide in the southeast corner of the site.

Groundwater levels in the unconfined aquifer range from 5 to 15 ft (1.5 to 4.6 m) or more below the ground surface. Topographic "lows" to the east of the site are perennial marshy areas. The groundwater flow direction is primarily from southeast

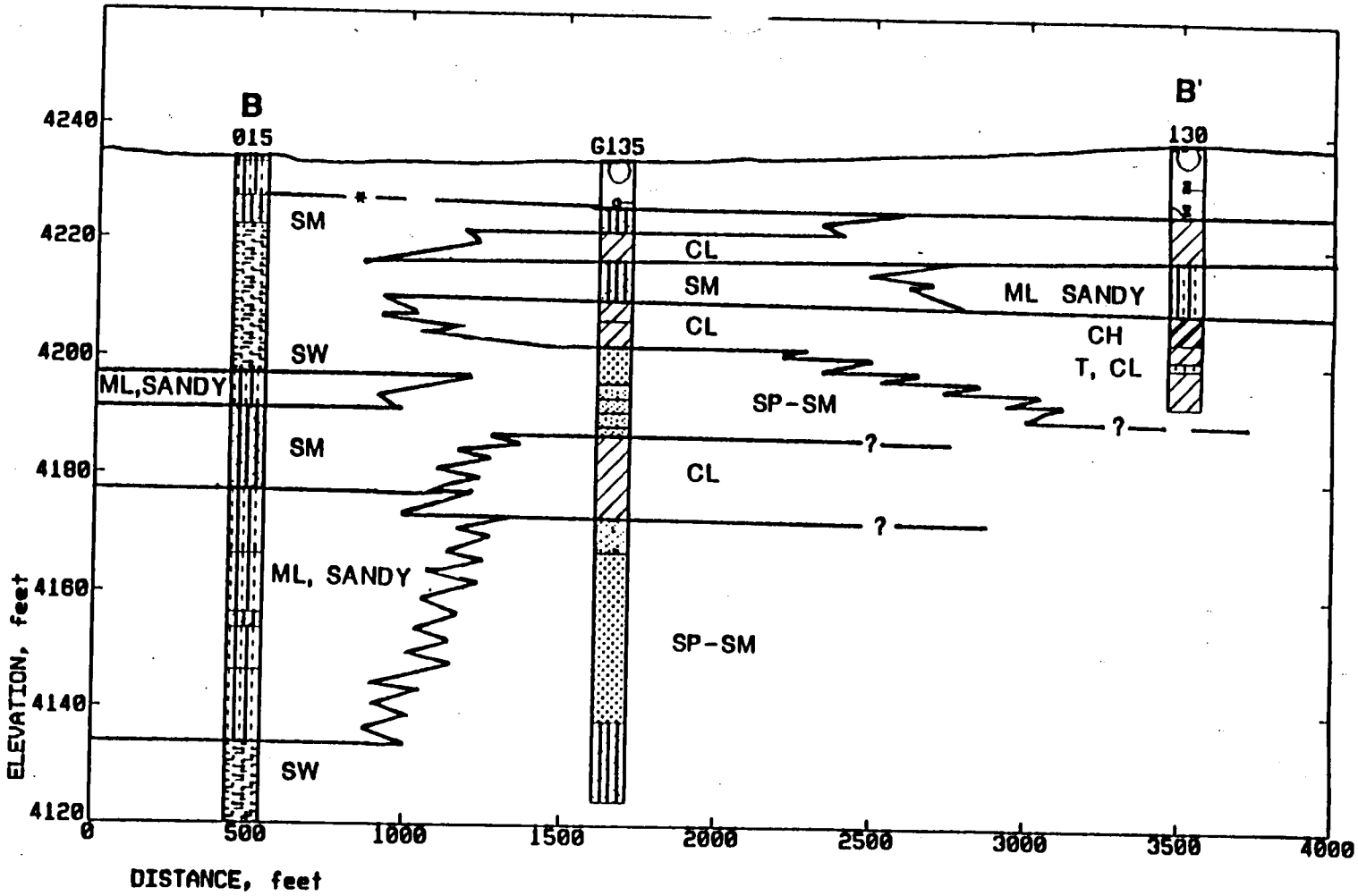


* PRE REMEDIAL ACTION LOG

NOTE: 1. ELEVATIONS AND DISTANCES ARE GIVEN IN FEET. TO CONVERT FROM FEET TO METERS, MULTIPLY FEET BY 0.3048.

2. SEE LOGS IN ATTACHMENTS 1 AND 2 FOR DEFINITION OF LITHOLOGIC UNIT ABBREVIATIONS.

FIGURE 3.2
GEOLOGIC CROSS SECTION A-A'
SALT LAKE CITY, UTAH SITE

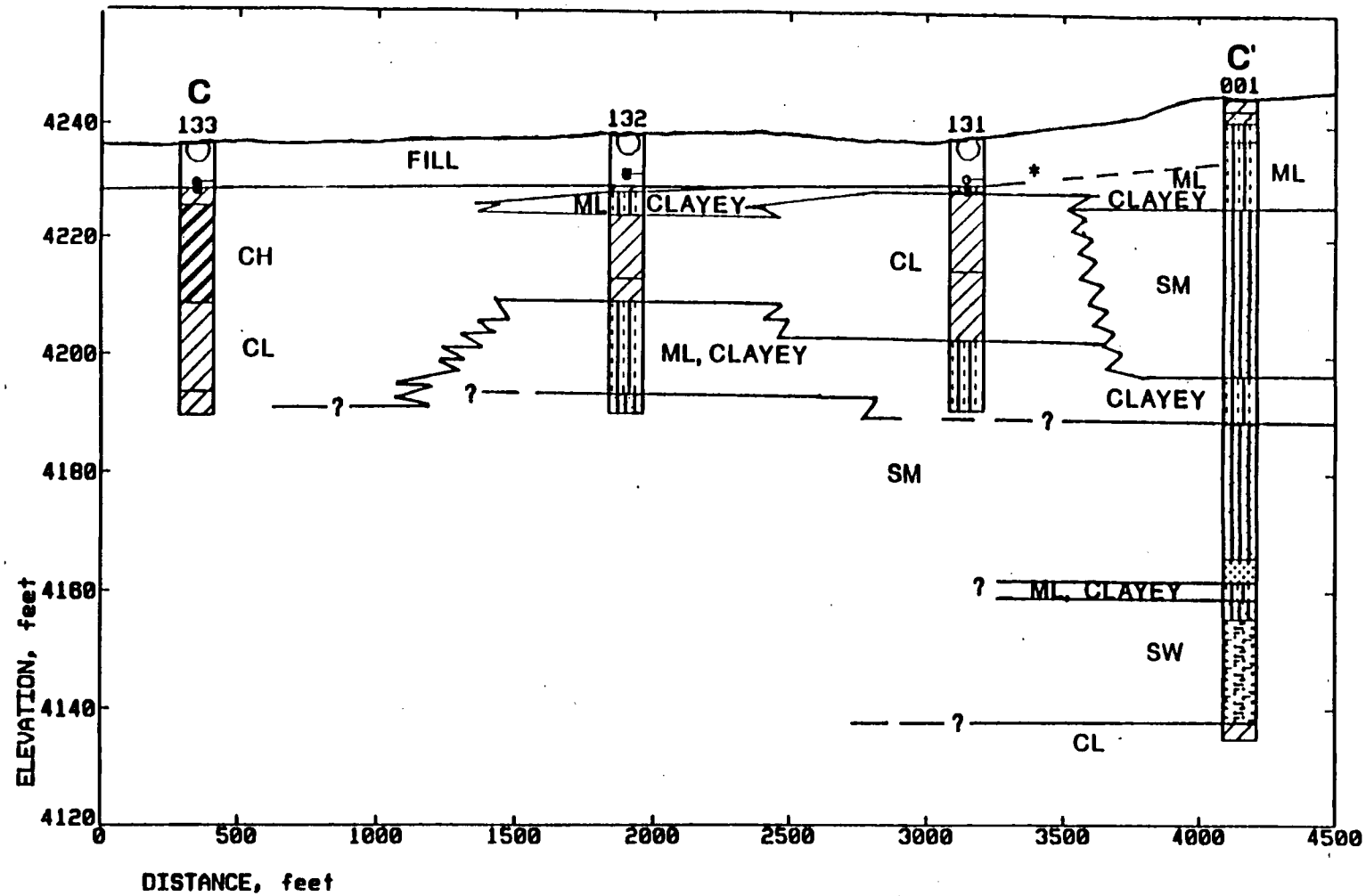


* PRE REMEDIAL ACTION LOG

NOTE: 1. ELEVATIONS AND DISTANCES ARE GIVEN IN FEET. TO CONVERT FROM FEET TO METERS, MULTIPLY FEET BY 0.3048.

2. SEE LOGS IN ATTACHMENTS 1 AND 2 FOR DEFINITION OF LITHOLOGIC UNIT ABBREVIATIONS.

FIGURE 3.3
GEOLOGIC CROSS SECTION B-B'
SALT LAKE CITY, UTAH SITE

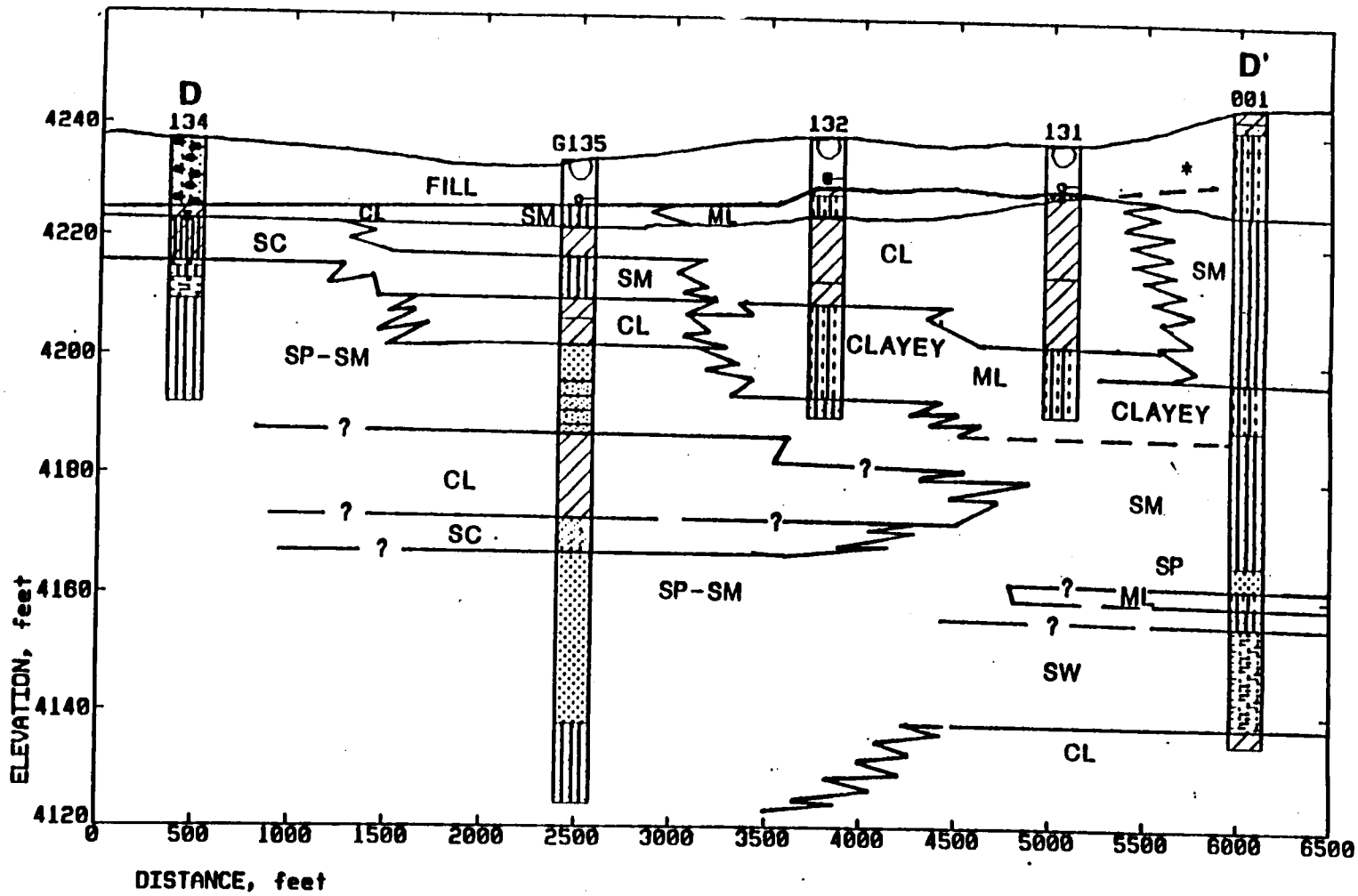


* PRE REMEDIAL ACTION LOG

NOTE: 1. ELEVATIONS AND DISTANCES ARE GIVEN IN FEET. TO CONVERT FROM FEET TO METERS, MULTIPLY FEET BY 0.3048.

2. SEE LOGS IN ATTACHMENTS 1 AND 2 FOR DEFINITION OF LITHOLOGIC UNIT ABBREVIATIONS.

FIGURE 3.4
GEOLOGIC CROSS SECTION C-C'
SALT LAKE CITY, UTAH SITE



*PRE REMEDIAL ACTION LOG

NOTE: 1. ELEVATIONS AND DISTANCES ARE GIVEN IN FEET. TO CONVERT FROM FEET TO METERS, MULTIPLY FEET BY 0.3048.

2. SEE LOGS IN ATTACHMENTS 1 AND 2 FOR DEFINITION OF LITHOLOGIC UNIT ABBREVIATIONS.

FIGURE 3.5
GEOLOGIC CROSS SECTION D-D'
SALT LAKE CITY, UTAH SITE

to northwest. A water table contour map of the shallow unconfined aquifer is shown in Figure 3.6.

Groundwater from the shallow unconfined aquifer is the source of water for small-scale irrigation, but is seldom used for water supply because of its low yield and because it is readily contaminated by surface conditions (Seiler and Waddell, 1984).

3.2.3 Confined aquifer

The confined aquifer begins 70 ft (20 m) below the ground surface and contains groundwater under substantial artesian pressure. The hydraulic head levels ranged 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 source of recharge to the confined aquifer is infiltration of precipitation and snowmelt along the flanks of the Wasatch and Oquirrh Mountains. Beneath the site, the groundwater in this aquifer flows toward the west northwest. Natural discharge is upwards to the unconfined aquifer system. The absence of any prominent aquitard stratum on the west side of the site (boreholes 015 and 134) indicates the potential for upward leakage of groundwater from the lower system and mixing with groundwater in the shallow system in this area. Artificial discharge includes pumpage of wells completed in the confined aquifer system.

No piezometric contour map of the deeper confined aquifer was constructed because on-site data of groundwater elevations were lacking.

3.3 HYDRAULIC CHARACTERISTICS

An aquifer pumping test was conducted on monitor well 135 to determine transmissivity and hydraulic conductivity of the shallow aquifer. The aquifer test data were analyzed on an IBM-compatible personal computer using WHIP™, a well hydraulics interpretation program. Transmissivities calculated from the drawdown and recovery analyses ranged from 9.4 to 16.0 ft^2/day (2.9 to 4.9 m^2/day) [Calc. No. SLC-07-92-14-02-00 (DOE, 1992)]. Computed hydraulic conductivities ranged from 0.27 to 0.46 ft/day (0.08 to 0.14 m/day) if a saturated thickness of 35 ft (11 m) is assumed. Storativity could not be determined because the drawdown and recovery data from only the pumping well were suitable for analyses.

Nearby piezometers 136, 137, and 138 were used as observation wells. Piezometer 136, located 11.7 ft (3.6 m) away from the pumping well, showed a drop of 0.62 ft (0.19 m) in water level in response to pumping. Piezometer 137, located 50.5 ft (15.4 m) away from the pumping well, showed a drop of 0.41 ft (0.13 m) in water level in response to pumping. The water level observed in piezometer 138, located 99.4 ft (30.3 m) from the pumping well, fluctuated above and below the initial static water level during the drawdown phase of the aquifer pumping test.

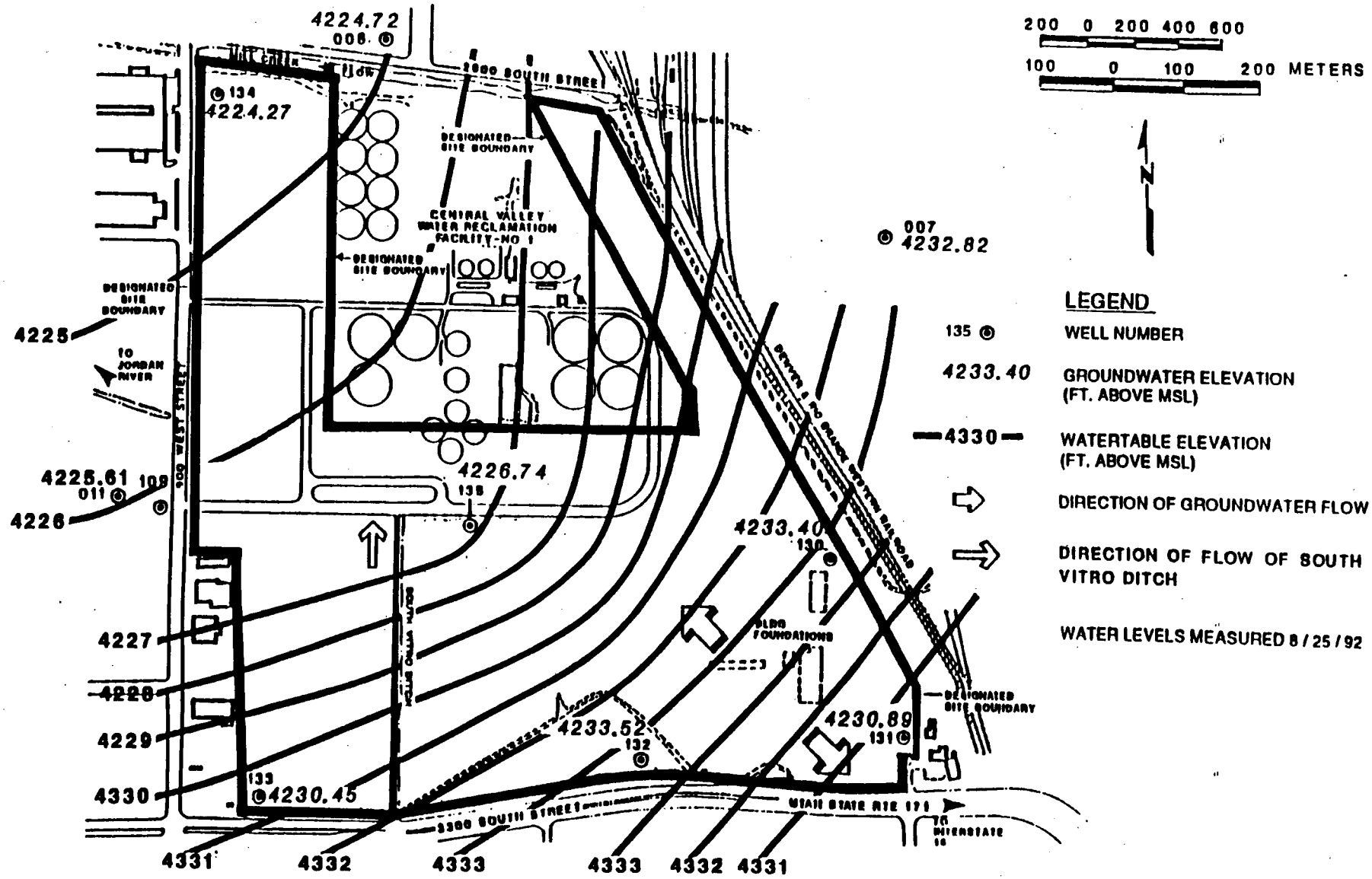


FIGURE 3.6
WATER TABLE SURFACE OF THE UNCONFINED AQUIFER
SALT LAKE CITY, UTAH SITE

Water level changes in piezometer 138 appeared to act independently of the drawdown that occurred in the pumping well.

The average linear groundwater velocity in the shallow unconfined aquifer was calculated using a hydraulic conductivity of 0.46 ft/day (0.14 m/day) [the hydraulic conductivity is based on a maximum transmissivity of 16 ft^2/day (4.9 m^2/day) derived from the aquifer pumping test divided by a saturated thickness of 35 ft (12 m)], a hydraulic gradient of 0.005, and an assumed effective porosity of 0.20. Using Darcy's Law, the average linear velocity for groundwater flow in the shallow unconfined aquifer is approximately 4 ft per year (1.3 m per year).

3.4 SOILS CHARACTERIZATION

Soil samples from nine locations (boreholes 571 through 579) were collected from just beneath the water table and below the clean fill and analyzed for major ions, trace elements, metals, uranium, and radium (see Figure 3.1). Each sample was collected with a 2-foot-long, split-spoon sampler and was analyzed using EPA Method 3050 (EPA, 1986). Elevated concentrations of molybdenum, sulfate, and uranium were found in the soils collected from borehole 575, as compared to concentrations found in soils collected from boreholes located hydraulically upgradient of borehole 575. Borehole 575 is adjacent to monitor well 135 where elevated concentrations of molybdenum, sulfate, TDS, and uranium were found in groundwater as compared to background groundwater concentrations. Some residual contamination from the tailings exists in the soils in the area around borehole 575. Except for an elevated concentration of molybdenum in the soils of boreholes 572 and 579, the constituent concentrations in the soils of the remaining borehole locations were all within the range of background levels. The soil chemistry data are presented in Attachment 4.

3.5 GROUNDWATER QUALITY

3.5.1 Background groundwater quality

Shallow unconfined aquifer

Background groundwater quality in the shallow unconfined aquifer was established using monitor wells 130 through 133 and monitor well 007. These monitor wells are upgradient and crossgradient from the site. Background groundwater quality in the shallow unconfined aquifer is characterized by chloride concentrations ranging from 16 to 56 milligrams per liter (mg/L); sodium concentrations ranging from 25 to 132 mg/L; TDS concentrations ranging from approximately 300 to 550 mg/L; and sulfate concentrations ranging from 2 to 6 mg/L. Concentrations of arsenic exceeded the proposed EPA maximum concentration limit (MCL) in some samples collected from background monitor wells but not in samples collected from downgradient wells. Background groundwater quality for the unconfined aquifer is summarized in Table 3.2 and is presented in its entirety in Attachment 5.

Table 3.2 Summary of background groundwater quality of the unconfined aquifer at the Vitro site (mg/L)

Constituent		Well 007	Well 130	Well 131	Well 132	Well 133
Major ions						
Calcium		12	25.1	102	22.8	26.3
Chloride		56	17.4	17.4	15.7	17
Iron		0.12	0.563	33.3	0.6	0.64
Magnesium		33.3	35.1	58.7	34.6	40.5
Manganese		0.03	0.074	0.913	0.066	0.047
pH		7.94	7.56	7.62	7.68	7.67
Potassium		26	29.4	34.2	29.2	27
Sodium		132	25.4	27.1	58	39.4
Sulfate		<10	2.61	5.92	2.81	4.96
TDS		540	318	328	381	355
EPA inorganics with MCLs						
	MCL					
Arsenic	0.05	0.05	0.027	0.06	0.057	0.126
Barium	1.0	0.11	0.174	0.423	0.181	0.239
Cadmium	0.01	<0.0005	<0.001	0.0017	<0.001	<0.001
Chromium	0.05	<0.01	<0.01	0.021	<0.01	<0.01
Lead	0.05	<0.005	<0.003	0.077	<0.003	<0.003
Mercury	0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Molybdenum	0.1	<0.01	<0.01	<0.01	<0.01	<0.01
Net gross alpha (pCi/L)	15.0	7.06	0	19.4	0.59	0.55
Nitrate (as NO_3)	44	5.5	<1.0	<1.0	<1.0	<1.0
Radium-226 and -228 (pCi/L)	5.0	0	1.2	4.0	0.6	2.3
Selenium	0.01	0.005	<0.005	<0.05	<0.005	<0.005
Silver	0.05	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium*	0.044	<0.001	0.0005	0.0038	0.0003	0.0011

Note: mg/L = milligrams per liter; pCi/L = picocuries per liter.
*0.044 mg/L is the mass equivalent to the 30 pCi/L MCL for uranium.

Confined aquifer

Background groundwater quality in the confined aquifer is characterized by TDS values of approximately 300 mg/L and a sulfate content of approximately 20 mg/L. The confined aquifer is an important source of domestic, agricultural, and industrial water supply in the Salt Lake Valley. No constituent exceeded the proposed EPA MCL for groundwater.

3.5.2 Extent of existing contamination

Shallow unconfined aquifer

Groundwater samples collected from monitor wells 134 and 135 were used to characterize on-site downgradient groundwater quality. Groundwater samples collected from monitor wells 008, 011, and 109 were used to characterize groundwater quality just west and northwest (downgradient) of the site boundary. Residual groundwater contamination from the former tailings piles still exists in the unconfined aquifer, both on the site and downgradient from the site. Concentrations of chloride, sodium, sulfate, TDS, and uranium in downgradient groundwater are generally elevated by one to two orders of magnitude as compared to concentrations in background groundwater. Concentrations of molybdenum, selenium, and uranium exceeded the proposed EPA MCL in some downgradient monitor wells. Table 3.3 summarizes the groundwater quality in the downgradient monitor wells. Table 3.4 compares the average background groundwater concentrations with the average downgradient groundwater concentrations for selected constituents.

The concentration distribution for sulfate, which typifies the concentration distribution patterns of other major ions (calcium, chloride, magnesium, sodium, and TDS) found at elevated concentrations, is shown in Figure 3.7. Concentration distributions of molybdenum and uranium are shown in Figure 3.8. A sulfate plume exists, with the highest concentrations occurring nearly in the center of the site at monitor well 135 and extending off the site to the west-northwest. The concentration distribution for sulfate in groundwater in the shallow unconfined aquifer is typical of the distribution of concentrations for major ions, molybdenum, and uranium. The concentration distribution for sulfate also indicates that contaminated groundwater has migrated from the site to the west and northwest in the vicinity of monitor wells 011, 109, and 008. Since 1983, when monitoring began, groundwater on the site and in nearby off-site areas in the unconfined aquifer has shown elevated concentrations of chloride, sodium, sulfate, TDS, and uranium. The groundwater quality data collected during 1992 as part of this investigation confirm the presence of contamination as shown by the historical data.

Confined aquifer

No radioactive constituents and metals that would be associated with the tailings pile were found in levels above background in groundwater in the confined aquifer. Groundwater quality for the confined aquifer is presented in Attachment 5.

Table 3.3 Summary of downgradient groundwater quality of the unconfined aquifer at the Vitro site (mg/L)

Constituent		Well 008	Well 011	Well 109	Well 134	Well 135
Major ions						
Calcium		257	57.4	87.5	96.3	148
Chloride		850	968	1150	217	2780
Iron		3.18	1.28	5.24	1.64	1.67
Magnesium		363	182	271	81	846
Manganese		0.31	0.11	0.45	0.155	0.22
pH		7.12	7.36	7.17	7.19	7.48
Potassium		41	44	78	33.3	237
Sodium		697	1150	1770	230	3040
Sulfate		1760	1260	2630	370	5520
TDS		4500	4030	6510	1300	13500
EPA inorganics with MCLs						
	MCL					
Arsenic	0.05	<0.03	<0.03	<0.03	0.0477	<0.005
Barium	1.0	0.31	0.02	0.01	0.471	<0.2
Cadmium	0.01	<0.0005	<0.0005	<0.0005	<0.001	<0.01
Chromium	0.05	<0.01	<0.01	<0.01	<0.01	<0.02
Lead	0.05	<0.005	<0.03	<0.03	<0.003	<0.003
Mercury	0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Molybdenum	0.1	<0.01	0.15	0.07	0.02	0.18
Net gross alpha (pCi/L)	15.0	0	0	4.3	0	6.5
Nitrate (as NO_3)	44	4.6	3.7	2.4	<0.1	<0.1
Radium-226 and -228 (pCi/L)	5.0	2.3	2.0	2.8	0.9	0.7
Selenium	0.01	0.03	<0.005	0.03	<0.005	<0.05
Silver	0.05	<0.01	<0.01	<0.01	<0.01	<0.02
Uranium*	0.044	<0.001	0.051	0.16	0.057	0.015

*0.044 mg/L is the mass equivalent to the 30 pCi/L MCL for uranium.

Table 3.4 Summary of average background and average downgradient groundwater quality of the unconfined aquifer at the Vitro site (mg/L)

Constituent		Average background	Average downgradient
Major ions			
Calcium		21.5	129.2
Chloride		26.5	1193
Iron		0.48	2.6
Magnesium		35.9	348.6
Manganese		0.054	0.25
pH		7.71	7.3
Potassium		27.9	86.7
Sodium		63.7	1377.4
Sulfate		3.85	2308
TDS		398.5	5968
EPA inorganics with MCLs			
	MCL		
Arsenic	0.05	0.065	0.019
Barium	1.0	0.176	0.18
Cadmium	0.01	0.0004	0.001
Chromium	0.05	<0.01	0.006
Lead	0.05	0.0024	0.007
Mercury	0.002	<0.0002	<0.0002
Molybdenum	0.1	<0.01	0.085
Net gross alpha (pCi/L)	15.0	2.05	2.2
Nitrate (as NO_3)	44	1.75	2.3
Radium-226 and -228 (pCi/L)	5.0	1.03	1.74
Selenium	0.01	0.003	0.018
Silver	0.05	<0.01	0.006
Uranium*	0.044	<0.001	0.057

*0.044 mg/L is the mass equivalent to the 30 pCi/L MCL for uranium.

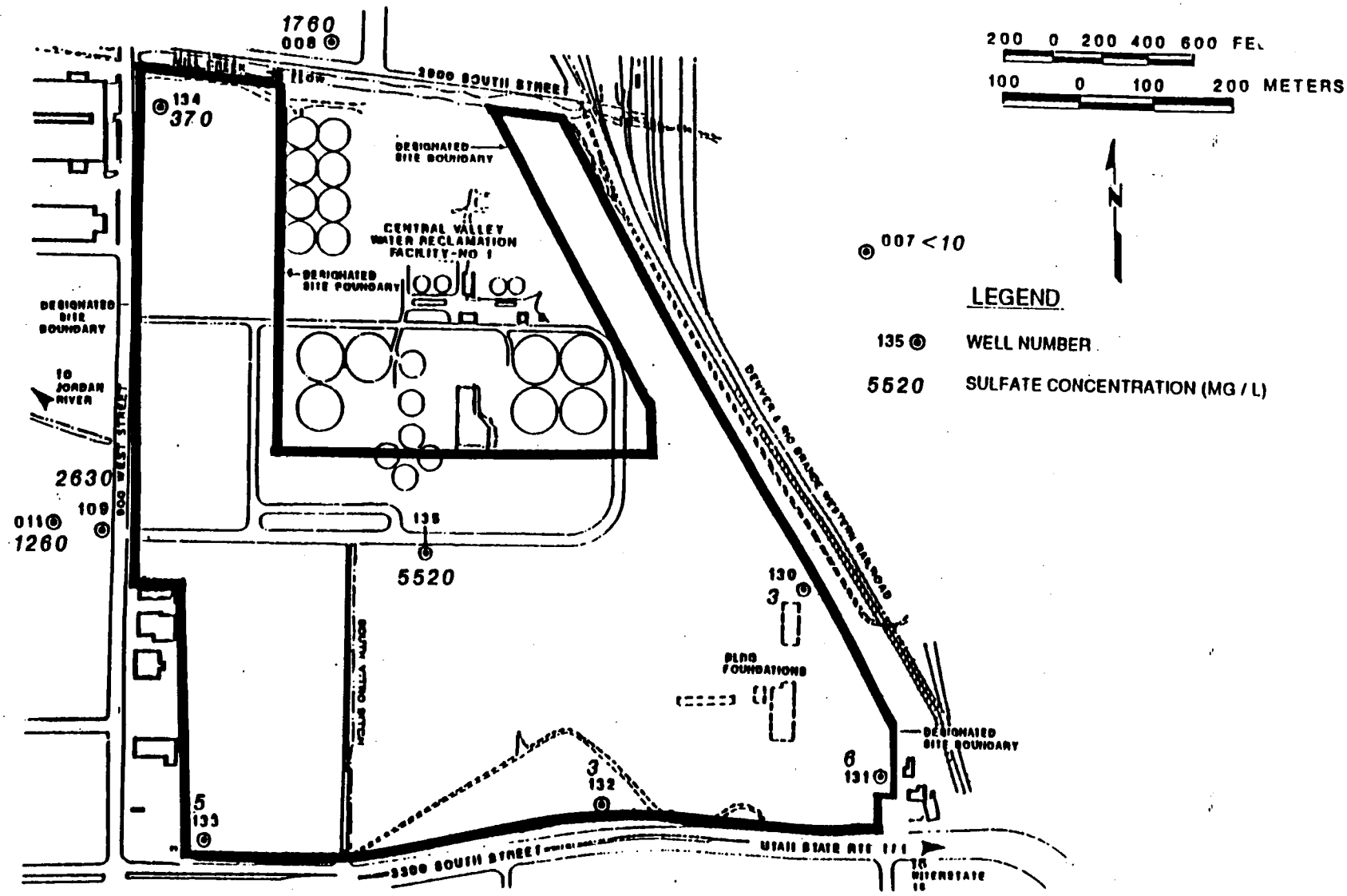


FIGURE 3.7
CONCENTRATION DISTRIBUTIONS OF SULFATE IN THE UNCONFINED AQUIFER
SALT LAKE CITY, UTAH SITE

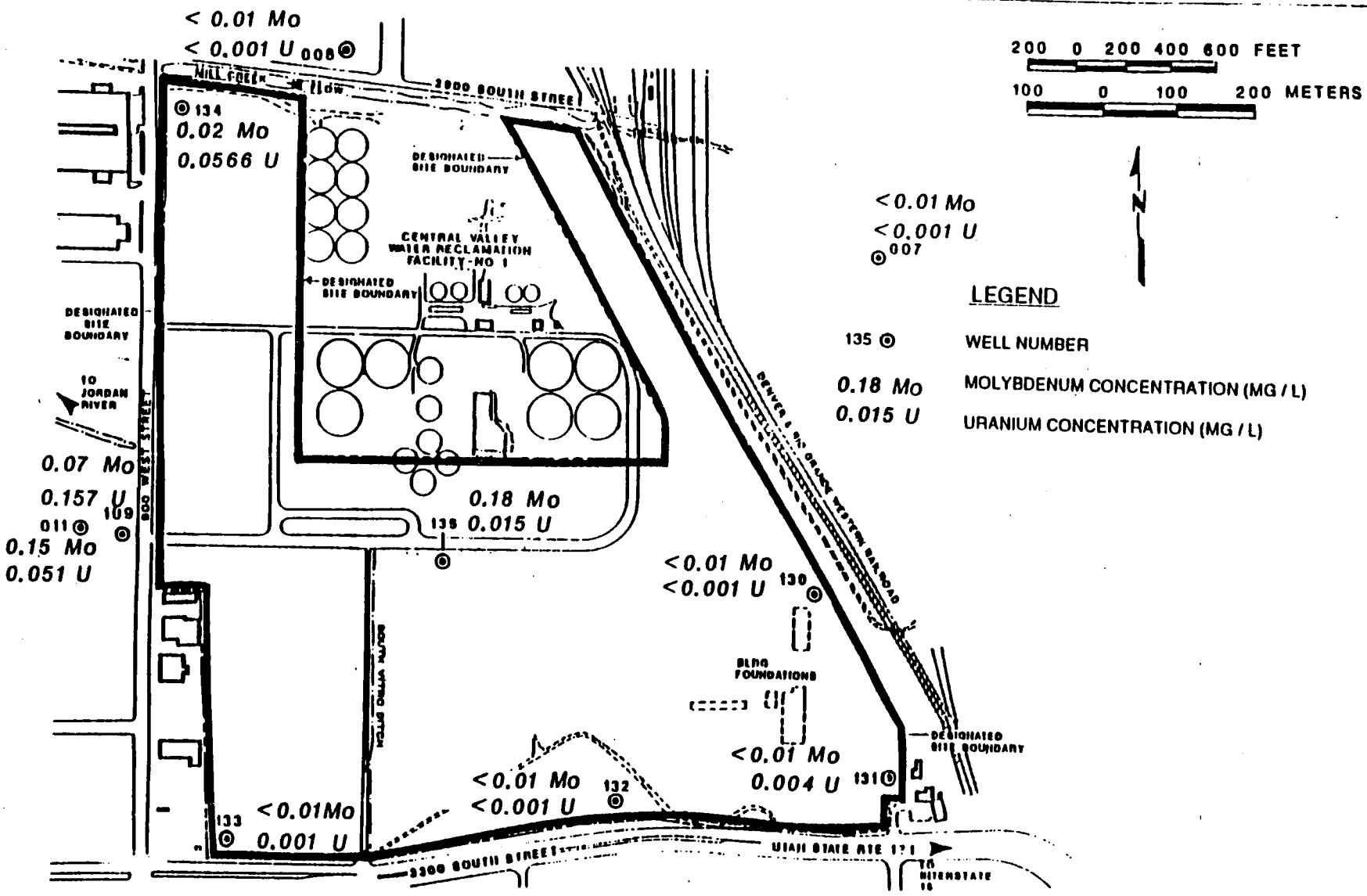


FIGURE 3.8
CONCENTRATION DISTRIBUTIONS OF MOLYBDENUM AND URANIUM IN THE UNCONFINED AQUIFER SALT LAKE CITY, UTAH SITE

The good quality of groundwater in the confined aquifer, relative to the shallow unconfined aquifer, is maintained by the upward vertical hydraulic gradient between the two aquifers, which prevents downward migration of site-related contamination from the unconfined aquifer. The potential for contamination of the confined aquifer exists if the hydraulic head in the confined aquifer declines so that the direction of flow between the two aquifers reverses. It is conceivable that localized migration of groundwater from the shallow-unconfined aquifer into the confined aquifer could occur now in the area of the cone of depression caused by large-scale pumping from wells developed in the confined aquifer.

4.0 SUMMARY AND CONCLUSIONS

The groundwater and soil investigation was performed by the TAC at the direction of the DOE UMTRA Project Office during FY92. The investigation at the Vitro site consisted of the installation of monitoring wells and soil borings, aquifer testing, and the collection and analyses of groundwater and soil samples. The results of the investigation are as follows:

- The groundwater regime under the site is generally characterized by two aquifer systems: a near-surface unconfined system and a deeper confined system. Near the Vitro site, groundwater in both aquifers flows to the west-northwest.

- The average linear groundwater velocity in the shallow unconfined aquifer is 4 ft/yr (1.3 m/yr).

- Residual contamination consisting of molybdenum, sulfate, and uranium, most likely derived from the former Vitro tailings, exists in the soils at levels above background underlying the central area of the site.

- Contamination exists in groundwater in the shallow unconfined aquifer as a result of uranium processing activities. The highest concentrations of chloride, sodium, sulfate, and TDS occur at monitor well 135, near the center of the site. The contamination extends off the site to the west-northwest, with the highest concentrations of uranium observed in the northwestern corner of the site and off-site to the west.

- Historically, groundwater on-site and off-site in the shallow unconfined aquifer has had elevated concentrations of chloride, sodium, sulfate, TDS, and uranium. This is consistent with the on-site groundwater quality conditions found during this investigation.

- No contamination associated with the former tailings pile was found in levels exceeding background in groundwater in the deeper confined aquifer system.

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ATTACHMENT 1

WELL BORING LOGS
OF WELLS INSTALLED DURING JUNE-JULY 1992

SALT LAKE CITY, UTAH, SITE

PROJECT VITRO PROCESS SITE
SALT LAKE CITY UTAH

LOG OF WELL BORING NO. 130

JOB NO. SLC01 DATE 06/26/92
SURFACE ELEVATION 4237.96
TOP OF FILTER PACK 13.90
L CASING TYPE 2.0-IN.SCHED.40 PVC
APLETION LACUSTRINE

TOTAL DEPTH 45.0 feet
RIG TYPE CME-75
BORING TYPE HS AUGER
LOCATION N 4300.60 E 6389.97
DATUM MSL

Depth	Well Con.	Remarks	Lithology	USCS	Visual Classification
0		Installed 2-in PVC well.		GM	FILL: SILTY GRAVEL, with fine sand, subrounded, loose, moist, lt. brown.
		Placed protective casing to 3.4 with grout to 3.0 ft. Placed bentonite chip seal from 3.0 to 7.6 ft.			
5					
		Installed bentonite pellet seal from 7.6 to 13.9 ft.			
10					
		Installed filter pack from 13.9 to TD.		CL	LACUSTRINE: SILTY CLAY, medium plasticity, saturated, grey.
15					
20				ML	SILT, some fine sand, saturated, lt. green.
25					
30				CH	CLAY, high plasticity, saturated, grey to lt. grey.
35				CL	SILTY CLAY, low plasticity, saturated, green.
		Placed well screen from 31.8 to 41.8feet. Note: Most of water comes from sand zone at 37 feet.		SP	SILTY SAND, medium to coarse, saturated, tan.
40				CL	SILTY CLAY, low plasticity, saturated, green.
45		Placed two foot sump at 41.8 to 43.8 ft.			TD AT 45 FEET.
50					

GROUNDWATER

DEPTH	HOUR	DATE
11.0	18:31	6-26-92
6.8	07:12	6-26-92

JEG TAC TEAM

PROJECT VITRO PROCESS SITE
SALT LAKE CITY UTAH

LOG OF WELL BORING NO. 131

JOB NO. SLC01 DATE 06/29/92
SURFACE ELEVATION 4237.75
TOP OF FILTER PACK 10.40
WELL CASING TYPE 2.0-IN.SCHED.40 PVC
COMPLETION LACUSTRINE

TOTAL DEPTH 47.0 feet
RIG TYPE CME-75
BORING TYPE HS AUGER
LOCATION N 3264.85 E 6689.24
DATUM MSL

Depth	Well Con.	Remarks	Lithology	USCS	Visual Classification
0		Installed 2-in PVC well.		GM	FILL: SILTY SAND AND GRAVEL, poorly graded, medium sand, angular to subrounded, loose, lt. tan. slightly moist.
		Placed protective casing to 3.3 with grout to 2.5 ft. Placed bentonite chip seal from 2.5 to 7.6 ft.			
5					
				SM	LACUSTRINE: SILTY SAND, poorly graded, fine, very moist, dark tan.
		Installed bentonite pellet seal from 7.6 to 10.3 ft.		CL	SILTY CLAY, medium plasticity, very moist, tan.
10		Installed filter pack from 10.3 to TD.			
15					
20					
				CL	SILTY CLAY, low plasticity, saturated, green.
25					
30					
35				ML	CLAYEY SILT, low plasticity, saturated, grey.
		Placed well screen from 34.7 to 44.7 feet.			
40					
45		Placed two foot sump at 44.7 to 46.7 ft.			
					TD AT 47 FEET.
50					

GROUNDWATER

DEPTH	HOUR	DATE
9.4	12:01	6-29-92

JEG TAC TEAM

PROJECT VITRO PROCESS SITE
SALT LAKE CITY, UTAH

LOG OF WELL BORING NO. 132

JOB NO. SLC01 DATE 06/29/92
SURFACE ELEVATION 4238.29
TOP OF FILTER PACK 12.30
L CASING TYPE 2.0-IN.SCHED.40 PVC
.PLETION LACUSTRINE

TOTAL DEPTH 48.3 feet
RIG TYPE CME-75
BORING TYPE HS AUGER
LOCATION N 3273.28 E 5443.72
DATUM MSL

Depth	Well Con.	Remarks	Lithology	USCS	Visual Classification
0		Installed 2-in PVC well.		GM	FILL: SILTY SAND AND GRAVEL, poorly to well graded, loose, slightly moist, lt. tan.
5		Placed protective casing to 4.0 with grout to 3.0 ft. Placed bentonite chip seal from 3.8 to 8.7 ft.			
10		Installed bentonite pellet seal from 8.7 to 12.3 ft.		SC	LACUSTRINE: CLAYEY SAND, with silt, fine, moist, green.
		Installed filter pack from 12.3 to TD.		ML	CLAYEY SILT, with fine sand, medium plasticity, saturated, greenish brown.
15				CL	SILTY CLAY, medium plasticity, saturated, greenish brown.
20					
25				CL	SILTY CLAY, low plasticity, saturated, green.
30				ML	CLAYEY SILT, low plasticty, saturated, green.
35		Placed well screen from 36.3 to 46.3 feet.			
40					
45		Placed two foot sump at 46.3 to 48.3 ft.		SM	SILTY SAND, little clay, very fine grained, saturated, greyish green.
50					TD AT 48 FEET.

GROUNDWATER

DEPTH	HOUR	DATE
7.4	14:46	6-29-92

JEG TAC TEAM

PROJECT VITRO PROCESS SITE
SALT LAKE CITY, UTAH

LOG OF WELL BORING NO. 133

JOB NO. SLC01 DATE 06/26/92
SURFACE ELEVATION 4236.53
TOP OF FILTER PACK 7.00
WELL CASING TYPE 2.0-IN.SCHED.40 PVC
COMPLETION LACUSTRINE

TOTAL DEPTH 47.0 feet
RIG TYPE CME-75
BORING TYPE HS AUGER
LOCATION N 3150.88 E 3891.11
DATUM MSL

Depth	Well Con.	Remarks	Lithology	USCS	Visual Classification
0		Installed 2-in PVC well.		GM	FILL: SILTY SAND AND GRAVEL, poorly graded, fine sand, very loose, slighly moist, light reddish brown.
		Placed protective casing to 3.6 with grout to 3.0 ft. Placed bentonite chip seal from 3.0 to 4.7 ft.			
5		Installed bentonite pellet seal from 4.7 to 7.0 ft.		CL	LACUSTRINE: SILTY CLAY, medium plasticity, moist, greenish grey.
10		Cave-in from 7 to 10 ft.		CH	CLAY, high plasticity, very stiff, saturated, yellowish brown.
		Installed filter pack from 10.0 to TD.			
15					
20					
25					
				CL	SILTY CLAY, medium plasticity, saturated, green.
30					
35		Placed well screen from 35.0 to 45.0 feet.			
40					
				CL	SILTY CLAY, low plasticity, very soft, saturated, grey.
45		Placed two foot sump at 45.0 to 47.0 ft.			
					TD AT 47 FEET.
50					

GROUNDWATER

DEPTH	HOUR	DATE
8.6	16:01	6-26-92
8.2	06:59	6-27-92

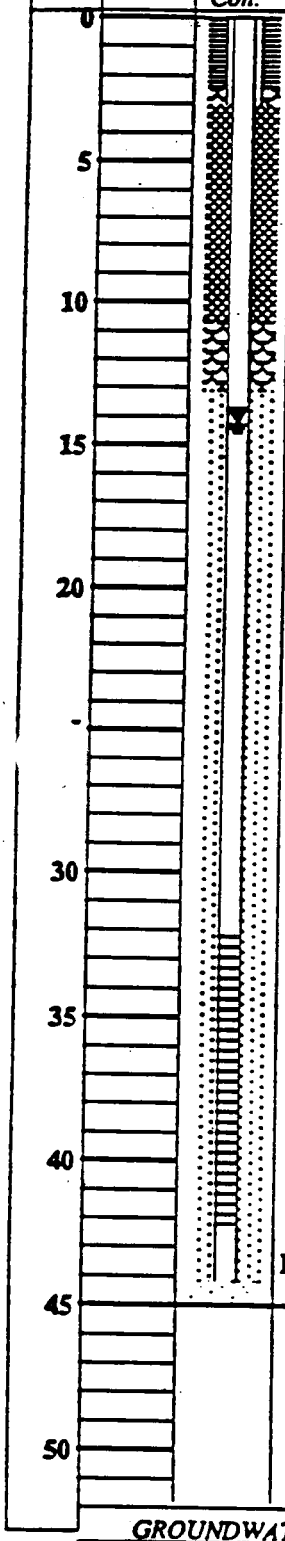
JEG TAC TEAM

PROJECT VITRO PROCESS SITE
SALT LAKE CITY, UTAH

LOG OF WELL BORING NO. 134

JOB NO. SLC01 DATE 06/26/92
SURFACE ELEVATION 4236.72
TOP OF FILTER PACK 13.10
WELL CASING TYPE 2.0-IN.SCHED.40 PVC
COMPLETION LACUSTRINE

TOTAL DEPTH 45.0 feet
RIG TYPE CME-75
BORING TYPE HS AUGER
LOCATION N 6077.66 E 3687.18
DATUM MSL



Depth	Remarks	USCS	Visual Classification
0	Installed 2-in PVC well.	GP	FILL: SILTY SAND AND GRAVEL, poorly graded, fine to medium sand, loose, slightly moist, lt. brown to tan.
	Placed protective casing to 3.0 with grout to 2.4 ft. Placed bentonite chip seal from 2.8 to 10.7 ft.		
5			Note: Moist to saturated below 8 feet.
10	Installed bentonite pellet seal from 10.7 to 13.1 ft.		
	Installed filter pack from 13.1 to TD.	CL	LACUSTINE: SILTY CLAY, medium plasticity, moist, lt. grey to brown.
15		SM	
		SC	SILTY TO CLAYEY SAND, poorly graded fine sand, saturated, greenish brown.
20		SW	SAND, little silt, fine to coarse, sub angular, saturated, lt. green.
		SM	
		SW	SILTY SAND, little clay, fine, saturated, greenish brown.
			SAND, little silt, well graded, saturated, lt. green.
		SM	SILTY SAND, very fine, loose, saturated, green.
30			
	Placed well screen from 32.2 to 42.2 feet.		Note: lens of well graded sand at 33 to 33.5 ft.
35			
40			
	Placed two foot sump at 42.2 to 44.2 ft.		
45			TD AT 45 FEET.
50			

GROUNDWATER

DEPTH	HOUR	DATE
14.3	11:29	6-26-92
14.3	07:16	6-27-92

JEG TAC TEAM

PROJECT VITRO PROCESS SITE
SALT LAKE CITY UTAH

LOG OF WELL BORING NO. 135

JOB NO. SLC01 DATE 06/29/92
SURFACE ELEVATION 4233.83
TOP OF FILTER PACK 12.00
WELL CASING TYPE 6.0-IN.SCHED.40 PVC
COMPLETION LACUSTRINE

TOTAL DEPTH 47.6 feet
RIG TYPE CME-75
BORING TYPE HS AUGER
LOCATION N 4223.31 E 4533.89
DATUM MSL

Depth	Well Con.	Remarks	Lithology	USCS	Visual Classification
0		Installed 6-in PVC casing for pumping test well. Placed protective casing to 3.8 with grout to 3.6 ft. Placed bentonite chip seal from 3.6 to 12.0 ft.		GP	FILL: SILTY SAND AND GRAVEL, poorly graded, subangular. loos, very moist, lt. brown.
5				ML	LACUSTRINE: CLAYEY SILT, low plasticity, very moist, green.
10		Installed filter pack from 12.0 to TD.		CL	SILTY CLAY, low to med. plasticity, very moist, greyish green.
15				SM	SILTY SAND, medium to coarse grained, saturated, greyish brown.
20		(Conducted geophysical logging of borehole to 95 feet in. adjacent exploratory hole G 135)		SM	SILTY SAND, medium, saturated, greyish green.
25				ML	CLAYEY SILT, with fine sand, low plasticity, lt. greenish grey.
30					
35		Placed well screen from 25.5 to 45.5 feet.		ML	SANDY SILT, very fine sand, very soft, saturated, dk. grey.
40					
45		Placed two foot sump at 45.5 to 47.5 ft.			
50					TD AT 47.6 FT

GROUNDWATER

DEPTH	HOUR	DATE
9.2	07:40	7-1-92

JEG TAC TEAM

PROJECT VITRO PROCESS SITE
SALT LAKE CITY, UTAH

LOG OF TEST BORING NO. G135

JOB NO. SLC01 DATE 06/25/92

LOCATION N4223.0 E4539.0
RIG TYPE TH-60
BORING TYPE ROTARY MUD 6.0-IN.
SURFACE ELEV 4233.90
DATUM MSL

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30 in. free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								GM	Geophysical logging hole located adjacent to pumping test wellNo. 135.	FILL: SILTY GRAVEL, some sand poorly graded.
5										
10								SM	Logged by drill cuttings of rotary mud circulation for comparison with E-log.	LACUSTRINE: SILTY SAND, little clay, low plasticity, yellow to tan.
15								CL	Borehole decommissioned upon completion of logging using bentonite seal.	SILTY CLAY, medium plasticity, greyish green.
20								SM		SILTY SAND, little clay, fine, mod. soft, lt. greyish brn.
25								CL		SILTY CLAY, some fine sand, low plasticity, grey.
30								CL		SANDY CLAY, fine sand, low plasticity, tan to grey.
35								SP		SAND, with few sandy clay lenses, medium grained, mod. to well cemented, lt. tan.
40								CL SP		Intercalated lenses, SAND AND CLAY, fine sand, med. plasticity, grey. Note: mod. cemented sand lenses from 43 ft.
45									Top of confining strata for lower artesian zone located at 48 ft.	
50								CL		SILTY CLAY, medium plasticity, little to some fine sand, grey to dark grey.

GROUNDWATER

DEPTH	HOUR	DATE

SAMPLE TYPE
RX - Rock Coring - NX or HX
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
G - Grab, cuttings sample

JEG TAC TEAM

PROJECT VITRO PROCESS SITE
SALT LAKE CITY, UTAH

LOG OF TEST BORING NO. G135

JOB NO. SLC01 DATE 06/25/92

LOCATION N4223.0 E4539.0
RIG TYPE TH-60
BORING TYPE ROTARY MUD 6.0-IN.
SURFACE ELEV 4233.90
DATUM MSL

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Classification	REMARKS	VISUAL CLASSIFICATION
55										LACUSTRINE DEPOSITS, Continued.
60										
								SP		SAND, fine to very fine, little clay, dk. grey.
								SC		
65										
								SP		SAND, very fine dk. grey.
70									Lower sand zone below 68 feet caves easily.	
75										
80										
85										
90										
95										
								SM		SILTY SAND, medium to coarse, subrounded, lt. grey to dk. grey.
100										

GROUNDWATER

DEPTH	HOUR	DATE

SAMPLE TYPE

RX - Rock Coring - NX or HX
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
G - Grab, cuttings sample

JEG TAC TEAM

PROJECT VITRO PROCESS SITE
SALT LAKE CITY, UTAH

LOG OF TEST BORING NO. G135

JOB NO. SLC01 DATE 06/25/92

LOCATION N4223.0 E4539.0
RIG TYPE TH-60
BORING TYPE ROTARY MUD 6.0-IN.
SURFACE ELEV 4233.90
DATUM MSL

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot-140 lb. 30-free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
105										
110										TD AT 110 FEET.

GROUNDWATER

DEPTH	HOUR	DATE

SAMPLE TYPE
RX - Rock Coring - NX or HX
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
G - Grab, cuttings sample

JEG TAC TEAM

PROJECT VITRO PROCESS SITE
SALT LAKE CITY, UTAH

LOG OF WELL BORING NO. 136

JOB NO. SLC01 DATE 06/30/92
SURFACE ELEVATION 4233.74
TOP OF FILTER PACK 11.50
WELL CASING TYPE 2.0-IN.SCHED.40 PVC
COMPLETION LACUSTRINE

TOTAL DEPTH 45.0 feet
RIG TYPE CME-75
BORING TYPE HS AUGER
LOCATION N 4225.96 E 4522.61
DATUM MSL

Depth	Well Con.	Remarks	Lithology	USCS	Visual Classification
0		Installed 2-in PVC well.		GM	FILL: SILTY SAND AND GRAVEL, poorly graded, subangular, loose, moist, lt. brown.
		Placed protective casing to 3.4 with grout to 2.8 ft. Placed bentonite chip seal from 2.8 to 11.5 ft.			
5				ML	LACUSTRINE: CLAYEY SILT, with fine sand, low plasticity, very moist, greyish green.
				CL	SILTY CLAY, low to med. plasticity, saturated, lt. green.
10				SM	SILTY SAND, medium to fine, saturated, brown to greyish brown.
		Installed filter pack from 11.5 to TD.			
15					
20				ML	CLAYEY SILT, with fine sand, low plasticity, saturated, greyish brown.
25					
30					
		Placed well screen from 33 to 43 feet.		ML	SANDY SILT, very fine sand, saturated, dark grey.
35					
40					
		Placed two foot sump at 43 to 45 ft.			
45					TD AT 45 FEET.
50					

GROUNDWATER

DEPTH	HOUR	DATE
9.2	07:54	7-1-92

JEG TAC TEAM

PROJECT VITRO PROCESS SITE
SALT LAKE CITY UTAH

LOG OF WELL BORING NO. 137

JOB NO. SLC01 DATE 07/01/92
SURFACE ELEVATION 4234.15
TOP OF FILTER PACK 13.00
WELL CASING TYPE 2.0-IN.SCHED.40 PVC
COMPLETION LACUSTRINE

TOTAL DEPTH 45.0 feet
RIG TYPE CME-75
BORING TYPE HS AUGER
LOCATION N 4218.43 E 4584.21
DATUM MSL

Depth	Well Con.	Remarks	Lithology	USCS	Visual Classification
0		Installed 2-in PVC well.		GM	FILL: SILTY SAND AND GRAVEL, poorly graded, subangular, loose, moist lt. brown.
		Placed protective casing to 3.3 with grout to 3.0 ft. Placed bentonite chip seal from 3.0 to 13.0 ft.			
5					
10					
		Installed filter pack from 13.0 to TD.		SM	LACUSTRINE: SILTY SAND, medium to coarse, little clay, saturated, greyish brown.
15					
				SM	SILTY SAND, med. to coarse, little clay, saturated, greyish green.
20					
25					Note: only trace of clay below 24 ft.
30					
		Placed well screen from 33 to 43 feet.		ML	SANDY SILT, little clay, low plasticity, lt. grey to green.
35					
				ML	SANDY SILT, fine sand, saturated, very soft, dk grey.
40					
		Placed two foot sump at 43 to 45 ft.			
45					TD AT 45 FEET
50					

GROUNDWATER

DEPTH	HOUR	DATE

JEG TAC TEAM

PROJECT VITRO PROCESS SITE
SALT LAKE CITY, UTAH

LOG OF WELL BORING NO. 138

JOB NO. SLC01 DATE 06/30/92
SURFACE ELEVATION 4233.06
TOP OF FILTER PACK 12.20
WELL CASING TYPE 2.0-IN.SCHED.40 PVC
COMPLETION LACUSTRINE

TOTAL DEPTH 45.0 feet
RIG TYPE CME-75
BORING TYPE HS AUGER
LOCATION N 4123.92 E 4532.40
DATUM MSL

Depth	Well Con.	Remarks	Lithology	USCS	Visual Classification
0		Installed 2-in PVC well.		GM	FILL: SILTY SAND AND GRAVEL, poorly graded, subrounded, loose, very moist, brown.
		Placed protective casing to 3.2 with grout to 2.5 ft. Placed bentonite chip seal from 2.5 to 12.2 ft.			
5					
				ML	LACUSTRINE: CLAYEY SILT, low plasticity, very moist, dark green.
10					
		Installed filter pack from 12.2 to TD.		CL	SILTY CLAY, low plasticity, saturated, brown to grey.
15					
				SM	SILTY SAND, fine to med. saturated, lt. grey.
20					
				SC	CLAYEY SAND, fine to med. slightly plastic, saturated, lt. grey.
25					
				SM	CLAYEY SAND, very fine sand, loose, saturated, dk. grey.
30					
		Placed well screen from 33 to 43 feet.			
35					
40					
		Placed two foot sump at 43 to 45 ft.			
45					TD AT 45 FEET.
50					

GROUNDWATER

DEPTH	HOUR	DATE
5.5	07:58	7-1-92

JEG TAC TEAM

ATTACHMENT 2

WELL BORING LOGS
FROM PREVIOUS WORK REFERENCED IN THIS STUDY

SALT LAKE CITY, UTAH, SITE

PROJECT VITRO PROCESS SITE
SALT LAKE CITY, UTAH

LOG OF WELL BORING NO. 001

JOB NO. SLC01 DATE 04/13/83
SURFACE ELEVATION 4244.82
OF FILTER PACK 80.00
CASING TYPE OBSERVATION WELL
COMPLETION LACUSTRINE DEPOSITS

TOTAL DEPTH 115.0 feet
RIG TYPE CME-55
BORING TYPE HOLLOW STEM AUGER
LOCATION N 2717.65 E 7535.58
DATUM MSL

Depth	Well Con.	Remarks	Lithology	USCS	Visual Classification
0		Installed 2-in. PVC observation well to 115 feet. Grout seal placed to 80 feet. Natural sand filter pack from . 80 to 115 ft. .010-in slot screen placed at 99.8 to 109.8 ft. Std. pen. test at 5 ft intervals as indicated.		CL	SOIL-ALLUVIUM: SANDY CLAY, fine grained sand, low plasticity, moist, dark brown.
				SC	CLAYEY SAND, fine grained, low plasticity, med. dense, moist, brown to dk. brown.
5				ML	LACUSTRINE: CLAYEY SILT, some fine sand, laminated, nonplastic to low plasticity, firm, wet, lt. greyish brown.
				ML	CLAYEY SILT, low plasticity, mod. firm, wet, lt. greyish brown with mottled reddish brown. Note: Color grading to brown AT 11.5 FEET.
10		N=20 @ 5 to 6.5 ft. N=9 @ 10 to 11.5 ft.			
15		N=5 @ 15 to 16.5 ft.			
20		N=9 @ 20 to 21.5 ft.		SM	SILTY SAND, fine, trace fine gravel, nonplastic, loose to mod. firm, wet, greyish brown to grey.
25		N=9 @ 25 to 26.5 ft.			
30		N=11 @ 30 to 31.5 ft.			
35		N=4 @ 35 to 36.5 ft.			
40		N=7 @ 40 to 41.5 ft.			
45		N=25 @ 45 to 46.5 ft.			
50		N=6 @ 50 to 51.5 ft.		ML	CLAYEY SILT, nonplastic to low plasticity, soft, wet, greyish brown with mottled black.

GROUNDWATER

DEPTH	HOUR	DATE

JEG TAC TEAM

PROJECT VITRO PROCESS SITE
SALT LAKE CITY, UTAH

LOG OF WELL BORING NO. 001

JOB NO. SLC01 DATE 04/13/83
SURFACE ELEVATION 4244.82
TOP OF FILTER PACK
WELL CASING TYPE OBSERVATION WELL
COMPLETION LACUSTRINE DEPOSITS

TOTAL DEPTH 115.0 feet
RIG TYPE CME-55
BORING TYPE HOLLOW STEM AUGER
LOCATION N 2717.65 E 7535.58
DATUM MSL

Depth	Well Con.	Remarks	Lithology	USCS	Visual Classification
					LACUSTRINE DEPOSITS, Continued.
55		N=31 @ 55 to 56.5 ft.		SM	SILTY SAND, fine grained, nonplastic, med. dense, to dense, wet, grey.
60		N=27 @ 60 to 61.5 ft.			Note: Occasional thin seams of clayey sand and sandy silt.
65		N=19 @ 65 to 66.5 ft.			
70		N=11 @ 70 to 71.5 ft.			
75		N=26 @ 75 to 76.5 ft.			
80		N=16 @ 80 to 81.5 ft.		SP	SAND, fine to med. grained, mod. stratified, nonplastic, med. dense, wet, grey.
85		N=42 @ 85 to 86.5 ft.		ML	CLAYEY SILT, trace sand, nonplastic to low plasticity, soft to mod. firm, wet, greyish brown.
				SM	SILTY SAND, fine, nonplastic, dense, wet, greyish brown.
90		N=36 @ 90 to 91.5 ft.		SW	SAND, trace silt, fine to coarse grained sand, some fine gravel, subrounded to subangular, nonplastic, very dense, wet, lt. grey.
95		N=50+ @ 95 to 96.5 ft.			
100		Stopped auger at 110; continued with rotary wash to 115 ft.			

GROUNDWATER

DEPTH	HOUR	DATE

JEG TAC TEAM

PROJECT VITRO PROCESS SITE
SALT LAKE CITY, UTAH

LOG OF WELL BORING NO. 001

JOB NO. SLC01 DATE 04/13/83
SURFACE ELEVATION 4244.82
OF FILTER PACK
WELL CASING TYPE OBSERVATION WELL
COMPLETION LACUSTRINE DEPOSITS

TOTAL DEPTH 115.0 feet
RIG TYPE CME-55
BORING TYPE HOLLOW STEM AUGER
LOCATION N 2717.65 E 7535.58
DATUM MSL

	Depth	Well Con.	Remarks	Lithology	USCS	Visual Classification
105						LACUSTRINE DEPOSITS, Continued.
					CL	SILTY CLAY, trace sand, low plasticity, very stiff, wet, grey.
110						
115						TD AT 115 FEET.
120						
125						
130						
135						
140						
145						
150						
155						

GROUNDWATER

DEPTH	HOUR	DATE

JEG TAC TEAM

LOG OF WELL BORING NO. 002

PROJECT VITRO PROCESS SITE
SALT LAKE CITY, UTAH

JOB NO. SLC01 DATE 03/26/83

SURFACE ELEVATION 4237.90

OF FILTER PACK

L CASING TYPE OBSERVATION WELL

COMPLETION LACUSTRINE DEPOSITS

TOTAL DEPTH 135.0 feet

RIG TYPE CME-55

BORING TYPE HOLLOW STEM AUGER

LOCATION N 5522.05 E 6618.50

DATUM MSL

Depth	Well Con.	Remarks	Lithology	USCS	Visual Classification
0		Installed 2-in. PVC observation well to 131.5 feet. Grout seal placed to 110 ft.;Natural sand filter pack placed from 110 to 135 ft.;.010-in. slot screen placed at 119 to 129 ft. Std. pen. test at 5 ft intervals as indicated. N=5 @ 5 to 6.5 ft. N=11 @ 10 to 11.5 ft.		SC	LACUSTRINE-ALLUVIUM: CLAYEY SAND, with thin seams of sandy clay, fine sand, nonplastic to low plasticity, soft, wet, dk. grey to greyish brown.
5				SM	LACUSTRINE: SILTY SAND, fine, nonplastic, med. dense, wet, greyish brown.
10				ML	SANDY SILT, fine sand, nonplastic, very soft ot mod. firm, wet, greyish brown.
15		N=4 @ 15 to 16.5 ft.			
20		N=7 @ 20 to 21.5 ft.			
25		N=7 @ 25 to 26.5 ft.			
30		N=8 @ 30 to 31.5 ft.			
35		N=10 @ 35 to 36.5 ft.			
40		N=12 @ 40 to 41.5 ft.		SM	SILTY SAND, fine, nonplastic, med. dense, wet, greyish brown.
45		N=6 @ 45 to 46.5 ft.		CL	SANDY CLAY, fine sand, low plasticity, med. stiff, wet, greyish brown.
50		N=28 @ 50 to 51.5 ft.		SM	SILTY SAND, fine, nonplastic, med. dense, wet, greyish brown.

GROUNDWATER

DEPTH	HOUR	DATE

JEG TAC TEAM

PROJECT VITRO PROCESS SITE
SALT LAKE CITY, UTAH

LOG OF WELL BORING NO. 002

JOB NO. SLC01 DATE 03/26/83
SURFACE ELEVATION 4237.90
TOP OF FILTER PACK
WELL CASING TYPE OBSERVATION WELL
COMPLETION LACUSTRINE DEPOSITS

TOTAL DEPTH 135.0 feet
RIG TYPE CME-55
BORING TYPE HOLLOW STEM AUGER
LOCATION N 5522.05 E 6618.50
DATUM MSL

	Depth	Well Con.	Remarks	Lithology	USCS	Visual Classification
						LACUSTRINE DEPOSITS, Continued.
55			N=22 @ 55 to 56.5 ft.			
					ML	CLAYEY SILT, nonplastic to low plasticity, soft, wet, dk. greyish brown to dark grey.
60			N=7 @ 60 to 61.5 ft.			
					ML	SANDY SILT, with some clay, fine sand, nonplastic, mod. firm, wet, greyish brown.
65			N=14 @ 65 to 66.5 ft.			
					ML	CLAYEY SILT, nonplastic to low plasticity, firm, wet, dark greyish brown.
70			N=19 @ 70 to 71.5 ft.			
75			N=19 @ 75 to 76.5 ft.			
80			N=44 @ 80 to 81.5 ft.		SM	SILTY SAND, fine grained, nonplastic, very dense, wet, lt. greyish brown.
85			N=50+ @ 85 ft.			Note: Occasional seams of med. sand and clayey silt.
90			N=50+ @ 90 ft.			
95			N=50+ @ 95 ft.			
100			N=41 @ 100 to 101.5 ft.		ML	CLAYEY SILT, nonplastic, firm to very firm, very dark greyish brown.

GROUNDWATER

DEPTH	HOUR	DATE

JEG TAC TEAM

PROJECT VITRO PROCESS SITE
SALT LAKE CITY, UTAH

LOG OF WELL BORING NO. 002

JOB NO. SLC01 DATE 03/26/83
SURFACE ELEVATION 4237.90
OF FILTER PACK
WELL CASING TYPE OBSERVATION WELL
COMPLETION LACUSTRINE DEPOSITS

TOTAL DEPTH 135.0 feet
RIG TYPE CME-55
BORING TYPE HOLLOW STEM AUGER
LOCATION N 5522.05 E 6618.50
DATUM MSL

	Depth	Well Con.	Remarks	Lithology	USCS	Visual Classification
105			N=26 @ 105 to 106.5 ft.			LACUSTRINE DEPOSITS, Continued.
110			N=17 @ 110 to 111.5 ft.			
115			N=24 @ 115 to 116.5 ft.			
120			N=50+ @ 120 ft.		ML SM	SILTY SAND, to sandy silt, fine sand, nonplastic, very dense, wet, greyish brown to brown.
125			N=32 @ 125 to 126.5 ft.			
130			N=49 @ 130 to 131.5 ft.			
135			Auger stopped at 130; Continued with rotary wash to 135 ft.			TD AT 135 FEET.
140						
145						
150						
155						

GROUNDWATER

DEPTH	HOUR	DATE

JEG TAC TEAM

PROJECT VITRO PROCESS SITE
SALT LAKE CITY, UTAH

LOG OF WELL BORING NO. 008

JOB NO. SLC01 DATE 03/10/83
SURFACE ELEVATION 4234.96
TOP OF FILTER PACK
WELL CASING TYPE OBSERVATION WELL
COMPLETION LACUSTRINE DEPOSITS

TOTAL DEPTH 40.0 feet
RIG TYPE CME-55
BORING TYPE HOLLOW STEM AUGER
LOCATION N 6328.93 E 4444.33
DATUM MSL

Depth	Well Con.	Remarks	Lithology	USCS	Visual Classification
0		Installed 3-in PVC observation well to 29.4 feet. Grout seal placed to 12.7 feet; bentonite seal from 12.7 to 13.7 ft.; .010-in. slot screen placed from 26.4 to 28.4 ft. Natural sand filter pack placed from 13.7 to 40 ft. Std. pen. test at 5 ft intervals as indicated.		ML SC	SOIL: CLAYEY SILT TO SANDY CLAY, (typical), moist.
5				SP	LACUSTRINE: CLAYEY SAND, fine to medium, low plasticity, mod. firm, moist, grey.
					SAND, fine to med. grained, nonplastic, med. dense, moist, grey.
10				SM	SILTY SAND, fine, nonplastic, med. dense, moist, grey.
		N=13 @ 0 to 1.5 ft.		SW	SAND, medium to coarse, grades to fine to coarse with depth, subrounded, nonplastic, dense to very dense, moist to wet, grey.
15		N=17 @ 5 to 5.6 ft.			
		N=12 @ 10 to 11.5 ft.			
20		N=35 @ 15 to 16.5 ft.			
25		N=46 @ 20 to 21.5 ft.			
		N=82 @ 25 to 26.5 ft.			
30		N=14 @ 30 to 31.5 ft.		ML	CLAYEY SILT, trace sand, nonplastic to low plasticity, mod. firm, wet, grey with dark grey mottling.
35		Stopped sampler at 31.5 ft.			
40					TD AT 40 FEET.
45					
50					

GROUNDWATER

DEPTH	HOUR	DATE

JEG TAC TEAM

PROJECT VITRO PROCESS SITE
SALT LAKE CITY, UTAH

LOG OF WELL BORING NO. 015

JOB NO. SLC01 DATE 03/19/83
SURFACE ELEVATION 4234.37
OF FILTER PACK
CASING TYPE PUMP TEST WELL
COMPLETION LACUSTRINE DEPOSITS

TOTAL DEPTH 133.0 feet
RIG TYPE CME-55
BORING TYPE HOLLOW STEM AUGER
LOCATION N 4414.34 E 3378.24
DATUM MSL

Depth	Well Con.	Remarks	Lithology	USCS	Visual Classification
0		Installed 10-in. steel cased well to 122 feet for pumping test.		ML ML	SOIL: CLAYEY SILT, TO SANDY CLAY, (typical), moist.
5		Grout seal to 80 ft.; bentonite seal from 80 to 83 ft.; No.6-9filter pack from 83 to 133 ft. .050-in. slot screen from 102-112 feet; sump from 112 to 122 ft.			LACUSTRINE: SANDY SILT, some clay, fine to med. sand, nonplastic, soft, moist, brown, mottled grey.
10				SM	SILTY SAND, fine to medium, poorly graded, nonplastic, very loose, wet, grey.
15		Std. pen. test at 5 ft intervals as indicated. N=6 @ 5 to 6.5 ft. N=1 @ 10 to 11.5 ft. N=19 @ 15 to 16.5 ft.		SW	SAND, some silt, fine to coarse sand, poorly to well graded, subrounded to subangular, mod. stratified, nonplastic, med to very dense, wet, grey.
20		N=25 @ 20 to 21.5 ft.			
25		N=22 @ 25 to 26.5 ft.			
30		N=59 @ 30 to 31.5 ft.			
35		N=43 @ 35 to 36.5 ft.			Note: Trace fine gravel at 35 ft.
40		N=23 @ 40 to 41.5 ft.		ML	SANDY SILT, some clay, fine sand, nonplastic, firm wet, grey.
45		N=58 @ 45 to 46.5 ft.		SM	SILTY SAND, fine to medium, nonplastic, grey to dk. very dense, wet, grey.
50		N=78 @ 50 to 51.5 ft.			

GROUNDWATER

DEPTH	HOUR	DATE

JEG TAC TEAM

PROJECT VITRO PROCESS SITE
SALT LAKE CITY, UTAH

LOG OF WELL BORING NO. 015

JOB NO. SLC01 DATE 03/19/83
SURFACE ELEVATION 4234.37
TOP OF FILTER PACK
WELL CASING TYPE PUMP TEST WELL
COMPLETION LACUSTRINE DEPOSITS

TOTAL DEPTH 133.0 feet
RIG TYPE CME-55
BORING TYPE HOLLOW STEM AUGER
LOCATION N 4414.34 E 3378.24
DATUM MSL

Depth	Well Con.	Remarks	Lithology	USCS	Visual Classification
					LACUSTRINE DEPOSITS, Continued.
55		N=43 @ 55 to 56.5 ft.			
				ML	SANDY SILT, some clay seams, fine sand, laminated, nonplastic, very firm to hard, wet, grey to dark grey.
60		N=56 @ 60 to 61.5 ft.			
65		N=35 @ 65 to 66.5 ft.			
				ML	CLAYEY SILT, trace sand, thinly bedded, nonplastic, firm, wet, grey with dark grey mottling.
70		N=16 @ 70 to 71.5 ft.			
75		N=19 @ 75 to 76.5 ft.			
				SM	SILTY SAND, fine, nonplastic, firm, wet, grey.
80		N=33 @ 80 to 81.5 ft.		ML	SANDY SILT, some clay seams, fine sand, nonplastic, hard, wet, grey.
85		N=57 @ 85 to 86.5 ft.			
				ML	CLAYEY SILT, trace sand, nonplastic, firm to very firm, wet, greyish brown.
90		N=23 @ 90 to 91.5 ft.			
95		N=30 @ 95 to 96.5 ft.			
100		N=50+ @100 to 100.5 ft.		SW	SILTY SAND, fine to coarse grained, subrounded to subangular, nonplastic, very dense, wet, grey.

GROUNDWATER

DEPTH	HOUR	DATE

JEG TAC TEAM

PROJECT VITRO PROCESS SITE
SALT LAKE CITY, UTAH

LOG OF WELL BORING NO. 015

JOB NO. SLC01 DATE 03/19/83
SURFACE ELEVATION 4234.37
OF FILTER PACK
CASING TYPE PUMP TEST WELL
COMPLETION LACUSTRINE DEPOSITS

TOTAL DEPTH 133.0 feet
RIG TYPE CME-55
BORING TYPE HOLLOW STEM AUGER
LOCATION N 4414.34 E 3378.24
DATUM MSL

	Depth	Well Con.	Remarks	Lithology	USCS	Visual Classification
105						
110						
115						
120						
125						
130						
						TD AT 130 FEET.
135						
140						
145						
150						
155						

GROUNDWATER

DEPTH	HOUR	DATE

JEG TAC TEAM

ATTACHMENT 3

GEOPHYSICAL LOGS, BORINGS G-130 AND G-135

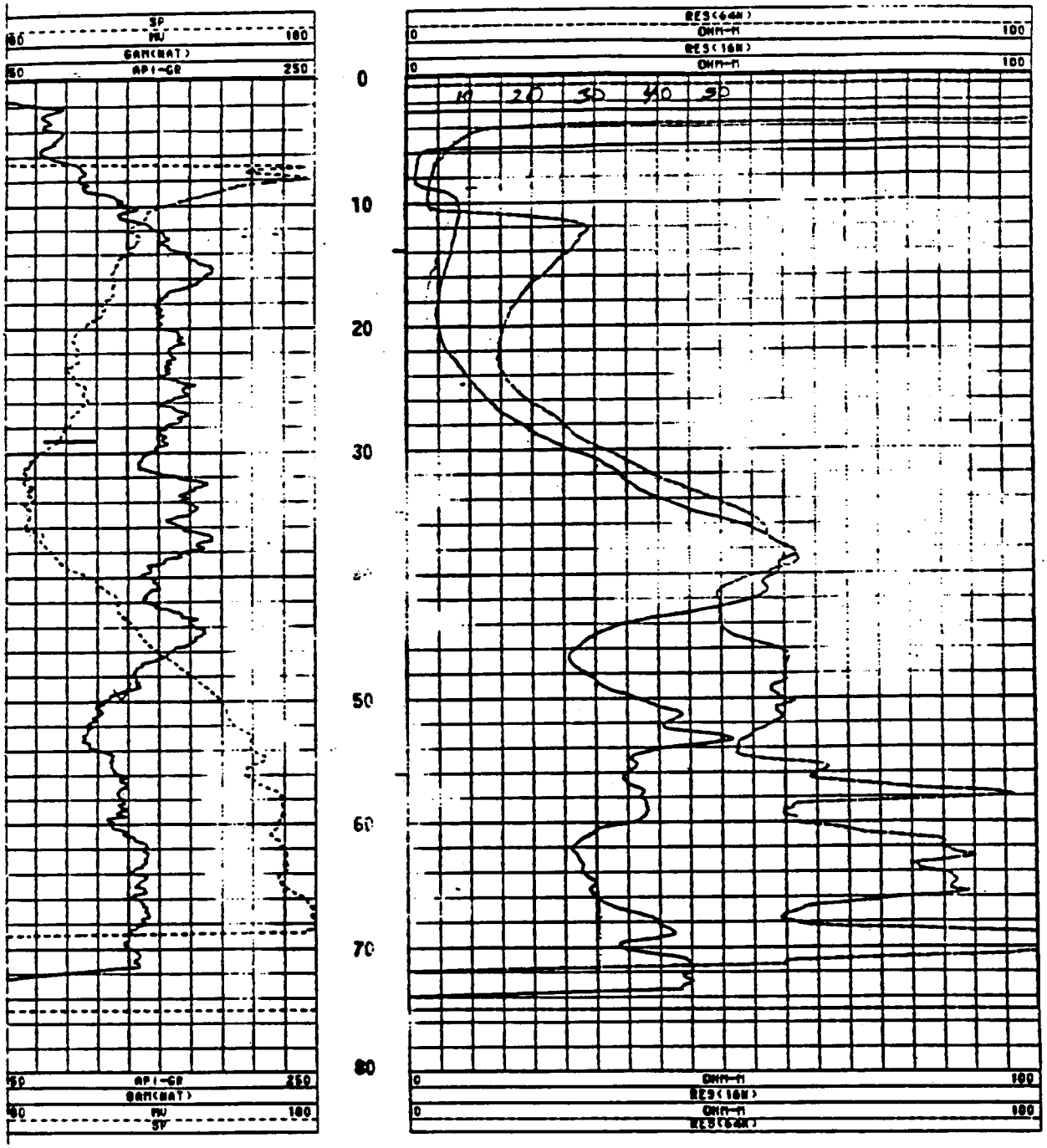
Run #2

Century GEOPHYSICAL CORP.

G - 130

COMPANY	: P C EXPLORATION			OTHER SERVICES:	
WELL	: G - 130				
LOC ON/FIELD	: 3300 S. AT 900 W.				
CO.	: SALT LAKE				
STATE	: UTAH				
SECTION	:	TOWNSHIP	:	RANGE	:
DATE	: 06/25/92	PERMANENT DATUM	: G.L.	ELEVATIONS	
DEPTH DRILLER	: 115	ELEV. PERM. DATUM:		KB	:
LOG BOTTOM	: 75.00	LOG MEASURED FROM:	G.L.	DF	:
LOG TOP	: -2.30	DRL MEASURED FROM:	G.L.	GL	:
CASING DRILLER	: 10	LOGGING UNIT	: 9010		
CASING TYPE	: STEEL	FIELD OFFICE	: CHINO VALLEY		
CASING THICKNESS	: .375	RECORDED BY	: R.FEDERWISCH		
BIT SIZE	: 6	BOREHOLE FLUID	: WATER	FILE	: ORIGINAL
MAGNETIC DECL.	: 12.5	RM	: 0	TYPE	: 9041A
MATRIX DENSITY	:	RM TEMPERATURE	: 0	LOG	: 1
FLUID DENSITY	:	MATRIX DELTA T	:	PLOT	: ELOG 6
NEUTRON MATRIX	: SANDSTONE	FLUID DELTA T	:	THRESH:	
REMARKS	:				

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS


SP
MV
100
GAM(NAT)
API-GR
250
0
10
20
30
50
60
70
80
RES(64N)
OHM-M
RES(16N)
10 20 30 40 50

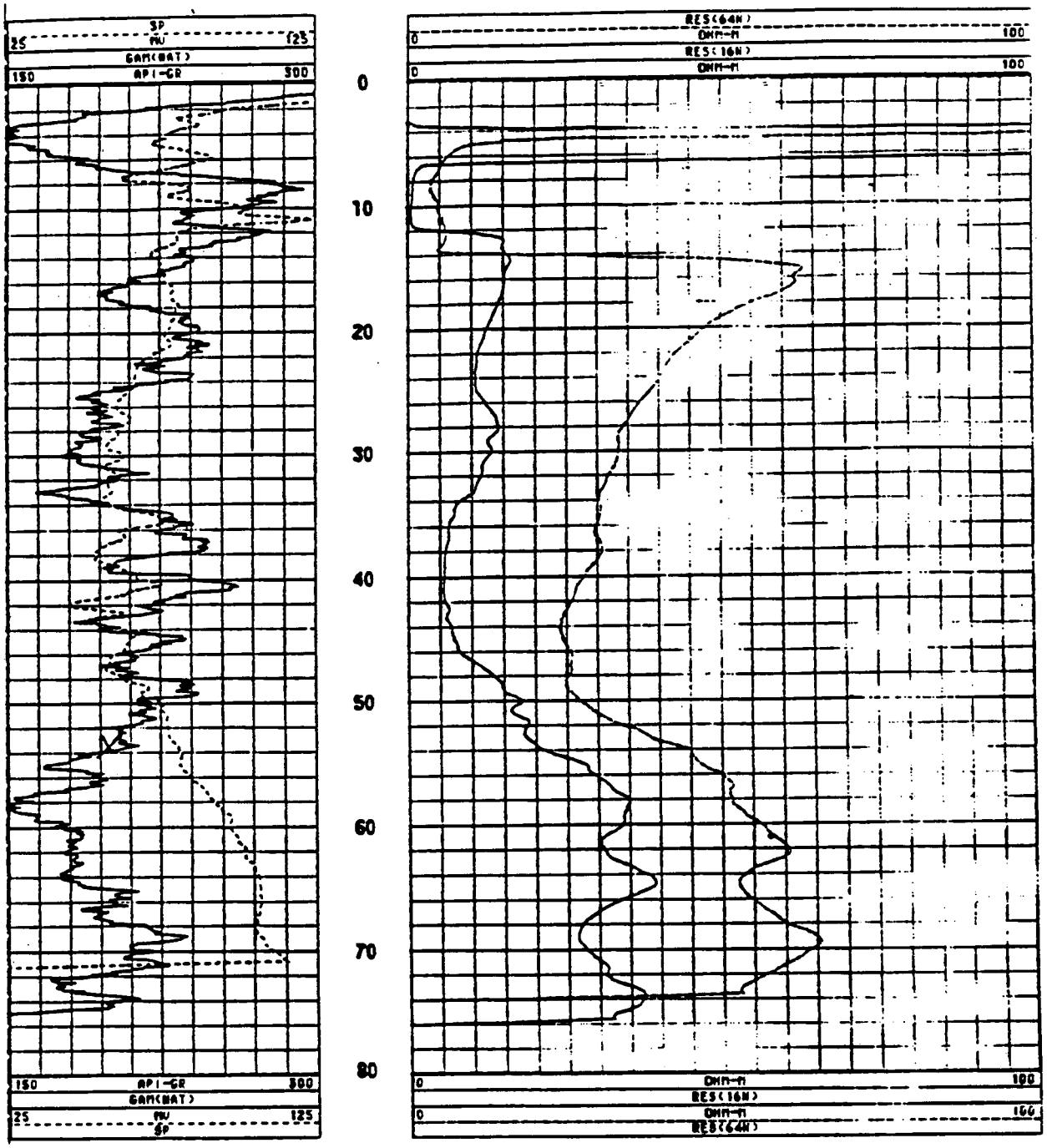
3rd Run

Century GEOPHYSICAL CORP.

G - 135

COMPANY	: P C EXPLORATION			OTHER SERVICES:	
WELL	: G - 135				
LOCATION/FIELD	: 3300 S. AT 900 W.				
COUNTY	: SALT LAKE				
STATE	: UTAH				
SE/ N	:	TOWNSHIP	:	RANGE	:
DATE	: 06/25/92	PERMANENT DATUM	: G.L.	ELEVATIONS	
DEPTH DRILLER	: 110	ELEV. PERM. DATUM	:	KB	:
LOG BOTTOM	: 95.60	LOG MEASURED FROM	: G.L.	DF	:
LOG TOP	: -4.60	DRL MEASURED FROM	: G.L.	GL	:
CASING DRILLER	: 10	LOGGING UNIT	: 9010		
CASING TYPE	: STEEL	FIELD OFFICE	: CHINO VALLEY		
CASING THICKNESS	: .375	RECORDED BY	: R.FEDERWISCH		
BIT SIZE	: 5.25	BOREHOLE FLUID	: WATER	FILE	: ORIGINAL
MAGNETIC DECL.	: 12.5	RM	: 0	TYPE	: 9041A
MATRIX DENSITY	:	RM TEMPERATURE	: 0	LOG	: 3
FLUID DENSITY	:	MATRIX DELTA T	:	PLOT	: ELOG 6
NEUTRON MATRIX	: SANDSTONE	FLUID DELTA T	:	THRESH	:
REMARKS	:				

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS


SP
25 MV 125
GAM(NAT)
150 API-GR 300
0
10
20
30
40
50
60
70
80
RES(64N)
0 OHM-M 100
RES(16N)
0 OHM-M 100
150 API-GR 300
GAM(NAT)
25 MV 125
SP
0 OHM-M 100
RES(16N)
0 OHM-M 100
RES(64N)

ATTACHMENT 4

SOIL CHEMISTRY DATA

SOIL CHEMISTRY DATA BY PARAMETER
SITE: SLC01 SALT LAKE CITY
06/24/92 TO 06/29/92
REPORT DATE: 01/05/93

PARAMETER NAME	LOC. ID	LOG DATE	SAMP ID	DEPTH RANGE (FT)	DIG. CODE	SAMP DESC	UNITS OF MEASURE	PARAMETER PVI	VALUE	FLAGS	PARAMETER UNCERT.
% SOLIDS	0571	06/29/92	0001	8 -10			%		75.92		-
	0572	06/29/92	0001	9 -11					80.65		-
	0573	06/26/92	0001	11 -13					79.36		-
	0574	06/26/92	0001	14 -16					80.55		-
	0575	06/29/92	0001	8 -10					71.53		-
	0576	06/26/92	0001	14 -16					72.26		-
	0577	06/24/92	0001	9 -11					77.72		-
	0578	06/24/92	0001	13.5 -15.5					76.85		-
	0579	06/24/92	0001	8.5 -10.5					81.88		-
ALUMINUM	0571	06/29/92	0001	8 -10			MG/KG		17300	*	-
	0572	06/29/92	0001	9 -11					11300	*	-
	0573	06/26/92	0001	11 -13					11800	*	-
	0574	06/26/92	0001	14 -16					5260	*	-
	0575	06/29/92	0001	8 -10					12200	*	-
	0576	06/26/92	0001	14 -16					17400	*	-
	0577	06/24/92	0001	9 -11					3880	*	-
	0578	06/24/92	0001	13.5 -15.5					8660	*	-
	0579	06/24/92	0001	8.5 -10.5					7720	*	-
ANTIMONY	0571	06/29/92	0001	8 -10			MG/KG	<	0.3		-
	0572	06/29/92	0001	9 -11				<	0.3		-
	0573	06/26/92	0001	11 -13				<	0.3		-
	0574	06/26/92	0001	14 -16					0.302		-
	0575	06/29/92	0001	8 -10				<	0.3		-
	0576	06/26/92	0001	14 -16				<	0.3		-
	0577	06/24/92	0001	9 -11				<	0.3		-
	0578	06/24/92	0001	13.5 -15.5				<	0.3		-
	0579	06/24/92	0001	8.5 -10.5				<	0.3		-
ARSENIC	0571	06/29/92	0001	8 -10			MG/KG		14	*N	-
	0572	06/29/92	0001	9 -11					24.9	*N	-
	0573	06/26/92	0001	11 -13					6.12	*N	-
	0574	06/26/92	0001	14 -16					31.6	*N	-
	0575	06/29/92	0001	8 -10					7.39	*N	-
	0576	06/26/92	0001	14 -16					29.7	*N	-
	0577	06/24/92	0001	9 -11					4.65	*N	-
	0578	06/24/92	0001	13.5 -15.5					10.3	*N	-
	0579	06/24/92	0001	8.5 -10.5					12.4	*N	-
BARIUM	0571	06/29/92	0001	8 -10			MG/KG		121		-
	0572	06/29/92	0001	9 -11					144		-
	0573	06/26/92	0001	11 -13					150		-
	0574	06/26/92	0001	14 -16					114		-
	0575	06/29/92	0001	8 -10					218		-
	0576	06/26/92	0001	14 -16					143		-
	0577	06/24/92	0001	9 -11					42.1		-
	0578	06/24/92	0001	13.5 -15.5					90.4		-
	0579	06/24/92	0001	8.5 -10.5					105		-
BERYLLIUM	0571	06/29/92	0001	8 -10			MG/KG		0.851		-
	0572	06/29/92	0001	9 -11					0.508		-
	0573	06/26/92	0001	11 -13					0.536		-
	0574	06/26/92	0001	14 -16				<	0.5		-
	0575	06/29/92	0001	8 -10					0.56		-
	0576	06/26/92	0001	14 -16					0.83		-
	0577	06/24/92	0001	9 -11				<	0.5		-
	0578	06/24/92	0001	13.5 -15.5				<	0.5		-
	0579	06/24/92	0001	8.5 -10.5				<	0.5		-

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT
OTHER PARAMETER VALUE FLAGS: * - DUPLICATE ANALYSIS NOT WITHIN CONTROL LIMITS
N - SPIKE SAMPLE RECOVERY NOT WITHIN CONTROL LIMITS
SAMPLE DIGESTION TYPE CODES: -
SAMPLE DESCRIPTION CODES: -

SOIL CHEMISTRY DATA BY PARAMETER
SITE: SLC01 SALT LAKE CITY
06/24/92 TO 06/29/92
REPORT DATE: 01/05/93

PARAMETER NAME	LOC. ID	LOG DATE	SAMP ID	DEPTH RANGE (FT)	DIG. CODE	SAMP DESC	UNITS OF MEASURE	PARAMETER PVI	VALUE	FLAGS	PARAMETER UNCERT.
CADMIUM	0571	06/29/92	0001	8 -10	-		MG/KG		0.572	N	-
	0572	06/29/92	0001	9 -11					0.4	N	-
	0573	06/26/92	0001	11 -13					0.722	N	-
	0574	06/26/92	0001	14 -16					0.514	N	-
	0575	06/29/92	0001	8 -10					0.753	N	-
	0576	06/26/92	0001	14 -16					0.802	N	-
	0577	06/24/92	0001	9 -11				<	0.1	N	-
	0578	06/24/92	0001	13.5 -15.5					0.548	N	-
	0579	06/24/92	0001	8.5 -10.5					0.565	N	-
CALCIUM	0571	06/29/92	0001	8 -10			MG/KG		64300		-
	0572	06/29/92	0001	9 -11					57300		-
	0573	06/26/92	0001	11 -13					50800		-
	0574	06/26/92	0001	14 -16					187000		-
	0575	06/29/92	0001	8 -10					64200		-
	0576	06/26/92	0001	14 -16					63100		-
	0577	06/24/92	0001	9 -11					20000		-
	0578	06/24/92	0001	13.5 -15.5					39000		-
	0579	06/24/92	0001	8.5 -10.5					34600		-
CHLORIDE	0571	06/29/92	0001	8 -10			MG/KG		247		-
	0572	06/29/92	0001	9 -11					52.4		-
	0573	06/26/92	0001	11 -13					109		-
	0574	06/26/92	0001	14 -16					49.4		-
	0575	06/29/92	0001	8 -10					232		-
	0576	06/26/92	0001	14 -16					1010		-
	0577	06/24/92	0001	9 -11					39.5		-
	0578	06/24/92	0001	13.5 -15.5					171		-
	0579	06/24/92	0001	8.5 -10.5					42.1		-
CHROMIUM	0571	06/29/92	0001	8 -10			MG/KG		20.9	N	-
	0572	06/29/92	0001	9 -11					13.3	N	-
	0573	06/26/92	0001	11 -13					14.1		-
	0574	06/26/92	0001	14 -16					9.9	N	-
	0575	06/29/92	0001	8 -10					13.4	N	-
	0576	06/26/92	0001	14 -16					20.2	N	-
	0577	06/24/92	0001	9 -11					5.4	N	-
	0578	06/24/92	0001	13.5 -15.5					12.3	N	-
	0579	06/24/92	0001	8.5 -10.5					10.8	N	-
COBALT	0571	06/29/92	0001	8 -10			MG/KG		9.02		-
	0572	06/29/92	0001	9 -11					6.82		-
	0573	06/26/92	0001	11 -13					6.52		-
	0574	06/26/92	0001	14 -16					5		-
	0575	06/29/92	0001	8 -10					25.5		-
	0576	06/26/92	0001	14 -16					9		-
	0577	06/24/92	0001	9 -11					5.93		-
	0578	06/24/92	0001	13.5 -15.5					6.38		-
	0579	06/24/92	0001	8.5 -10.5					7.71		-
COPPER	0571	06/29/92	0001	8 -10			MG/KG		48.2	N	-
	0572	06/29/92	0001	9 -11					49	N	-
	0573	06/26/92	0001	11 -13					33.1		-
	0574	06/26/92	0001	14 -16					21.4	N	-
	0575	06/29/92	0001	8 -10					38.6	N	-
	0576	06/26/92	0001	14 -16					46.4	N	-
	0577	06/24/92	0001	9 -11					15.6	N	-
	0578	06/24/92	0001	13.5 -15.5					28.3	N	-
	0579	06/24/92	0001	8.5 -10.5					37.2	N	-
IRON	0571	06/29/92	0001	8 -10			MG/KG		21400		-

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT
OTHER PARAMETER VALUE FLAGS: N - SPIKE SAMPLE RECOVERY NOT WITHIN CONTROL LIMITS
SAMPLE DIGESTION TYPE CODES: -
SAMPLE DESCRIPTION CODES: -

SOIL CHEMISTRY DATA BY PARAMETER
SITE: SLC01 SALT LAKE CITY
06/24/92 TO 06/29/92
REPORT DATE: 01/05/93

PARAMETER NAME	LOC. ID	LOG DATE	SAMP ID	DEPTH RANGE (FT)	DIG. CODE	SAMP DESC	UNITS OF MEASURE	PARAMETER PVI	VALUE	FLAGS	PARAMETER UNCERT.
IRON	0572	06/29/92	0001	9 -11			MG/KG		15400		-
	0573	06/26/92	0001	11 -13					15300		-
	0574	06/26/92	0001	14 -16					11600		-
	0575	06/29/92	0001	8 -10					18200		-
	0576	06/26/92	0001	14 -16					20700		-
	0577	06/24/92	0001	9 -11					8130		-
	0578	06/24/92	0001	13.5 -15.5					14600		-
	0579	06/24/92	0001	8.5 -10.5					13500		-
LEAD	0571	06/29/92	0001	8 -10			MG/KG		26		-
	0572	06/29/92	0001	9 -11					29.1		-
	0573	06/26/92	0001	11 -13					28.4		-
	0574	06/26/92	0001	14 -16					16.7		-
	0575	06/29/92	0001	8 -10					26.1		-
	0576	06/26/92	0001	14 -16					32.3		-
	0577	06/24/92	0001	9 -11					6.87	*N	-
	0578	06/24/92	0001	13.5 -15.5					16.9	*N	-
	0579	06/24/92	0001	8.5 -10.5					26.9		-
MAGNESIUM	0571	06/29/92	0001	8 -10			MG/KG		18000		-
	0572	06/29/92	0001	9 -11					18800		-
	0573	06/26/92	0001	11 -13					14200		-
	0574	06/26/92	0001	14 -16					8580		-
	0575	06/29/92	0001	8 -10					18100		-
	0576	06/26/92	0001	14 -16					16100		-
	0577	06/24/92	0001	9 -11					6530		-
	0578	06/24/92	0001	13.5 -15.5					13200		-
	0579	06/24/92	0001	8.5 -10.5					14400		-
MANGANESE	0571	06/29/92	0001	8 -10			MG/KG		489		-
	0572	06/29/92	0001	9 -11					340		-
	0573	06/26/92	0001	11 -13					305		-
	0574	06/26/92	0001	14 -16					276		-
	0575	06/29/92	0001	8 -10					607		-
	0576	06/26/92	0001	14 -16					495		-
	0577	06/24/92	0001	9 -11					182		-
	0578	06/24/92	0001	13.5 -15.5					195		-
	0579	06/24/92	0001	8.5 -10.5					228		-
MERCURY	0571	06/29/92	0001	8 -10			MG/KG	<	0.1		-
	0572	06/29/92	0001	9 -11				<	0.1		-
	0573	06/26/92	0001	11 -13					0.1		-
	0574	06/26/92	0001	14 -16				<	0.1		-
	0575	06/29/92	0001	8 -10				<	0.1		-
	0576	06/26/92	0001	14 -16				<	0.1		-
	0577	06/24/92	0001	9 -11				<	0.1		-
	0578	06/24/92	0001	13.5 -15.5				<	0.1		-
	0579	06/24/92	0001	8.5 -10.5				<	0.1		-
MOLYBDENUM	0571	06/29/92	0001	8 -10			MG/KG	<	1	J	-
	0572	06/29/92	0001	9 -11					8.02	J	-
	0573	06/26/92	0001	11 -13				<	1	J	-
	0574	06/26/92	0001	14 -16					3.74	J	-
	0575	06/29/92	0001	8 -10					9.18	J	-
	0576	06/26/92	0001	14 -16					2.36	J	-
	0577	06/24/92	0001	9 -11				<	1	J	-
	0578	06/24/92	0001	13.5 -15.5				<	1	J	-
	0579	06/24/92	0001	8.5 -10.5					11.7	J	-

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT
OTHER PARAMETER VALUE FLAGS: * - DUPLICATE ANALYSIS NOT WITHIN CONTROL LIMITS
J - ESTIMATED VALUE
N - SPIKE SAMPLE RECOVERY NOT WITHIN CONTROL LIMITS
SAMPLE DIGESTION TYPE CODES: -
SAMPLE DESCRIPTION CODES: -

SOIL CHEMISTRY DATA BY PARAMETER
SITE: SLC01 SALT LAKE CITY
06/24/92 TO 06/29/92
REPORT DATE: 01/05/93

PARAMETER NAME	LOC. ID	LOG DATE	SAMP ID	DEPTH RANGE (FT)	DIG. CODE	SAMP DESC	UNITS OF MEASURE	PARAMETER PVI	VALUE	FLAGS	PARAMETER UNCERT.
NICKEL	0571	06/29/92	0001	8 -10			MG/KG		19.2		-
	0572	06/29/92	0001	9 -11					12.6		-
	0573	06/26/92	0001	11 -13					11.1		-
	0574	06/26/92	0001	14 -16					6.43		-
	0575	06/29/92	0001	8 -10					18.7		-
	0576	06/26/92	0001	14 -16					17.7		-
	0577	06/24/92	0001	9 -11					6.92		-
	0578	06/24/92	0001	13.5 -15.5					11.7		-
	0579	06/24/92	0001	8.5 -10.5					9.86		-
POTASSIUM	0571	06/29/92	0001	8 -10			MG/KG		5760	*	-
	0572	06/29/92	0001	9 -11					4070	*	-
	0573	06/26/92	0001	11 -13					3950	*	-
	0574	06/26/92	0001	14 -16					1340	*	-
	0575	06/29/92	0001	8 -10					4900	*	-
	0576	06/26/92	0001	14 -16					5980	*	-
	0577	06/24/92	0001	9 -11					1370	*	-
	0578	06/24/92	0001	13.5 -15.5					2300	*	-
	0579	06/24/92	0001	8.5 -10.5					2290	*	-
RADIUM-226 (TOTAL)	0571	06/29/92	0001	8 -10			PCI/G		4.9		0.8
	0572	06/29/92	0001	9 -11					4.7		0.8
	0573	06/26/92	0001	11 -13					4.3		0.7
	0574	06/26/92	0001	14 -16					4.1		0.7
	0575	06/29/92	0001	8 -10					3.2		0.6
	0576	06/26/92	0001	14 -16					4.8		0.8
	0577	06/24/92	0001	9 -11					4.1		0.7
	0578	06/24/92	0001	13.5 -15.5					4.1		0.7
	0579	06/24/92	0001	8.5 -10.5					4.3		0.7
RADIUM-228 (TOTAL)	0571	06/29/92	0001	8 -10			PCI/G		1.9		1.0
	0572	06/29/92	0001	9 -11					2.4		1.0
	0573	06/26/92	0001	11 -13					1.3		1.5
	0574	06/26/92	0001	14 -16					0.8		0.9
	0575	06/29/92	0001	8 -10					1.9		1.0
	0576	06/26/92	0001	14 -16					2.1		1.0
	0577	06/24/92	0001	9 -11					1.8		1.0
	0578	06/24/92	0001	13.5 -15.5					2.2		1.0
	0579	06/24/92	0001	8.5 -10.5					0.5		1.4
SELENIUM	0571	06/29/92	0001	8 -10			MG/KG	<	0.5	N	-
	0572	06/29/92	0001	9 -11				<	0.5	N	-
	0573	06/26/92	0001	11 -13				<	0.5	N	-
	0574	06/26/92	0001	14 -16				<	0.5	N	-
	0575	06/29/92	0001	8 -10				<	0.5	N	-
	0576	06/26/92	0001	14 -16				<	0.5	N	-
	0577	06/24/92	0001	9 -11				<	0.5	N	-
	0578	06/24/92	0001	13.5 -15.5					1.01	N	-
	0579	06/24/92	0001	8.5 -10.5				<	0.5	N	-
SILVER	0571	06/29/92	0001	8 -10			MG/KG		1.72		-
	0572	06/29/92	0001	9 -11					1.25		-
	0573	06/26/92	0001	11 -13					1.21		-
	0575	06/29/92	0001	8 -10					1.96		-
	0576	06/26/92	0001	14 -16					1.72		-
	0577	06/24/92	0001	9 -11				<	1		-
	0578	06/24/92	0001	13.5 -15.5				<	1		-
	0579	06/24/92	0001	8.5 -10.5				<	1		-
SODIUM	0571	06/29/92	0001	8 -10			MG/KG		885		-

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT
OTHER PARAMETER VALUE FLAGS: * - DUPLICATE ANALYSIS NOT WITHIN CONTROL LIMITS
N - SPIKE SAMPLE RECOVERY NOT WITHIN CONTROL LIMITS

SAMPLE DIGESTION TYPE CODES: -
SAMPLE DESCRIPTION CODES: -

SOIL CHEMISTRY DATA BY PARAMETER
SITE: SLC01 SALT LAKE CITY
06/24/92 TO 06/29/92
REPORT DATE: 01/05/93

PARAMETER NAME	LOC. ID	LOG DATE	SAMP ID	DEPTH RANGE (FT)	DIG. CODE	SAMP DESC	UNITS OF MEASURE	PARAMETER PVI	VALUE	FLAGS	PARAMETER UNCERT.
SODIUM	0572	06/29/92	0001	9 -11			MG/KG		870		-
	0573	06/26/92	0001	11 -13					501		-
	0574	06/26/92	0001	14 -16					257		-
	0575	06/29/92	0001	8 -10					696		-
	0576	06/26/92	0001	14 -16					2280		-
	0577	06/24/92	0001	9 -11					159		-
	0578	06/24/92	0001	13.5 -15.5					598		-
	0579	06/24/92	0001	8.5 -10.5					252		-
STRONTIUM	0571	06/29/92	0001	8 -10			MG/KG		189	J	-
	0572	06/29/92	0001	9 -11					148	J	-
	0573	06/26/92	0001	11 -13					111	J	-
	0574	06/26/92	0001	14 -16					164	J	-
	0575	06/29/92	0001	8 -10					748	J	-
	0576	06/26/92	0001	14 -16					149	J	-
	0577	06/24/92	0001	9 -11					53.5	J	-
	0578	06/24/92	0001	13.5 -15.5					103	J	-
	0579	06/24/92	0001	8.5 -10.5					67.9	J	-
SULFATE	0571	06/29/92	0001	8 -10			MG/KG		319		-
	0572	06/29/92	0001	9 -11					429		-
	0573	06/26/92	0001	11 -13					150		-
	0574	06/26/92	0001	14 -16					428		-
	0575	06/29/92	0001	8 -10					4020		-
	0576	06/26/92	0001	14 -16					1480		-
	0577	06/24/92	0001	9 -11					1410		-
	0578	06/24/92	0001	13.5 -15.5					909		-
	0579	06/24/92	0001	8.5 -10.5					834		-
THALLIUM	0571	06/29/92	0001	8 -10			MG/KG	<	0.5		-
	0572	06/29/92	0001	9 -11				<	0.5		-
	0573	06/26/92	0001	11 -13				<	0.5		-
	0574	06/26/92	0001	14 -16				<	0.5		-
	0575	06/29/92	0001	8 -10				<	0.5		-
	0576	06/26/92	0001	14 -16				<	0.5		-
	0577	06/24/92	0001	9 -11				<	0.5		-
	0578	06/24/92	0001	13.5 -15.5				<	0.5		-
	0579	06/24/92	0001	8.5 -10.5				<	0.5		-
TIN	0571	06/29/92	0001	8 -10			MG/KG	<	5	E	-
	0572	06/29/92	0001	9 -11				<	5	E	-
	0573	06/26/92	0001	11 -13				<	5	E	-
	0574	06/26/92	0001	14 -16				<	5	E	-
	0575	06/29/92	0001	8 -10				<	5	E	-
	0576	06/26/92	0001	14 -16				<	5	E	-
	0577	06/24/92	0001	9 -11				<	5	E	-
	0578	06/24/92	0001	13.5 -15.5				<	5	E	-
	0579	06/24/92	0001	8.5 -10.5				<	5	E	-
URANIUM (TOTAL)	0571	06/29/92	0001	8 -10			MG/KG		3.		-
	0572	06/29/92	0001	9 -11					3.		-
	0573	06/26/92	0001	11 -13					2.		-
	0574	06/26/92	0001	14 -16					4.		-
	0575	06/29/92	0001	8 -10					10.		-
	0576	06/26/92	0001	14 -16					2.		-
	0577	06/24/92	0001	9 -11					4.		-
	0578	06/24/92	0001	13.5 -15.5					2.		-
	0579	06/24/92	0001	8.5 -10.5					3.		-
VANADIUM	0571	06/29/92	0001	8 -10			MG/KG		33.6		-

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT
OTHER PARAMETER VALUE FLAGS: E - ESTIMATED VALUE BECAUSE OF INTERFERENCE
J - ESTIMATED VALUE

SAMPLE DIGESTION TYPE CODES: -
MPLE DESCRIPTION CODES: -

SOIL CHEMISTRY DATA BY PARAMETER
SITE: SLC01 SALT LAKE CITY
06/24/92 TO 06/29/92
REPORT DATE: 01/05/93

PARAMETER NAME	LOC. ID	LOG DATE	SAMP ID	DEPTH RANGE (FT)	DIG. CODE	SAMP DESC	UNITS OF MEASURE	PARAMETER PVI	VALUE	FLAGS	PARAMETER UNCERT.
VANADIUM	0572	06/29/92	0001	9 -11			MG/KG		28.3		-
	0573	06/26/92	0001	11 -13					25.8		-
	0574	06/26/92	0001	14 -16					31.6		-
	0575	06/29/92	0001	8 -10					34.1		-
	0576	06/26/92	0001	14 -16					35.5		-
	0577	06/24/92	0001	9 -11					15.5		-
	0578	06/24/92	0001	13.5 -15.5					22		-
	0579	06/24/92	0001	8.5 -10.5					23.5		-
ZINC	0571	06/29/92	0001	8 -10			MG/KG		95.8	N	-
	0572	06/29/92	0001	9 -11					68.4	N	-
	0573	06/26/92	0001	11 -13					65.1	N	-
	0574	06/26/92	0001	14 -16					35.5	N	-
	0575	06/29/92	0001	8 -10					75.3	N	-
	0576	06/26/92	0001	14 -16					86.4	N	-
	0577	06/24/92	0001	9 -11					33.6	N	-
	0578	06/24/92	0001	13.5 -15.5					60	N	-
	0579	06/24/92	0001	8.5 -10.5					68.8	N	-

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT
OTHER PARAMETER VALUE FLAGS: N - SPIKE SAMPLE RECOVERY NOT WITHIN CONTROL LIMITS
SAMPLE DIGESTION TYPE CODES: -
SAMPLE DESCRIPTION CODES: -

DATA FILE NAME: M:\DART\SLC01\SCI10008.DAT

ATTACHMENT 5

GROUNDWATER QUALITY DATA

SALT LAKE CITY, UTAH, SITE

GROUNDWATER QUALITY DATA BY PARAMETER
SITE: SLC01 SALT LAKE CITY
04/26/92 TO 07/23/92
REPORT DATE: 01/26/93

PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PVI	PARAMETER VALUE	FLAGS	PARAMETER UNCERTAINTY
ALKALINITY	0001	04/27/92	0001	LC	U	MG/L CACO3		250		-
	0002	04/27/92	0001	LC	U			282		-
	0003	04/26/92	0001	LC	C			235		-
	0007	04/27/92	0001	LU	U			439		-
	0008	04/27/92	0001	LU	C			599		-
	0011	04/26/92	0001	LU	D			667		-
	0109	04/26/92	0001	LU	D			795		-
	0130	07/23/92	0001	LU	O			321		-
	0132	07/23/92	0001	LU	O			404		-
	0133	07/23/92	0001	LU	O			420		-
	0134	07/22/92	0001	LU	D			493		-
	0135	07/22/92	0001	LU	O			1178		-
ALUMINUM	0001	04/27/92	0001	LC	U	MG/L	<	0.05		-
	0002	04/27/92	0001	LC	U		<	0.05		-
	0003	04/26/92	0001	LC	C		<	0.05		-
	0007	04/27/92	0001	LU	U		<	0.05		-
	0008	04/27/92	0001	LU	C		<	0.05		-
	0011	04/26/92	0001	LU	D		<	0.05		-
	0109	04/26/92	0001	LU	D		<	0.05		-
	0130	07/23/92	0001	LU	O			0.0867		-
	0132	07/23/92	0001	LU	O			0.124		-
	0133	07/23/92	0001	LU	O			0.141		-
	0134	07/22/92	0001	LU	D			0.074		-
	0135	07/22/92	0001	LU	O			0.143	I	-
AMMONIUM	0001	04/27/92	0001	LC	U	MG/L		4.3		-
	0002	04/27/92	0001	LC	U			6.1		-
	0003	04/26/92	0001	LC	C			5.2		-
	0007	04/27/92	0001	LU	U			7.7		-
	0008	04/27/92	0001	LU	C			10.9		-
	0011	04/26/92	0001	LU	D			3.1		-
	0109	04/26/92	0001	LU	D			1.8		-
	0130	07/23/92	0001	LU	O			9.02	*	-
	0132	07/23/92	0001	LU	O			11.7	*	-
	0133	07/23/92	0001	LU	O			9.42	*	-
	0134	07/22/92	0001	LU	D			6.6	*	-
	0135	07/22/92	0001	LU	O			4.02	*	-
ANTIMONY	0001	04/27/92	0001	LC	U	MG/L		0.004		-
	0002	04/27/92	0001	LC	U		<	0.003		-
	0003	04/26/92	0001	LC	C		<	0.003		-
	0007	04/27/92	0001	LU	U		<	0.003		-
	0008	04/27/92	0001	LU	C		<	0.003		-
	0011	04/26/92	0001	LU	D		<	0.003		-
	0109	04/26/92	0001	LU	D		<	0.003		-
	0130	07/23/92	0001	LU	O			0.0045		-
	0132	07/23/92	0001	LU	O		<	0.003		-
	0133	07/23/92	0001	LU	O			0.0041		-
	0134	07/22/92	0001	LU	D		<	0.003		-
	0135	07/22/92	0001	LU	O		<	0.015	IW	-
ARSENIC	0001	04/27/92	0001	LC	U	MG/L	<	0.005		-
	0002	04/27/92	0001	LC	U		<	0.005		-
	0003	04/26/92	0001	LC	C		<	0.005		-
	0007	04/27/92	0001	LU	U			0.05		-

FORMATION OF COMPLETION CODE:
LC - LACUSTRINE CONFINED
LU - LACUSTRINE UNCONFINED

FLOW RELATIONSHIP CODE:
U - UPGRADIENT
C - CROSS GRADIENT
D - DOWN GRADIENT
O - ON-SITE

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT

SAMPLE ID CODES:
0001 - FILTERED SAMPLE (.45 MICRONS)

HER PARAMETER VALUE FLAGS:
- DUPLICATE ANALYSIS NOT WITHIN CONTROL LIMITS
I - INCREASED DETECTION LIMIT DUE TO REQUIRED DILUTION
W - POST-DIGEST SPIKE OUT OF CNTR LIM WHILE SAMP ABS < 50% SPIKE

GROUNDWATER QUALITY DATA BY PARAMETER
SITE: SLC01 SALT LAKE CITY
04/26/92 TO 07/23/92
REPORT DATE: 01/26/93

PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PVI	PARAMETER VALUE	FLAGS	PARAMETER UNCERTAINTY
ARSENIC	0008	04/27/92	0001	LU	C	MG/L	<	0.03	I	-
	0011	04/26/92	0001	LU	D		<	0.03	I	-
	0109	04/26/92	0001	LU	D		<	0.03	I	-
	0130	07/23/92	0001	LU	O			0.0266		-
	0132	07/23/92	0001	LU	O			0.0566		-
	0133	07/23/92	0001	LU	O			0.126		-
	0134	07/22/92	0001	LU	D			0.0477	S	-
	0135	07/22/92	0001	LU	O		<	0.005		-
BARIUM	0001	04/27/92	0001	LC	U	MG/L		0.10		-
	0002	04/27/92	0001	LC	U			0.10		-
	0003	04/26/92	0001	LC	C			0.17		-
	0007	04/27/92	0001	LU	U			0.11		-
	0008	04/27/92	0001	LU	C			0.31		-
	0011	04/26/92	0001	LU	D			0.02		-
	0109	04/26/92	0001	LU	D			0.01		-
	0130	07/23/92	0001	LU	O			0.174		-
	0132	07/23/92	0001	LU	O			0.181		-
	0133	07/23/92	0001	LU	O			0.239		-
	0134	07/22/92	0001	LU	D			0.471		-
	0135	07/22/92	0001	LU	O		<	0.2	I	-
BERYLLIUM	0001	04/27/92	0001	LC	U	MG/L	<	0.005		-
	0002	04/27/92	0001	LC	U		<	0.005		-
	0003	04/26/92	0001	LC	C		<	0.005		-
	0007	04/27/92	0001	LU	U		<	0.005		-
	0008	04/27/92	0001	LU	C		<	0.005		-
	0011	04/26/92	0001	LU	D		<	0.005		-
	0109	04/26/92	0001	LU	D		<	0.005		-
	0130	07/23/92	0001	LU	O		<	0.005		-
	0132	07/23/92	0001	LU	O		<	0.005		-
	0133	07/23/92	0001	LU	O		<	0.005		-
	0134	07/22/92	0001	LU	D		<	0.005		-
	0135	07/22/92	0001	LU	O		<	0.01	I	-
CADMIUM	0001	04/27/92	0001	LC	U	MG/L	<	0.0005		-
	0002	04/27/92	0001	LC	U		<	0.0005		-
	0003	04/26/92	0001	LC	C		<	0.0005		-
	0007	04/27/92	0001	LU	U		<	0.0005		-
	0008	04/27/92	0001	LU	C		<	0.0005		-
	0011	04/26/92	0001	LU	D		<	0.0005		-
	0109	04/26/92	0001	LU	D		<	0.0005		-
	0130	07/23/92	0001	LU	O		<	0.001	W	-
	0132	07/23/92	0001	LU	O		<	0.001	W	-
	0133	07/23/92	0001	LU	O		<	0.001	W	-
	0134	07/22/92	0001	LU	D		<	0.001	W	-
	0135	07/22/92	0001	LU	O		<	0.01	IW	-
CALCIUM	0001	04/27/92	0001	LC	U	MG/L		68.4		-
	0002	04/27/92	0001	LC	U			45.8		-
	0003	04/26/92	0001	LC	C			56.9		-
	0007	04/27/92	0001	LU	U			12.0		-
	0008	04/27/92	0001	LU	C			257.		-
	0011	04/26/92	0001	LU	D			57.4		-
	0109	04/26/92	0001	LU	D			87.5		-
	0130	07/23/92	0001	LU	O			25.1		-

FORMATION OF COMPLETION CODE:
LU - LACUSTRINE UNCONFINED
LC - LACUSTRINE CONFINED

FLOW RELATIONSHIP CODE:
C - CROSS GRADIENT
D - DOWN GRADIENT
O - ON-SITE
U - UPGRADIENT

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT

SAMPLE ID CODES:
0001 - FILTERED SAMPLE (.45 MICRONS)

OTHER PARAMETER VALUE FLAGS:
I - INCREASED DETECTION LIMIT DUE TO REQUIRED DILUTION
S - REPORTED VALUE DETERMINED USING METHOD OF STD ADDITION (MSA)
W - POST-DIGEST SPIKE OUT OF CNTR LIM WHILE SAMP ABS < 50% SPIKE

GROUNDWATER QUALITY DATA BY PARAMETER
SITE: SLC01 SALT LAKE CITY
04/26/92 TO 07/23/92
REPORT DATE: 01/26/93

PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PARAMETER VALUE PVI	VALUE	FLAGS	PARAMETER UNCERTAINTY
CALCIUM	0132	07/23/92	0001	LU	O	MG/L		22.8		-
	0133	07/23/92	0001	LU	O			26.3		-
	0134	07/22/92	0001	LU	D			96.3		-
	0135	07/22/92	0001	LU	O			148	I	-
CHLORIDE	0001	04/27/92	0001	LC	U	MG/L		18.9		-
	0002	04/27/92	0001	LC	U			10.0		-
	0003	04/26/92	0001	LC	C			17.0		-
	0007	04/27/92	0001	LU	U			56.		-
	0008	04/27/92	0001	LU	C			850.		-
	0011	04/26/92	0001	LU	D			968.		-
	0109	04/26/92	0001	LU	D			1150.		-
	0130	07/23/92	0001	LU	O			17.4		-
	0132	07/23/92	0001	LU	O			15.7		-
	0133	07/23/92	0001	LU	O			17		-
	0134	07/22/92	0001	LU	D			217		-
	0135	07/22/92	0001	LU	O			2780		-
CHROMIUM	0001	04/27/92	0001	LC	U	MG/L	<	0.01		-
	0002	04/27/92	0001	LC	U		<	0.01		-
	0003	04/26/92	0001	LC	C		<	0.01		-
	0007	04/27/92	0001	LU	U		<	0.01		-
	0008	04/27/92	0001	LU	C		<	0.01		-
	0011	04/26/92	0001	LU	D		<	0.01		-
	0109	04/26/92	0001	LU	D		<	0.01		-
	0130	07/23/92	0001	LU	O		<	0.01		-
	0132	07/23/92	0001	LU	O		<	0.01		-
	0133	07/23/92	0001	LU	O		<	0.01		-
	0134	07/22/92	0001	LU	D		<	0.01		-
	0135	07/22/92	0001	LU	O		<	0.02	I	-
COBALT	0001	04/27/92	0001	LC	U	MG/L	<	0.03		-
	0002	04/27/92	0001	LC	U		<	0.03		-
	0003	04/26/92	0001	LC	C		<	0.03		-
	0007	04/27/92	0001	LU	U		<	0.03		-
	0008	04/27/92	0001	LU	C		<	0.03		-
	0011	04/26/92	0001	LU	D		<	0.03		-
	0109	04/26/92	0001	LU	D		<	0.03		-
	0130	07/23/92	0001	LU	O		<	0.05		-
	0132	07/23/92	0001	LU	O		<	0.05		-
	0133	07/23/92	0001	LU	O		<	0.05		-
	0134	07/22/92	0001	LU	D		<	0.05		-
	0135	07/22/92	0001	LU	O		<	0.1	I	-
COPPER	0001	04/27/92	0001	LC	U	MG/L	<	0.01		-
	0002	04/27/92	0001	LC	U		<	0.01		-
	0003	04/26/92	0001	LC	C		<	0.01		-
	0007	04/27/92	0001	LU	U		<	0.01		-
	0008	04/27/92	0001	LU	C		<	0.01		-
	0011	04/26/92	0001	LU	D		<	0.01		-
	0109	04/26/92	0001	LU	D		<	0.01		-
	0130	07/23/92	0001	LU	O		<	0.02		-
	0132	07/23/92	0001	LU	O		<	0.02		-
	0133	07/23/92	0001	LU	O		<	0.02		-
	0134	07/22/92	0001	LU	D		<	0.02		-
	0135	07/22/92	0001	LU	O		<	0.04	I	-
CYANIDE	0001	04/27/92	0001	LC	U	MG/L	<	0.01		-

FORMATION OF COMPLETION CODE:
LU - LACUSTRINE UNCONFINED
LC - LACUSTRINE CONFINED

FLOW RELATIONSHIP CODE:
O - ON-SITE
D - DOWN GRADIENT
U - UPGRADIENT
C - CROSS GRADIENT

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT

SAMPLE ID CODES:
0001 - FILTERED SAMPLE (.45 MICRONS)

OTHER PARAMETER VALUE FLAGS:
I - INCREASED DETECTION LIMIT DUE TO REQUIRED DILUTION

GROUNDWATER QUALITY DATA BY PARAMETER
SITE: SLC01 SALT LAKE CITY
04/26/92 TO 07/23/92
REPORT DATE: 01/26/93

PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PARAMETER PVI	VALUE	FLAGS	PARAMETER UNCERTAINTY
CYANIDE	0002	04/27/92	0001	LC	U	MG/L	<	0.01		-
	0003	04/26/92	0001	LC	C		<	0.01		-
	0007	04/27/92	0001	LU	U		<	0.01		-
	0008	04/27/92	0001	LU	C		<	0.01		-
	0011	04/26/92	0001	LU	D		<	0.01		-
	0109	04/26/92	0001	LU	D		<	0.01		-
	0130	07/23/92	0001	LU	O		<	0.01		-
	0132	07/23/92	0001	LU	O		<	0.01		-
	0133	07/23/92	0001	LU	O		<	0.01		-
	0134	07/22/92	0001	LU	D		<	0.01		-
	0135	07/22/92	0001	LU	O		<	0.01		-
FLUORIDE	0001	04/27/92	0001	LC	U	MG/L		0.2		-
	0002	04/27/92	0001	LC	U			0.3		-
	0003	04/26/92	0001	LC	C			0.3		-
	0007	04/27/92	0001	LU	U			0.7		-
	0008	04/27/92	0001	LU	C			0.5		-
	0011	04/26/92	0001	LU	D			1.7		-
	0109	04/26/92	0001	LU	D			2.6		-
	0130	07/23/92	0001	LU	O			0.7		-
	0132	07/23/92	0001	LU	O			0.9		-
	0133	07/23/92	0001	LU	O			0.67		-
	0134	07/22/92	0001	LU	D			0.81		-
	0135	07/22/92	0001	LU	O			1.18		-
GROSS ALPHA	0001	04/27/92	0001	LC	U	PCI/L		0.0		2.3
	0002	04/27/92	0001	LC	U			2.5		2.6
	0003	04/26/92	0001	LC	C			0.0		1.8
	0007	04/27/92	0001	LU	U			7.4		8.7
	0008	04/27/92	0001	LU	C			0.0		24.7
	0011	04/26/92	0001	LU	D			31.5		29.8
	0109	04/26/92	0001	LU	D			112.		38.6
	0130	07/23/92	0001	LU	O			0.0		2.4
	0132	07/23/92	0001	LU	O			0.8		3.1
	0133	07/22/92	0001	LU	O			1.3		2.9
	0134	07/22/92	0001	LU	D			31		17
	0135	07/22/92	0001	LU	O			17		71
GROSS BETA	0001	04/27/92	0001	LC	U	PCI/L		6.0		2.6
	0002	04/27/92	0001	LC	U			19.9		2.8
	0003	04/26/92	0001	LC	C			6.1		2.1
	0007	04/27/92	0001	LU	U			41.4		12.4
	0008	04/27/92	0001	LU	C			86.9		27.8
	0011	04/26/92	0001	LU	D			86.9		26.7
	0109	04/26/92	0001	LU	D			134.		31.8
	0130	07/23/92	0001	LU	O			27		5
	0132	07/23/92	0001	LU	O			21		5
	0133	07/22/92	0001	LU	O			22		4
	0134	07/22/92	0001	LU	D			42		18
	0135	07/22/92	0001	LU	O			130		90
IRON	0001	04/27/92	0001	LC	U	MG/L		0.03		-
	0002	04/27/92	0001	LC	U			0.25		-
	0003	04/26/92	0001	LC	C			0.12		-
	0007	04/27/92	0001	LU	U			0.12		-
	0008	04/27/92	0001	LU	C			3.18		-
	0011	04/26/92	0001	LU	D			1.28		-
	0109	04/26/92	0001	LU	D			5.24		-
	0130	07/23/92	0001	LU	O			0.563		-

FORMATION OF COMPLETION CODE:
LC - LACUSTRINE CONFINED
LU - LACUSTRINE UNCONFINED

FLOW RELATIONSHIP CODE:
U - UPGRADIENT
C - CROSS GRADIENT
D - DOWN GRADIENT
O - ON-SITE

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT

SAMPLE ID CODES:
0001 - FILTERED SAMPLE (.45 MICRONS)

GROUNDWATER QUALITY DATA BY PARAMETER
SITE: SLC01 SALT LAKE CITY
04/26/92 TO 07/23/92
REPORT DATE: 01/26/93

PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PARAMETER PVI	PARAMETER VALUE	FLAGS	PARAMETER UNCERTAINTY
IRON	0132	07/23/92	0001	LU	O	MG/L		0.6		-
	0133	07/23/92	0001	LU	O			0.64		-
	0134	07/22/92	0001	LU	D			1.64		-
	0135	07/22/92	0001	LU	O			1.67	I	-
LEAD	0001	04/27/92	0001	LC	U	MG/L	<	0.005		-
	0002	04/27/92	0001	LC	U		<	0.005		-
	0003	04/26/92	0001	LC	C		<	0.005		-
	0007	04/27/92	0001	LU	U		<	0.005		-
	0008	04/27/92	0001	LU	C		<	0.005		-
	0011	04/26/92	0001	LU	D		<	0.03	I	-
	0109	04/26/92	0001	LU	D		<	0.03	I	-
	0130	07/23/92	0001	LU	O		<	0.003		-
	0132	07/23/92	0001	LU	O		<	0.003		-
	0133	07/23/92	0001	LU	O		<	0.003		-
	0134	07/22/92	0001	LU	D		<	0.003		-
	0135	07/22/92	0001	LU	O		<	0.003		-
MAGNESIUM	0001	04/27/92	0001	LC	U	MG/L		23.6		-
	0002	04/27/92	0001	LC	U			20.0		-
	0003	04/26/92	0001	LC	C			20.8		-
	0007	04/27/92	0001	LU	U			33.3		-
	0008	04/27/92	0001	LU	C			363.		-
	0011	04/26/92	0001	LU	D			182.		-
	0109	04/26/92	0001	LU	D			271.		-
	0130	07/23/92	0001	LU	O			35.1		-
	0132	07/23/92	0001	LU	O			34.6		-
	0133	07/23/92	0001	LU	O			40.5		-
	0134	07/22/92	0001	LU	D			81		-
	0135	07/22/92	0001	LU	O			846	I	-
IANGANESE	0001	04/27/92	0001	LC	U	MG/L		0.06		-
	0002	04/27/92	0001	LC	U			0.09		-
	0003	04/26/92	0001	LC	C			0.05		-
	0007	04/27/92	0001	LU	U			0.03		-
	0008	04/27/92	0001	LU	C			0.31		-
	0011	04/26/92	0001	LU	D			0.11		-
	0109	04/26/92	0001	LU	D			0.45		-
	0130	07/23/92	0001	LU	O			0.074		-
	0132	07/23/92	0001	LU	O			0.066		-
	0133	07/23/92	0001	LU	O			0.047		-
	0134	07/22/92	0001	LU	D			0.155		-
	0135	07/22/92	0001	LU	O			0.22	I	-
MERCURY	0001	04/27/92	0001	LC	U	MG/L	<	0.0002		-
	0002	04/27/92	0001	LC	U		<	0.0002		-
	0003	04/26/92	0001	LC	C		<	0.0002		-
	0007	04/27/92	0001	LU	U		<	0.0002		-
	0008	04/27/92	0001	LU	C		<	0.0002		-
	0011	04/26/92	0001	LU	D		<	0.0002		-
	0109	04/26/92	0001	LU	D		<	0.0002		-
	0130	07/23/92	0001	LU	O		<	0.0002		-
	0132	07/23/92	0001	LU	O		<	0.0002		-
	0133	07/23/92	0001	LU	O		<	0.0002		-
	0134	07/22/92	0001	LU	D		<	0.0002		-
	0135	07/22/92	0001	LU	O		<	0.0002		-
MOLYBDENUM	0001	04/27/92	0001	LC	U	MG/L	<	0.01		-

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\RAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT

SAMPLE ID CODES:
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GROUNDWATER QUALITY DATA BY PARAMETER
SITE: SLC01 SALT LAKE CITY
04/26/92 TO 07/23/92
REPORT DATE: 01/26/93

PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PVI	PARAMETER VALUE	FLAGS	PARAMETER UNCERTAINTY
MOLYBDENUM	0002	04/27/92	0001	LC	U	MG/L	<	0.01		-
	0003	04/26/92	0001	LC	C		<	0.01		-
	0007	04/27/92	0001	LU	U		<	0.01		-
	0008	04/27/92	0001	LU	C		<	0.01		-
	0011	04/26/92	0001	LU	D			0.15		-
	0109	04/26/92	0001	LU	D			0.07		-
	0130	07/23/92	0001	LU	O		<	0.01		-
	0132	07/23/92	0001	LU	O		<	0.01		-
	0133	07/23/92	0001	LU	O		<	0.01		-
	0134	07/22/92	0001	LU	D			0.02		-
	0135	07/22/92	0001	LU	O			0.18	I	-
NET GROSS ALPHA *	0001	04/27/92	0001	LC	U	PCI/L		-0.34		-
	0002	04/27/92	0001	LC	U			2.16		-
	0003	04/26/92	0001	LC	C			-0.69		-
	0007	04/27/92	0001	LU	U			7.06		-
	0008	04/27/92	0001	LU	C			-0.34		-
	0011	04/26/92	0001	LU	D			-3.49		-
	0109	04/26/92	0001	LU	D			2.24		-
	0130	07/23/92	0001	LU	O			-0.34		-
	0132	07/23/92	0001	LU	O			0.46		-
	0133	07/22/92	0001	LU	O			0.61		-
	0134	07/22/92	0001	LU	D			-8.10		-
	0135	07/22/92	0001	LU	O			6.71		-
NICKEL	0001	04/27/92	0001	LC	U	MG/L	<	0.04		-
	0002	04/27/92	0001	LC	U		<	0.04		-
	0003	04/26/92	0001	LC	C		<	0.04		-
	0007	04/27/92	0001	LU	U		<	0.04		-
	0008	04/27/92	0001	LU	C		<	0.04		-
	0011	04/26/92	0001	LU	D		<	0.04		-
	0109	04/26/92	0001	LU	D		<	0.04		-
	0130	07/23/92	0001	LU	O		<	0.04		-
	0132	07/23/92	0001	LU	O		<	0.04		-
	0133	07/23/92	0001	LU	O		<	0.04		-
	0134	07/22/92	0001	LU	D		<	0.04		-
	0135	07/22/92	0001	LU	O		<	0.08	I	-
NITRATE	0001	04/27/92	0001	LC	U	MG/L		3.0		-
	0002	04/27/92	0001	LC	U			3.4		-
	0003	04/26/92	0001	LC	C			5.4		-
	0007	04/27/92	0001	LU	U			5.5		-
	0008	04/27/92	0001	LU	C			4.6		-
	0011	04/26/92	0001	LU	D			3.7		-
	0109	04/26/92	0001	LU	D			2.4		-
	0130	07/23/92	0001	LU	O		<	1		-
	0132	07/23/92	0001	LU	O		<	1		-
	0133	07/23/92	0001	LU	O		<	1		-
	0134	07/22/92	0001	LU	D		<	1		-
	0135	07/22/92	0001	LU	O		<	1		-
PH	0001	04/27/92	0001	LC	U	SU		7.92		-
	0002	04/27/92	0001	LC	U			7.78		-
	0003	04/26/92	0001	LC	C			7.91		-
	0007	04/27/92	0001	LU	U			7.94		-
	0008	04/27/92	0001	LU	C			7.12		-

* NET GROSS ALPHA (GROSS ALPHA - URANIUM) WITH 1 MG URANIUM = 686 PCI

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04/26/92 TO 07/23/92
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PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PARAMETER VALUE PVI	FLAGS	PARAMETER UNCERTAINTY
PH	0011	04/26/92	0001	LU	D	SU	7.36		-
	0109	04/26/92	0001	LU	D		7.17		-
	0130	07/23/92	0001	LU	O		7.56		-
	0132	07/23/92	0001	LU	O		7.68		-
	0133	07/23/92	0001	LU	O		7.67		-
	0134	07/22/92	0001	LU	D		7.19		-
	0135	07/22/92	0001	LU	O		7.48		-
POTASSIUM	0001	04/27/92	0001	LC	U	MG/L	6.85		-
	0002	04/27/92	0001	LC	U		9.41		-
	0003	04/26/92	0001	LC	C		4.56		-
	0007	04/27/92	0001	LU	U		26.		-
	0008	04/27/92	0001	LU	C		41.		-
	0011	04/26/92	0001	LU	D		44.		-
	0109	04/26/92	0001	LU	D		78.		-
	0130	07/23/92	0001	LU	O		29.4		-
	0132	07/23/92	0001	LU	O		29.2		-
	0133	07/23/92	0001	LU	O		27		-
	0134	07/22/92	0001	LU	D		33.3		-
	0135	07/22/92	0001	LU	O		237	I	-
RADIUM-226	0001	04/27/92	0001	LC	U	PCI/L	1.0		0.8
	0002	04/27/92	0001	LC	U		0.2		0.7
	0003	04/26/92	0001	LC	C		0.0		0.7
	0007	04/27/92	0001	LU	U		0.0		0.7
	0008	04/27/92	0001	LU	C		1.3		0.8
	0011	04/26/92	0001	LU	D		0.6		0.8
	0109	04/26/92	0001	LU	D		0.4		0.8
	0130	07/23/92	0001	LU	O		0.6		0.5
	0132	07/23/92	0001	LU	O		0.1		0.3
	0133	07/22/92	0001	LU	O		0.4		0.4
	0134	07/22/92	0001	LU	D		0.9		0.5
	0135	07/22/92	0001	LU	O		0.7		0.8
RADIUM-226 + RADIUM-228	0001	04/27/92	0001	LC	U	PCI/L	1.00		-
	0002	04/27/92	0001	LC	U		0.20		-
	0003	04/26/92	0001	LC	C		0.00		-
	0007	04/27/92	0001	LU	U		0.00		-
	0008	04/27/92	0001	LU	C		2.30		-
	0011	04/26/92	0001	LU	D		2.00		-
	0109	04/26/92	0001	LU	D		2.80		-
	0130	07/23/92	0001	LU	O		1.20		-
	0132	07/23/92	0001	LU	O		0.60		-
	0133	07/22/92	0001	LU	O		2.30		-
	0134	07/22/92	0001	LU	D		0.90		-
	0135	07/22/92	0001	LU	O		0.70		-
RADIUM-228	0001	04/27/92	0001	LC	U	PCI/L	0.0		1.9
	0002	04/27/92	0001	LC	U		0.0		1.9
	0003	04/26/92	0001	LC	C		0.0		1.8
	0007	04/27/92	0001	LU	U		0.0		1.8
	0008	04/27/92	0001	LU	C		1.0		2.0
	0011	04/26/92	0001	LU	D		1.4		2.0
	0109	04/26/92	0001	LU	D		2.4		2.1
	0130	07/23/92	0001	LU	O		0.6		1.2
	0132	07/23/92	0001	LU	O		0.5		1.2
	0133	07/22/92	0001	LU	O		1.9		1.3
	0134	07/22/92	0001	LU	D		0.0		1.9

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RADIUM-228	0135	07/22/92	0001	LU	O	PCI/L		0.0		2.6
SELENIUM	0001	04/27/92	0001	LC	U	MG/L	<	0.005		-
	0002	04/27/92	0001	LC	U		<	0.005		-
	0003	04/26/92	0001	LC	C		<	0.005		-
	0007	04/27/92	0001	LU	U		<	0.005		-
	0008	04/27/92	0001	LU	C			0.03		-
	0011	04/26/92	0001	LU	D		<	0.005		-
	0109	04/26/92	0001	LU	D			0.03		-
	0130	07/23/92	0001	LU	O		<	0.005		-
	0132	07/23/92	0001	LU	O		<	0.005		-
	0133	07/23/92	0001	LU	O		<	0.005		-
	0134	07/22/92	0001	LU	D		<	0.005		-
	0135	07/22/92	0001	LU	O		<	0.05	I	-
SILVER	0001	04/27/92	0001	LC	U	MG/L	<	0.01		-
	0002	04/27/92	0001	LC	U		<	0.01		-
	0003	04/26/92	0001	LC	C		<	0.01		-
	0007	04/27/92	0001	LU	U		<	0.01		-
	0008	04/27/92	0001	LU	C		<	0.01		-
	0011	04/26/92	0001	LU	D		<	0.01		-
	0109	04/26/92	0001	LU	D		<	0.01		-
	0130	07/23/92	0001	LU	O		<	0.01		-
	0132	07/23/92	0001	LU	O		<	0.01		-
	0133	07/23/92	0001	LU	O		<	0.01		-
	0134	07/22/92	0001	LU	D		<	0.01		-
	0135	07/22/92	0001	LU	O		<	0.02	I	-
SODIUM	0001	04/27/92	0001	LC	U	MG/L		19.		-
	0002	04/27/92	0001	LC	U			30.		-
	0003	04/26/92	0001	LC	C			20.		-
	0007	04/27/92	0001	LU	U			132.		-
	0008	04/27/92	0001	LU	C			697.		-
	0011	04/26/92	0001	LU	D			1150.		-
	0109	04/26/92	0001	LU	D			1770.		-
	0130	07/23/92	0001	LU	O			25.4		-
	0132	07/23/92	0001	LU	O			58		-
	0133	07/23/92	0001	LU	O			39.4		-
	0134	07/22/92	0001	LU	D			230		-
	0135	07/22/92	0001	LU	O			3040	I	-
SPECIFIC CONDUCTANCE	0001	04/27/92	0001	LC	U	UMHO/CM		606		-
	0002	04/27/92	0001	LC	U			505		-
	0003	04/26/92	0001	LC	C			516		-
	0007	04/27/92	0001	LU	U			961		-
	0008	04/27/92	0001	LU	C			5520		-
	0011	04/26/92	0001	LU	D			6160		-
	0109	04/26/92	0001	LU	D			8320		-
	0130	07/23/92	0001	LU	O			514		-
	0132	07/23/92	0001	LU	O			593		-
	0133	07/23/92	0001	LU	O			567		-
	0134	07/22/92	0001	LU	D			1580		-
	0135	07/22/92	0001	LU	O			13070		-
STRONTIUM	0001	04/27/92	0001	LC	U	MG/L		0.67		-
	0002	04/27/92	0001	LC	U			0.50		-
	0003	04/26/92	0001	LC	C			0.69		-
	0007	04/27/92	0001	LU	U			0.20		-

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PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PARAMETER PVI	VALUE	FLAGS	PARAMETER UNCERTAINTY
STRONTIUM	0008	04/27/92	0001	LU	C	MG/L		3.64		-
	0011	04/26/92	0001	LU	D			1.47		-
	0109	04/26/92	0001	LU	D			2.08		-
	0130	07/23/92	0001	LU	O			0.212		-
	0132	07/23/92	0001	LU	O			0.222		-
	0133	07/23/92	0001	LU	O			0.289		-
	0134	07/22/92	0001	LU	D			1.14		-
	0135	07/22/92	0001	LU	O			4.24	I	-
SULFATE	0001	04/27/92	0001	LC	U	MG/L		40.		-
	0002	04/27/92	0001	LC	U		<	10.		-
	0003	04/26/92	0001	LC	C			28.		-
	0007	04/27/92	0001	LU	U		<	10.		-
	0008	04/27/92	0001	LU	C			1760.		-
	0011	04/26/92	0001	LU	D			1260.		-
	0109	04/26/92	0001	LU	D			2630.		-
	0130	07/23/92	0001	LU	O			2.61		-
	0132	07/23/92	0001	LU	O			2.81		-
	0133	07/23/92	0001	LU	O			4.96		-
	0134	07/22/92	0001	LU	D			370		-
	0135	07/22/92	0001	LU	O			5520		-
SULFIDE	0001	04/27/92	0001	LC	U	MG/L		0.6		-
	0002	04/27/92	0001	LC	U			0.4		-
	0003	04/26/92	0001	LC	C			0.4		-
	0007	04/27/92	0001	LU	U			0.4		-
	0008	04/27/92	0001	LU	C			0.2		-
	0011	04/26/92	0001	LU	D		<	0.1		-
	0109	04/26/92	0001	LU	D			2.1		-
	0130	07/23/92	0001	LU	O		<	1		-
	0132	07/23/92	0001	LU	O		<	1		-
	0133	07/23/92	0001	LU	O		<	1		-
	0134	07/22/92	0001	LU	D		<	1		-
	0135	07/22/92	0001	LU	O		<	1		-
TEMPERATURE	0001	04/27/92	0001	LC	U	C - DEGREE		13.0		-
	0002	04/27/92	0001	LC	U			12.3		-
	0003	04/26/92	0001	LC	C			12.4		-
	0007	04/27/92	0001	LU	U			11.9		-
	0008	04/27/92	0001	LU	C			13.4		-
	0011	04/26/92	0001	LU	D			12.2		-
	0109	04/26/92	0001	LU	D			12.7		-
	0130	07/23/92	0001	LU	O			15.8		-
	0132	07/23/92	0001	LU	O			14.3		-
	0133	07/23/92	0001	LU	O			15.3		-
	0134	07/22/92	0001	LU	D			15.9		-
	0135	07/22/92	0001	LU	O			15.0		-
THALLIUM	0001	04/27/92	0001	LC	U	MG/L	<	0.005		-
	0002	04/27/92	0001	LC	U		<	0.005		-
	0003	04/26/92	0001	LC	C		<	0.005		-
	0007	04/27/92	0001	LU	U		<	0.005		-
	0008	04/27/92	0001	LU	C		<	0.005		-
	0011	04/26/92	0001	LU	D		<	0.005		-
	0109	04/26/92	0001	LU	D		<	0.03	I	-
	0130	07/23/92	0001	LU	O		<	0.005		-
	0132	07/23/92	0001	LU	O		<	0.005		-
	0133	07/23/92	0001	LU	O		<	0.005		-

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THALLIUM	0134	07/22/92	0001	LU	D	MG/L	<	0.005		-
	0135	07/22/92	0001	LU	O		<	0.005		-
THORIUM-230	0001	04/27/92	0001	LC	U	PCI/L		0.6		0.5
	0002	04/27/92	0001	LC	U			0.0		0.4
	0003	04/26/92	0001	LC	C			0.9		0.7
	0007	04/27/92	0001	LU	U			0.7		0.7
	0008	04/27/92	0001	LU	C			0.0		0.9
	0011	04/26/92	0001	LU	D			0.5		0.7
	0109	04/26/92	0001	LU	D			0.8		0.7
	0130	07/23/92	0001	LU	O			0.0		1.1
	0132	07/23/92	0001	LU	O			0.0		1.0
	0133	07/22/92	0001	LU	O			0.0		0.8
	0134	07/22/92	0001	LU	D			0.0		0.9
	0135	07/22/92	0001	LU	O			0.0		1.1
TIN	0001	04/27/92	0001	LC	U	MG/L	<	0.005		-
	0002	04/27/92	0001	LC	U		<	0.005		-
	0003	04/26/92	0001	LC	C		<	0.005		-
	0007	04/27/92	0001	LU	U			0.006		-
	0008	04/27/92	0001	LU	C		<	0.1	I	-
	0011	04/26/92	0001	LU	D		<	0.1	I	-
	0109	04/26/92	0001	LU	D		<	0.1	I	-
	0130	07/23/92	0001	LU	O		<	0.005		-
	0132	07/23/92	0001	LU	O		<	0.005		-
	0133	07/23/92	0001	LU	O		<	0.005		-
	0134	07/22/92	0001	LU	D		<	0.005		-
	0135	07/22/92	0001	LU	O		<	0.025	I	-
TOTAL DISSOLVED SOLIDS	0001	04/27/92	0001	LC	U	MG/L		343.		-
	0002	04/27/92	0001	LC	U			283.		-
	0003	04/26/92	0001	LC	C			302.		-
	0007	04/27/92	0001	LU	U			540.		-
	0008	04/27/92	0001	LU	C			4500.		-
	0011	04/26/92	0001	LU	D			4030.		-
	0109	04/26/92	0001	LU	D			6510.		-
	0130	07/23/92	0001	LU	O			318		-
	0132	07/23/92	0001	LU	O			381		-
	0133	07/23/92	0001	LU	O			355		-
	0134	07/22/92	0001	LU	D			1300		-
	0135	07/22/92	0001	LU	O			13500		-
TOTAL KJELDAHL NITROGEN	0001	04/27/92	0001	LC	U	MG/L		3.		-
	0002	04/27/92	0001	LC	U			5.		-
	0003	04/26/92	0001	LC	C			4.		-
	0007	04/27/92	0001	LU	U			6.		-
	0008	04/27/92	0001	LU	C			9.		-
	0011	04/26/92	0001	LU	D			2.		-
	0109	04/26/92	0001	LU	D			2.		-
	0130	07/23/92	0001	LU	O			9.22		-
	0132	07/23/92	0001	LU	O			11.5		-
	0133	07/23/92	0001	LU	O			9.66		-
	0134	07/22/92	0001	LU	D			6.91		-
	0135	07/22/92	0001	LU	O			4.26		-
TOTAL ORGANIC CARBON	0001	04/27/92	0001	LC	U	MG/L		2.		-
	0002	04/27/92	0001	LC	U			2.		-
	0003	04/26/92	0001	LC	C			2.		-

FORMATION OF COMPLETION CODE:
LU - LACUSTRINE UNCONFINED
LC - LACUSTRINE CONFINED

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT
O - ON-SITE
U - UPGRADIENT
C - CROSS GRADIENT

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT

SAMPLE ID CODES:
0001 - FILTERED SAMPLE (.45 MICRONS)

OTHER PARAMETER VALUE FLAGS:
I - INCREASED DETECTION LIMIT DUE TO REQUIRED DILUTION

GROUNDWATER QUALITY DATA BY PARAMETER
SITE: SLC01 SALT LAKE CITY
04/26/92 TO 07/23/92
REPORT DATE: 01/26/93

PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PARAMETER PVI	VALUE	FLAGS	PARAMETER UNCERTAINTY
TOTAL ORGANIC CARBON	0007	04/27/92	0001	LU	U	MG/L		4.		-
	0008	04/27/92	0001	LU	C			8.		-
	0011	04/26/92	0001	LU	D			7.		-
	0109	04/26/92	0001	LU	D			9.		-
	0130	07/23/92	0001	LU	O			5.97		-
	0132	07/23/92	0001	LU	O			7.98		-
	0133	07/23/92	0001	LU	O			5.95		-
	0134	07/22/92	0001	LU	D			5.92		-
	0135	07/22/92	0001	LU	O			14.4		-
URANIUM	0001	04/27/92	0001	LC	U	MG/L	<	0.001		-
	0002	04/27/92	0001	LC	U		<	0.001		-
	0003	04/26/92	0001	LC	C			0.001		-
	0007	04/27/92	0001	LU	U		<	0.001		-
	0008	04/27/92	0001	LU	C		<	0.001		-
	0011	04/26/92	0001	LU	D			0.051		-
	0109	04/26/92	0001	LU	D			0.160		-
	0130	07/23/92	0001	LU	O		<	0.001		-
	0132	07/23/92	0001	LU	O		<	0.001		-
	0133	07/22/92	0001	LU	O			0.001		-
	0134	07/22/92	0001	LU	D			0.057		-
	0135	07/22/92	0001	LU	O			0.015		-
VANADIUM	0001	04/27/92	0001	LC	U	MG/L	<	0.01		-
	0002	04/27/92	0001	LC	U		<	0.01		-
	0003	04/26/92	0001	LC	C		<	0.01		-
	0007	04/27/92	0001	LU	U		<	0.01		-
	0008	04/27/92	0001	LU	C		<	0.01		-
	0011	04/26/92	0001	LU	D		<	0.01		-
	0109	04/26/92	0001	LU	D		<	0.01		-
	0130	07/23/92	0001	LU	O		<	0.01		-
	0132	07/23/92	0001	LU	O		<	0.01		-
	0133	07/23/92	0001	LU	O		<	0.01		-
	0134	07/22/92	0001	LU	D		<	0.01		-
	0135	07/22/92	0001	LU	O			0.021	I	-
ZINC	0001	04/27/92	0001	LC	U	MG/L	<	0.005		-
	0002	04/27/92	0001	LC	U		<	0.005		-
	0003	04/26/92	0001	LC	C		<	0.005		-
	0007	04/27/92	0001	LU	U		<	0.005		-
	0008	04/27/92	0001	LU	C		<	0.005		-
	0011	04/26/92	0001	LU	D		<	0.03	I	-
	0109	04/26/92	0001	LU	D		<	0.03	I	-
	0130	07/23/92	0001	LU	O			0.015		-
	0132	07/23/92	0001	LU	O			0.012		-
	0133	07/23/92	0001	LU	O			0.012		-
	0134	07/22/92	0001	LU	D			0.02		-
	0135	07/22/92	0001	LU	O			0.123	I	-

FORMATION OF COMPLETION CODE:
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FLOW RELATIONSHIP CODE:
U - UPGRADIENT
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PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT

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I - INCREASED DETECTION LIMIT DUE TO REQUIRED DILUTION

DATA FILE NAME: M:\DART\SLC01\GWQ10004.DAT

Attachment D

DOE/AL/62350-191
REV. 0

REPORT OF GROUND WATER MONITORING FOR EXPANSION OF THE GOLF COURSE, SALT LAKE CITY, UTAH, VITRO PROCESSING SITE

June 1995

Prepared for
U.S. Department of Energy
UMTRA Project
Albuquerque, New Mexico

Prepared by
Jacobs Engineering Group Inc.
Albuquerque, New Mexico

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LIST OF ACRONYMS

Acronym	Definition
CVWRF	Central Valley Water Reclamation Facility
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
HELP	Hydrologic Evaluation of Landfill Performance
UMTRA	Uranium Mill Tailings Remedial Action

1.0 INTRODUCTION

To determine the potential impacts of the proposed golf course expansion on the south side of the Vitro site, ground water data from the UMTRA Vitro processing site were evaluated in response to the U.S. Department of Energy (DOE) Uranium Mill Tailings Remedial Action (UMTRA) Project Office request. Golf in the Round, Inc., has proposed an expansion of the present driving range to include a 9-hole golf course on the UMTRA Vitro processing site, which is owned by the Central Valley Water Reclamation Facility (CVWRF) (Figure 1). An expanded golf course would increase irrigation and increase the amount of water that could infiltrate the soil, recharging the unconfined aquifer. Increased water levels in the aquifer could alter the ground water flow regime; contaminants in the shallow ground water could then migrate off the site or discharge to surface water in the area. Dewatering of the unconfined aquifer on CVWRF property could also impact site contaminant migration; a significant amount of ground water extraction at CVWRF could reduce the amount of contaminant migration off the site.

Since 1978, data have been collected at the site to determine the distribution of tailings materials (removed from the site from 1985 to 1987) and to characterize the presence and migration of contaminants in sediments, soils, surface water, and ground water at the former Vitro processing site.

Available data suggest that irrigating an expanded golf course may cause contamination to spread more rapidly within the unconfined aquifer. The public is not at risk from current Vitro processing site activities, nor is risk expected due to golf course expansion. However, ecological risk could increase with increased surface water contamination and the development of ground water seeps.

2.0 SITE MONITORING PROGRAM

Ground water and surface water monitoring activities at the site are based on U.S. Environmental Protection Agency (EPA) regulations (40 CFR Part 192). Data collected during the monitoring activities described below are used for site characterization and risk assessment. Environmental monitoring at the Vitro processing site included the sampling of ground water in selected monitor wells at the site and sampling surface water and sediment from South Vitro Ditch. For this evaluation of the proposed golf course expansion, additional data were obtained from 1994 irrigation (water use) records of the driving range and 1994 rainfall data from the U.S. Weather Service station at the Salt Lake City airport. An UMTRA site hydrogeologist and geochemist visited the site on 1 March 1995 to obtain ground water and surface water level data and water usage data for the driving range, and to investigate current site conditions. On 25 May 1995, the UMTRA characterization and remedial design technical manager visited the site to evaluate the potential effects of construction activities at CVWRF on surface and ground water conditions.

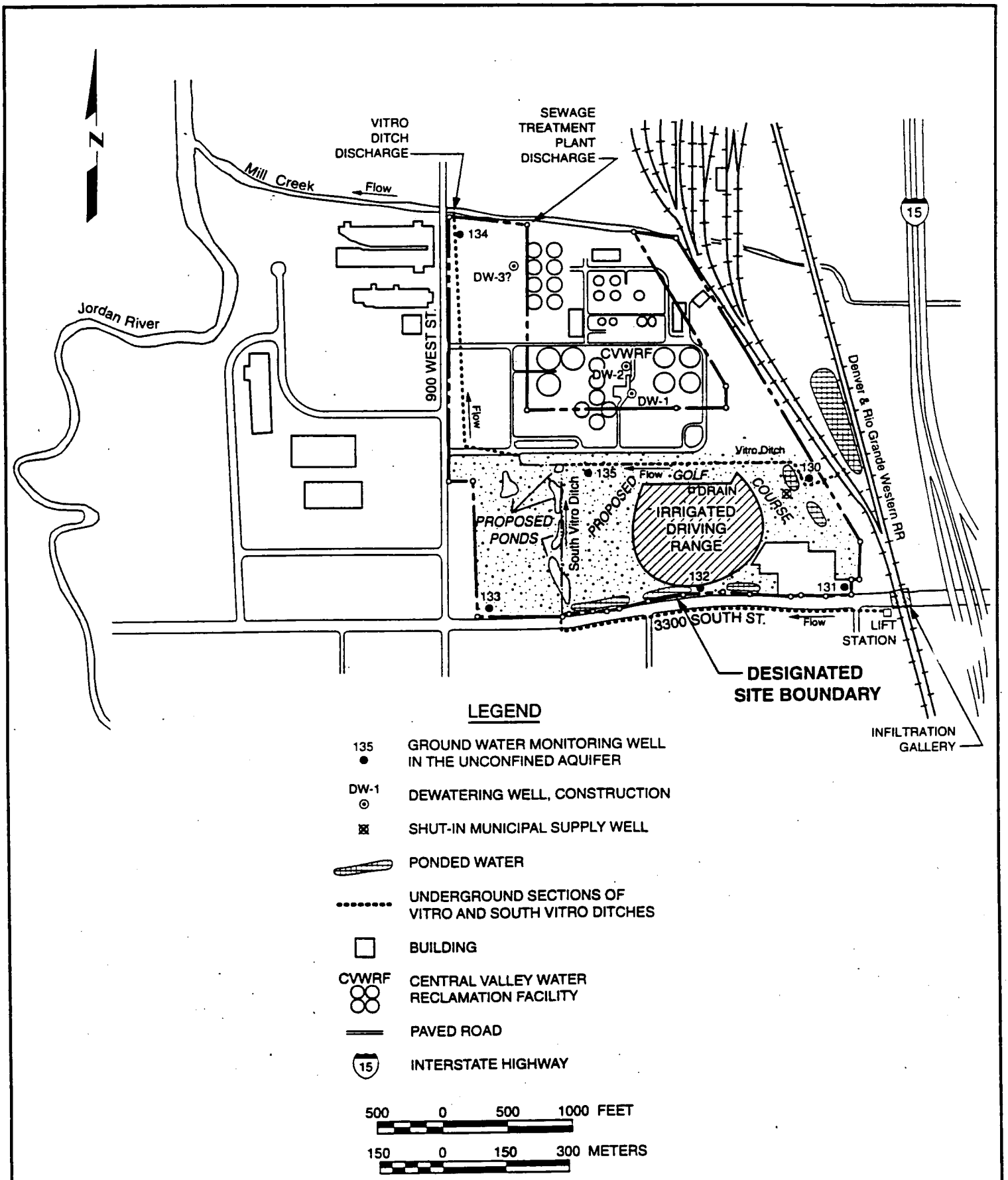


FIGURE 1
SITE LOCATION MAP
SALT LAKE CITY, UTAH, VITRO PROCESSING SITE

MAC: SITE/SLC/GOLF COURSE/SITELOC

A data logger installed in monitor well 131 in July 1994 was used to record water levels at hourly intervals. A monthly ground water monitoring program began in February 1994 to determine whether irrigating the driving range would create a ground water recharge mound in the shallow unconfined aquifer beneath the former Vitro site. This ground water mounding could accelerate the movement of any contaminants off the site. Ground water levels were measured monthly in monitor wells 130, 132, 133, 134, and 135. Figure 1 shows the locations of these wells.

3.0 IMPACTS OF GOLF COURSE IRRIGATION ON GROUND WATER LEVELS

3.1 SITE HYDROGEOLOGIC SETTING

The shallow unconfined aquifer at the site consists of Quaternary age unconsolidated silt, clayey-silt, silty-clay, and lenticular sands deposited in a fluvial-lacustrine environment. Monitor wells at the site extend to depths of about 45 feet (ft) (14 meters [m]) below ground surface. Below these depths a series of interlayered clays and silts acts as a confining layer to a deeper artesian aquifer. Water supply wells in the area that are completed in the artesian aquifer extract water from about 200 to 700 ft (60 to 210 m) below ground surface, although confined conditions have been encountered in boreholes at depths of about 70 ft (21 m).

In the shallow, unconfined aquifer, depths to ground water from the ground surface vary from about 4 to 6 ft (1.2 to 1.8 m) near monitor well 132 in the southeast corner of the site, and from about 10 to 12 ft (3 to 3.7 m) at monitor well 134 in the northwest corner of the site (Figure 2).

3.2 OBSERVED IMPACTS OF RAINFALL AND IRRIGATION ON GROUND WATER LEVELS

Monitor well data collected in 1994 indicate water levels in the unconfined aquifer are controlled primarily by precipitation. Water levels in monitor wells 130 through 135 declined to their lowest levels during the summer (the period of low rainfall) and increased to their highest levels during the late fall and winter (the period of highest rainfall and snowfall) (Figures 3 and 4). Water levels in these monitor wells responded quickly to precipitation (Figure 4).

One inch of monthly precipitation apparently increases water levels in the unconfined aquifer about 8 inches (20 centimeters [cm]). In 1994, monthly rainfall varied from a trace in July to as much as 2.4 and 2.9 inches (6.1 and 7.4 cm) in October and November, respectively. During the same period, water levels in the unconfined aquifer rose as much as 32 inches (81 cm) (Table 1).

Irrigation appears to have had much less effect on water levels than precipitation. Irrigation records show that about 0.2 to 0.9 inches (0.5 to 2.3 cm) of water were applied each month to the driving range from May

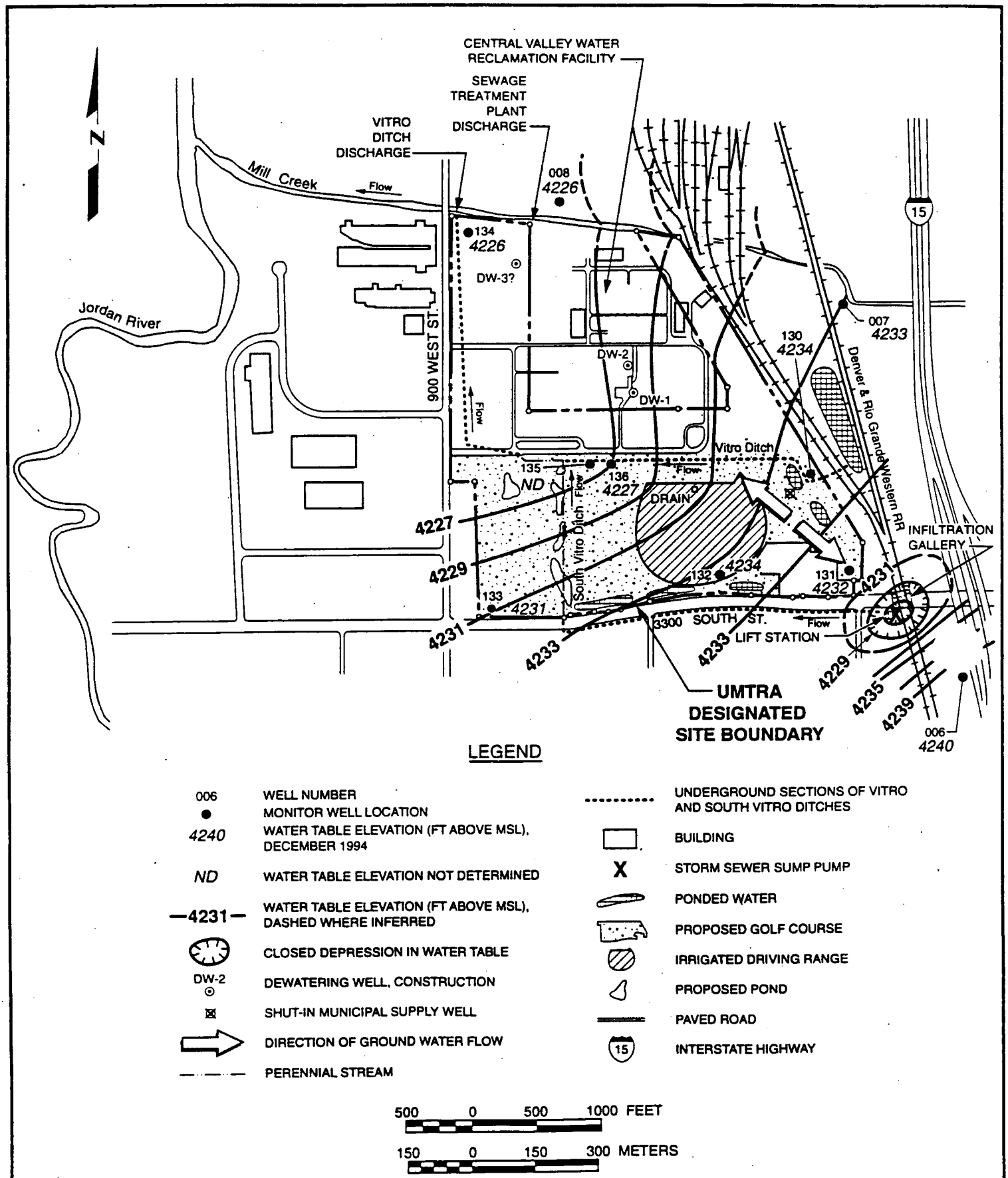
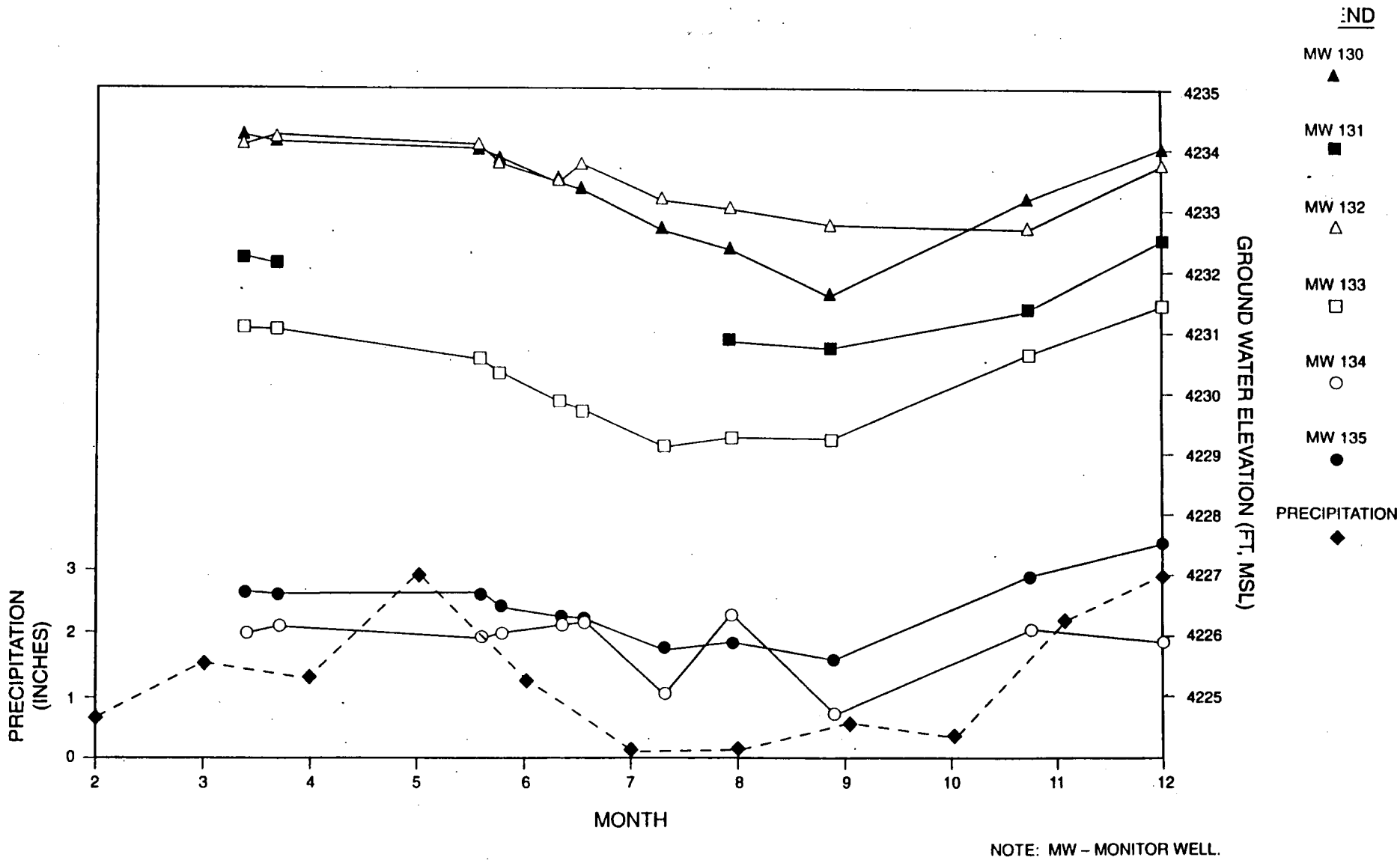


FIGURE 2
GROUND WATER TABLE CONTOURS OF THE UNCONFINED AQUIFER
SALT LAKE CITY, UTAH, SITE

MAC: SITE/SLC/GOLF COURSE/WATTBLE2



NOTE: MW – MONITOR WELL.

FIGURE 3
MONTHLY AND/OR BIMONTHLY GROUND WATER LEVELS IN THE UNCONFINED AQUIFER
SALT LAKE CITY, UTAH, VITRO PROCESSING SITE

MAC: SITE/SLC/GOLF COURSE/GWELEVSUNCON

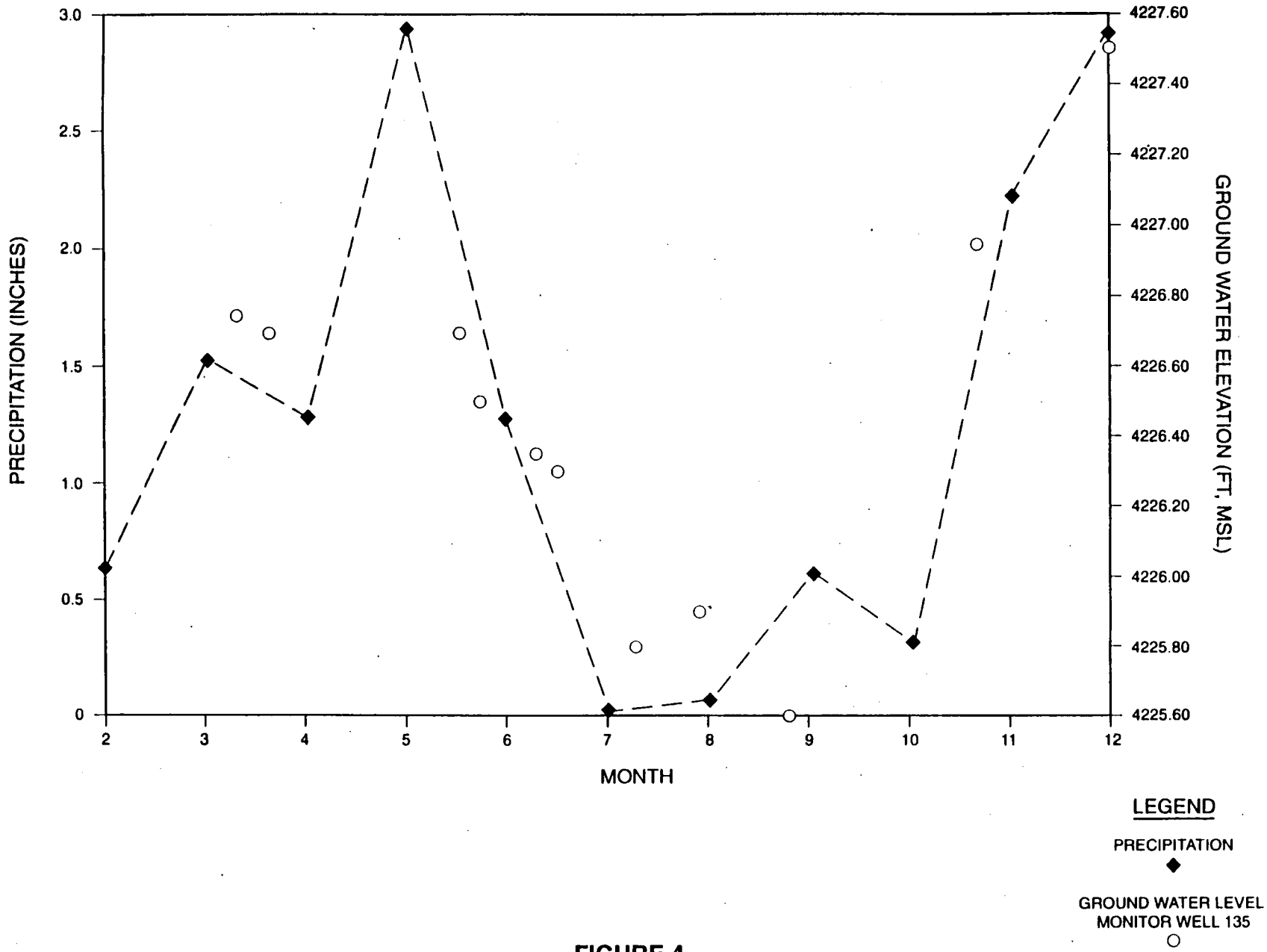


FIGURE 4
RELATION BETWEEN MONTHLY PREC[illegible]TATION AND GROUND WATER LEVELS
SALT LAKE CITY, UTAH [illegible]RO PROCESSING SITE

MAC: SITE/SLC/GOL[illegible]E/PRECIPVSGW

Table 1 Ground water elevations in the unconfined aquifer, Salt Lake City, Utah, Vitro processing site

Surface elevation (feet above MSL)	Monitor well					
	SLC-01 -0130 4240.22	SLC-01 -0131 4240.01	SLC-01 -0132 4239.99	SLC-01 -0133 4238.83	SLC-01 -0134 4239.50	SLC-01 0-135 4236.10
Sampling date (1994)	Water level elevations (feet above MSL)					
March 11	4234.27	4232.26	4234.12	4231.13	4226.10	4226.75
March 18	4234.17	4232.16	4234.22	4231.08	4226.20	4226.70
May 17	4234.00	NM	4234.09	4230.58	4226.00	4226.70
May 23	4233.87	NM	4233.79	4230.33	4226.05	4226.50
June 9	4233.52	NM	4233.49	4229.88	4226.20	4226.35
June 15	4233.37	NM	4233.77	4229.73	4226.23	4226.30
July 8	4232.72	NM	4233.19	4229.13	4225.05	4225.80
July 28	4232.37	4230.9	4233.04	4229.28	4226.35	4225.90
August 26	4231.62	4230.75	4232.74	4229.23	4224.70	4225.60
October 21	4233.17	4231.35	4232.69	4230.63	4226.10	4226.95
November 30	4233.98	4232.50	4233.73	4231.41	4225.88	4227.50
Maximum	4234.27	4232.50	4234.22	4231.41	4226.35	4227.50
Minimum	4231.62	4230.75	4232.69	4229.13	4224.70	4225.60
Range (feet)	2.65	1.75	1.53	2.28	1.65	1.90

Water levels measured using a steel tape.

NM – not measured.
MSL – mean sea level.

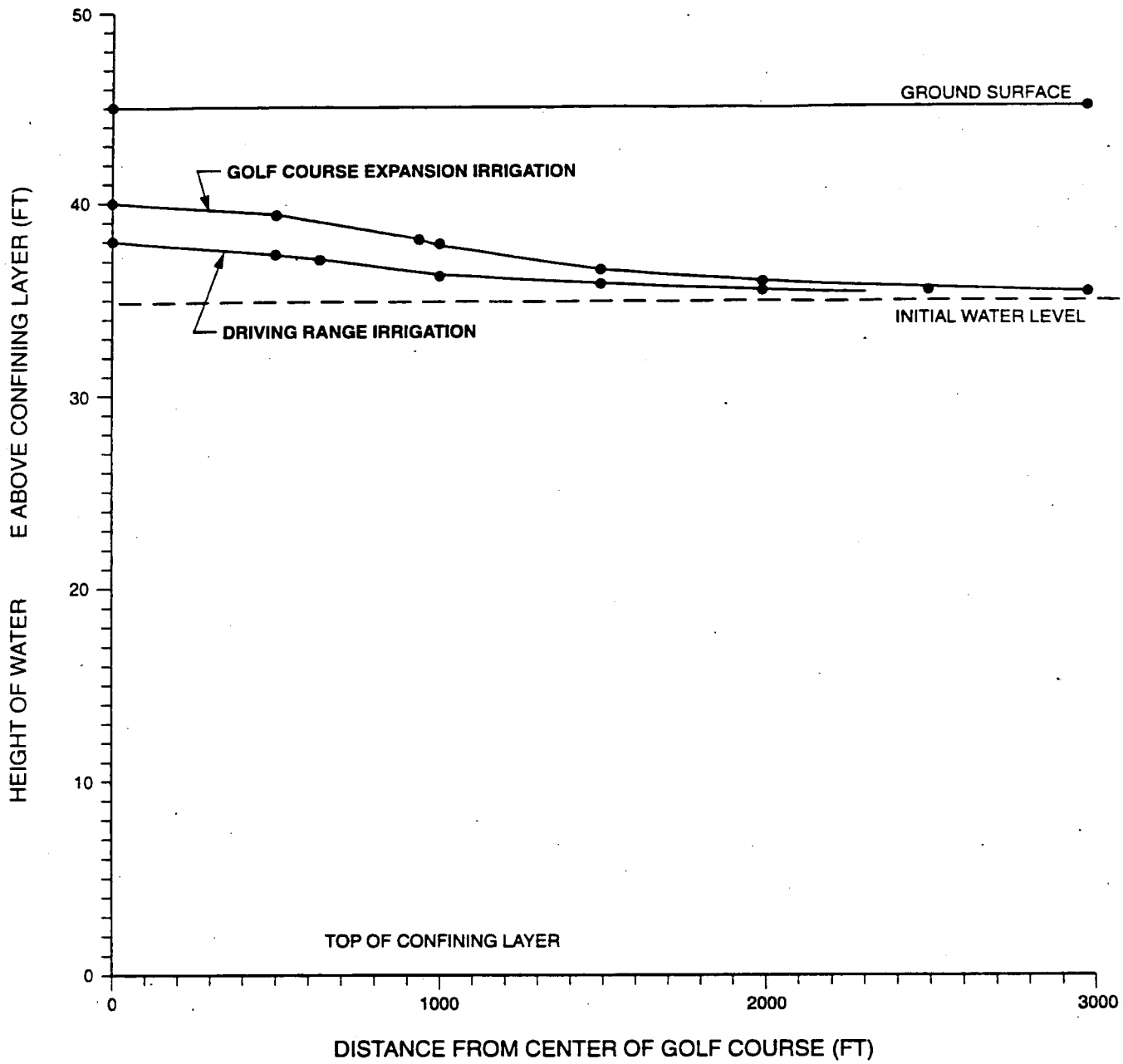
through September 1994 for a total of about 3 inches (8 cm) (Table 2 and Figure 5).

Assuming a similar relation as precipitation to water level changes in the unconfined aquifer, irrigation could cause a 1.5- to 7-inch (3.8- to 18-cm) increase in water levels beneath the driving range relative to unirrigated areas. The only monitor well within the irrigated area (on its extreme southern edge) is monitoring well 132; wells 130 and 133 are farther from the irrigated area. Water levels in well 132 declined 6 and 13 inches (15 and 33 cm) below the levels measured in wells 130 and 133, respectively (Figure 3). This 6- to 13-inch (15- to 33-cm) difference in water levels is consistent with the amount of water applied during irrigation, suggesting irrigation or an irrigation system may cause the seasonal development of a localized ground water mound. However, this conclusion is tentative because 1) the effects of irrigation appear to be small compared to the effects of precipitation and land surface reconstruction, and 2) monitor wells have not been placed in the area that would be most affected by irrigation.

Other factors besides golf course irrigation could be affecting ground water flow at the site. Some of these factors are recharge from ponded areas near the driving range, and ground water extraction from dewatering wells at CVWRF and at a lift station at the railroad/3300 South Street underpass near the southeast corner of the site (Figure 1). A ground water contour map of the shallow aquifer (Figure 2) shows that ground water flows predominantly southeast to northwest across the site. More details of water levels and ground water flow are discussed in a separate report, "Ground Water Elevation Monitoring at the Uranium Mill Tailings Remedial Action Project, Salt Lake City, Utah, Vitro Processing Site" (in preparation).

3.3 GROUND WATER MODELING

A one-dimensional, analytical model, the *Hydrologic Evaluation of Landfill Performance* (HELP) (EPA, 1984) was used to predict possible changes in ground water levels in the unconfined aquifer due to increased irrigation (DOE, 1993). The model assumes that approximately 45 inches (115 cm) of irrigation water are applied during the growing season, and that 11 inches (28 cm) of this water infiltrates to recharge the aquifer during that time. These assumptions are very conservative because the total amount of irrigation water used during the 1994 growing season was only about 3 inches (8 cm). Therefore, real infiltration to the aquifer would be much less than that projected in the analytical model. This very conservative model predicted that after 2500 days of irrigation, a ground water mound could develop. This mound could be approximately 5 ft (1.5 m) high at the center with a radius of about 2500 ft (760 m) (Figure 6). To evaluate the effect of this mound on ground water velocities, hydraulic gradients at current conditions were compared to predicted mounding conditions.



NOTES

1. RECHARGE RATE = 0.001 FT/DAY.
2. TIME SINCE IRRIGATION BEGAN = 2500 DAYS.

FIGURE 6
GROUND WATER MOUND DUE TO RECHARGE FROM IRRIGATION
SALT LAKE CITY, UTAH, VITRO PROCESSING SITE

Ground water flows predominantly from the center of the proposed golf course northwest toward monitor well 134 (Figure 2). The center of the proposed golf course expansion is approximately 2500 ft (760 m) away from this well. Seasonal variations in water table elevations cause head differences between these two points that range from about 4 to 6 ft (1 to 2 m). The current hydraulic gradient between these two points ranges from 0.0016 to 0.0024 (this calculation is in preparation). If a 5-ft (1.5-m) ground water mound developed after 2500 days of irrigation, the difference in head between these two points would range from about 9 to 11 ft (3 to 4 m). The resultant hydraulic gradient between these two points would then range from 0.0036 to 0.0044. This change would approximately double the ground water velocity and the rate of potential contaminant migration toward the northwest edge of the former processing site.

The current ground water velocity is low, ranging from about 10 to 20 ft (3 to 6 m) per year. Doubling the ground water velocity could increase ground water velocities in the vicinity of the mound to as much as 40 ft (12 m) per year, still a low value for ground water flow velocity.

A 5-ft (1.5-m) ground water mound would also change ground water flow patterns. Development of a ground water mound may increase the cross-site gradient (east to west) and possibly reverse gradients to the south of the site, potentially allowing some off-site contaminant movement.

4.0 IMPACTS OF IRRIGATION ON THE MAGNITUDE AND EXTENT OF GROUND WATER CONTAMINATION

Changes in ground water flow patterns caused by irrigation and the associated ground water mound could spread contaminants into formerly upgradient and crossgradient areas.

The February and December 1994 sampling rounds showed a significant change in ground water chemistry in three monitor wells on the upgradient-to-crossgradient boundaries of the site (monitor wells 130, 132, and 133). This change involved a significant increase in several site-related contaminants, including uranium, molybdenum, manganese, iron, chloride and sulfate; the changes were similar in all three wells (Table 3). A similar increase occurred during 1992-1993 in monitor well 131 for the same constituents (Table 3). Together, these data suggest there is a very sharp boundary between contaminated and noncontaminated ground water near the upgradient edge of the site, and that this boundary moved during the last year. There is not sufficient information to determine whether the movement is lateral or vertical.

The cause of this movement of the contaminated ground water is not known. The current ground water flow conceptual model (Figure 2) shows the affected wells are located on the upgradient edge of the site, but in an area once occupied by tailings piles. Irrigation of the driving range began in September 1992 (based on records of water use). Since then, contamination has appeared in one well downgradient of the irrigated area (well 131) and

Table 2 Precipitation and irrigation at the Golf-in-the Round driving range, Salt Lake City, Utah, Vitro processing site

Monthly usage	Gallons used[a]	Inches applied[b]	Monthly precipitation (inches)[c]
1993			
August	0	0	NR
September	504,000	0.77	NR
October	120,000	0.18	NR
November	64,000	0.10	NR
December	0	0	NR
1994			
January	0	0	0.62
February	0	0	1.53
March	0	0	1.28
April	88,000	0.13	2.94
May	149,000	0.23	1.29
June	295,000	0. 45	trace
July	558,000	0.85	0.06
August	457,000	0.70	0.61
September	334,000	0.51	0.32
October	120,000	0.18	2.24
November	46,000	0.07	2.96
December	0	0	1.43
1995			
January	0	0	1.81
February	0	0	1.08

[a]Data are from monthly water meter readings recorded by city of South Salt Lake. Meter is generally read on the 20th of each month.
[b]Inches calculated from the number of gallons applied over a 28-acre (11-hectare) irrigated area.
[c]Data are for Salt Lake County. Data obtained from the U.S. Weather Service.

Driving Range opened in September 1993.

NR – data not requested.

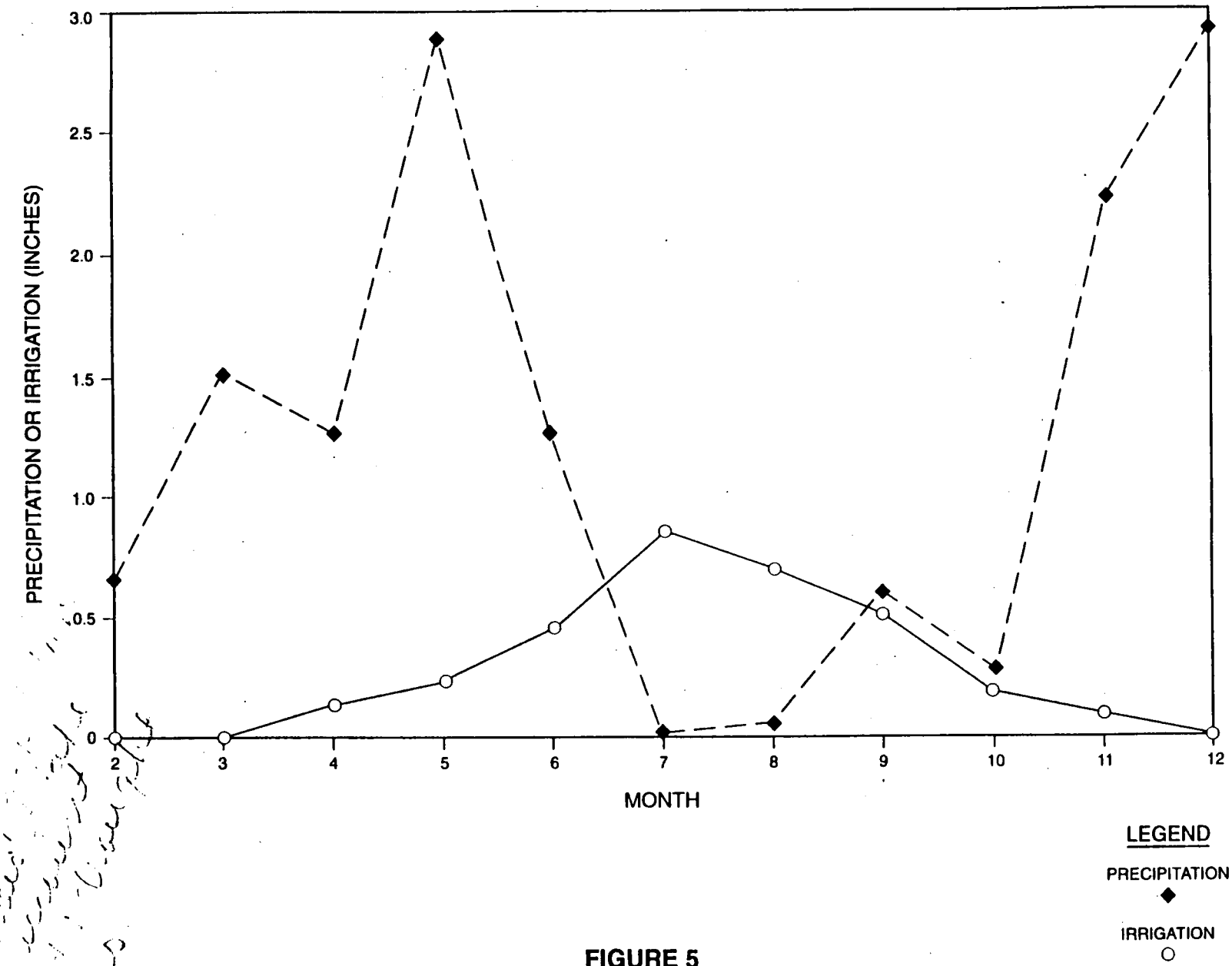


FIGURE 5
RELATION BETWEEN MONTHLY PRECIPITATION AND IRRIGATION
SALT LAKE CITY, UTAH RO PROCESSING SITE

MAC: SITE/SLC/GOLF COURSE/PRECIPVSIRR

Table 3 Change in water quality in monitor wells SLC-01-0130 through -0133, Salt Lake City, Utah, Vitro processing site

Parameter	Maximum concentration level	SLC-01-0130		SLC-01-0131		SLC-01-0132		SLC-01-0133	
		2/94	12/94	10/92	10/93	2/94	12/94	2/94	12/94
Arsenic	0.05	0.03	0.09	0.05	0.08	0.04	0.10	0.12	0.09
Calcium	NA	24	53	28	79	22	56	25	86
Chloride	NA	17	296	18	547	13	223	16	373
Iron	NA	0.8	2.3	0.6	1.4	0.6	2.2	0.47	3.6
Magnesium	NA	36	101	35	221	36	59	41	124
Manganese	NA	0.06	0.20	0.1	0.4	0.07	0.24	0.04	0.51
Molybdenum	0.1	<0.01	0.19	<0.01	0.9	<0.01	0.72	<0.01	0.02
Sodium	NA	24	270	25	525	56	320	39	280
Sulfate	NA	<1	214	<1	788	<1	297	9	292
TDS	NA	310	1470	327	2740	380	1330	340	1640
Uranium	0.044	<0.001	0.002	<0.0001	0.080	<0.001	0.001	<0.001	0.101

Notes: 1. Data are reported in milligrams per liter.
2. < indicates below level of detection (number given).

NA – no established maximum concentration level.
TDS – total dissolved solids.

three wells at the upgradient-to-crossgradient edges of the site (wells 130, 132, and 133). But these changes may not be related to irrigation of the driving range. Several other factors are possible, including the long-term vertical or horizontal movement of contaminants in ground water, vertical movement of contaminants through the well filter packs, and subtle changes in ground water flow patterns. Alterations in recharge due to commercial development in the area could explain the appearance of contamination along the upgradient edge of the site.

Regardless of the cause of chemical changes in upgradient wells, the effect is similar to the expected effect of extensive irrigation at the site: the off-site spread of ground water contamination into areas, including upgradient and crossgradient areas, that might not otherwise be impacted.

5.0 IMPACT OF THE PROPOSED GOLF COURSE ON SURFACE WATER AND SEDIMENTS

The proposed golf course expansion will convert South Vitro Ditch into a series of interconnected ponds (Figure 1). There is concern for potential environmental impacts because water in South Vitro Ditch contains site-related contaminants.

Surface water sampling in South Vitro Ditch in 1994 indicated the presence of contaminants, including uranium, molybdenum, sulfate, and chloride (Table 4). Sediment analysis also indicated the presence of contaminants, including arsenic, copper, silver and uranium (Table 5). These contaminants were also detected at similar levels in surface water and sediment samples collected in 1979.

Unlike the changes in ground water contamination, the appearance of surface water and sediment contamination in South Vitro Ditch is not recent and predates surface irrigation. Contaminants were not detected in surface water collected from South Vitro Ditch in 1993, indicating variable surface water quality or possible contaminated ground water being prepared from the underpass lift station and then diverted to South Vitro Ditch. Pumping at the lift station started well before contaminants were detected in monitor well 131.

Comparisons of surface water elevations to ground water elevations suggest that ground water could discharge to South Vitro Ditch at its southern end as a result of the relatively shallow ground water table (within 4 to 6 ft (1 to 2 m) of the surface) in this area. Thus, one possible source of surface water and sediment contamination in South Vitro Ditch is ground water discharge.

Without more thorough knowledge of ground water discharge to South Vitro Ditch, the complete effect of surface water irrigation cannot be assessed. However, if the present contamination is related to ground water discharge to the ditch, irrigation could increase this discharge, thereby increasing contaminant levels. The dilution effects from rainwater and snowmelt runoff in the ditch are low. In addition, if the ponds were excavated more than 4 ft (1 m) below grade, contaminated ground water could be encountered. The

Table 4 Selected unfiltered surface water quality results, Salt Lake City, Utah, Vitro processing site

		Mill Creek sampling locations		Unnamed ditch	South Vitro Ditch	
Parameter	Aquatic life water quality guideline	SLC-01-0180 upstream of site	SLC-01-0182 downstream of site	SLC-01-0191 east of site	SLC-01-0186 south end	SLC-01-0187 north end
Chloride	230[a]	122	279	769	240	324
Iron	1.0[a]	0.26	0.10	2.11	0.21	1.18
Lead	0.0032[a]	<0.003	<0.02	0.021	<0.003	0.014
Molybdenum	0.79[b]	<0.01	0.02	0.01	0.12	0.13
Sulfate	NA	138	133	138	179	242
Total Dissolved Solids	NA	729	960	1710	1040	1220
Uranium	8.4[c]	0.002	0.007	0.008	0.023	0.028

[a]From EPA (1991), chronic Federal Water Quality Criteria for the protection of freshwater aquatic life.
[b]Value from Eisler (1989).
[c]From water hardness chronic criteria (CDH, 1991).

Note: Concentrations are reported in milligrams per liter. Samples collected December 1994.

NA – guideline not available.

Table 5 Selected sediment sample analytical results, Salt Lake City, Utah, Vitro processing site

	Screening benchmark values[a]		Mill Creek sampling locations		Unnamed ditch	South Vitro Ditch	
Parameter	Effects range - low	Effects range-median	SLC-01-0180 upstream	SLC-01-0182 downstream	SLC-01-0191 east of site	SLC-01-0186 south end	SLC-01-0187 north end
Arsenic	8.2	70	4	14	54	13	61
Copper	34	270	18	33	141	92	404
Lead	47	218	25	29	485	245	344
Molybdenum	NA	NA	<1	<2	2	13	158
Silver	1.0	3.7	0.2	0.3	1.4	0.3	5.6
Uranium	NA	NA	2	3	5	6	10

[a]Ref.: Hull and Suter (1994).

Note: Concentrations are reported in milligrams per kilogram. Samples collected December 1994.

NA – guideline not available.

deeper and longer the ponds, the greater the potential for discharge of contaminated ground water to the ponds. This increased flux could further increase contamination levels in the pond water.

The presence of contaminated surface water in the proposed ponds could result in contaminant build-up in pond sediments. Based on contaminants currently observed in South Vitro Ditch, this would include arsenic, copper, lead, molybdenum, silver, and uranium. This contaminant buildup would provide another potential contaminant pathway to animals and plants. Contaminated ground water, surface water, and sediments may have toxic effects on some animals and plants.

6.0 POSSIBLE RISKS DUE TO THE PROPOSED GOLF COURSE EXPANSION

The baseline risk assessment (in preparation) concludes that while the contaminated ground water at the site is toxic to humans, there is presently no human health risk because the contaminated ground water is not used for drinking. Further, there are no identified users of ground water from the unconfined aquifer within a one mile radius of the site (DOE, 1994). While irrigation could increase the rate of off-site ground water migration, this potential impact apparently does not pose an immediate risk to human health.

The baseline risk assessment also concludes that surface water contamination in South Vitro Ditch could have toxic effects on some plants and aquatic organisms. Also, the contaminated sediments in the ditch could induce toxic effects in some aquatic organisms, although further study is needed to document these effects.

The proposed ponds could contain contaminated surface water and sediments from the contaminated ground water that would discharge into the ponds. Contamination levels in the pond water and sediments may be toxic to some animals and plants. Since the ponds will provide a surface area larger than South Vitro Ditch for aquatic habitat, contaminant exposure pathways for plants and animals could also increase.

One area that could be impacted by development of a ground water mound and reversal of ground water flow is the relatively low-lying pasture south of South 3300 Street near the southern end of South Vitro Ditch. A rise in ground water levels could result in discharge of contaminated ground water in this low area and the nearby drainage ditches.

7.0 DATA GAPS AND UNCERTAINTIES

Knowledge of ground water flow conditions at the site is limited by the low density of monitor wells and piezometers at the site. Presently, most of the area proposed for the golf course expansion is not monitored with wells or piezometers. Additional ground water level data are needed to measure water level differences between the area where irrigation presently occurs and nonirrigated areas so as to predict the effects of the golf course

expansion. Additional water level and chemical data are needed for the area near South Vitro Ditch to predict the effects of any potential ground water discharge to the proposed golf course ponds. Water levels in Mill Creek must be measured and compared with water levels in monitor well 134 to determine if ground water is discharging to Mill Creek in this area or if Mill Creek provides recharge to the shallow aquifer.

The effects of the dewatering operations at the CVWRF sewage treatment plant on ground water flow patterns and contaminant movement are not known. Ground water levels should be measured near the dewatering operations and compared with water level measurements from other monitoring wells and piezometers at the site. When these additional data are collected, a two-dimensional ground water flow model should be run to predict the effects of irrigation at the site and the influence of the dewatering operation on contaminant migration, and to evaluate potential impacts to surface water bodies in the area from potential changes in the ground water flow regime. To estimate the effects of these contaminants on the environment, data on plant and animal contaminant uptake in South Vitro Ditch are also needed. Elevations of the topographically low area south of the site are needed to determine whether ground water could discharge to the surface in this area in response to irrigation.

8.0 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions can be made about potential impacts from the proposed golf course expansion.

- Water level data and an analytical model suggest that irrigating the driving range and an expanded golf course may cause the development of a ground water mound at the Vitro processing site.

- Development of a ground water mound at the site may cause contamination to migrate more rapidly within the unconfined aquifer and to migrate into areas which might not otherwise be impacted.

- Expansion of the proposed golf course may impact the environment due to the potential for increased levels of surface water and sediment contamination, and the possible development of ground water seeps into topographically low areas.

- To minimize any increases in water levels in the shallow aquifer in the vicinity of the golf course, recharge from other sources (i.e., leaks from irrigation system, ponding of rainfall runoff) should be eliminated or controlled.

- There is no current risk to the general public at the Vitro processing site, nor is there any expected risk to the general public due to expansion of the golf course.

- The effects on surface sediments could be controlled by 1) enclosing South Vitro Ditch in a box culvert and not building ponds or 2) building ponds and routinely cleaning out and disposing of the sediment.

- *In situ* remediation methods for contaminated ground water and soils may be appropriate for mitigating any environmental risks in the vicinity of South Vitro Ditch.

9.0 LIST OF CONTRIBUTORS

The following individuals contributed to the preparation of this report.

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S. Wright, A. Holm	Document review
J. Torline, V. Beck	Editing
L. Sanchez	Text processing

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CODE OF FEDERAL REGULATIONS

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NRC/UMT/0493-0020

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

MAR 26 1993

Albert R. Chernoff, Project Manager
Uranium Mill Tailings Remedial Action
Project Office
U.S. Department of Energy
Albuquerque Operations Office
P.O. Box 5400
Albuquerque, New Mexico 87115

Dear Mr. Chernoff:

The Nuclear Regulatory Commission staff has received the Department of Energy (DOE) January 1993 report entitled "Final Hydrogeologic Characterization of the Former Vitro Processing Site, Salt Lake City, Utah." The NRC does not have a formal concurrence role for this type of report, but we understand that technical information in this document will support the Vitro Completion Report, which will receive NRC concurrence review. Consequently, the following comments are provided for your consideration in preparing the draft Completion Report.

1. Ground-water is encountered at relatively shallow depths (from about 5 to 12 feet deep) across the Vitro site. NRC staff is concerned that the contaminated ground-water on site may present a hazard to human health and the environment, if the property is released for unrestricted use and site development includes deep foundations requiring construction dewatering.

2. We are confident DOE will adequately address the ground-water contamination identified at the site, as a part of DOE's Programmatic Environmental Impact Statement (PEIS) for ground-water restoration. However, the NRC is concerned that the future land use and planned construction activities could adversely impact site access and any potential active ground-water restoration activities, if such measures are required for compliance with the EPA ground-water protection standards in 40 CFR 192.

We recognize that these and other concerns of this type must be evaluated on a case-by-case basis before an individual site can be released for unrestricted use. NRC staff has raised similar issues at other Uranium Mill Tailings Remedial Action Project sites such as, Lakeview, Oregon and Riverton, Wyoming; where other uses have been proposed for the former processing sites before the EPA ground-water standards have been met. We again emphasize DOE's need for continuing management and control at the processing sites where the tailings have been removed and the sites are released before ground-water cleanup, as discussed at past NRC/DOE management meetings. We anticipate that DOE will send a letter to us in the near future addressing this subject.

APR 2 7 42 AM '93

MAR 33 7 33 AM '93

If you have any questions regarding our comments, please contact me at FTS 8-301-504-3439, or the NRC Project Manager, Elaine Brummett at FTS 8-301-504-2533.

Sincerely,

John J. Surmeier, Chief
Uranium Recovery Branch
Division of Low-level Waste Management
and Decommissioning
Office of Nuclear Material Safety
and Safeguards

cc: L. Anderson, Utah
J. Stelmach, Alb

Attachment E

DOE/AL/62350-229
REV. 0

REPORT OF GROUND WATER MONITORING FOR EXPANSION OF THE GOLF COURSE, SALT LAKE CITY, UTAH, VITRO PROCESSING SITE

March 1996

Work performed under DOE Contract No. DE-AC04-91AL-62350

Prepared for
U.S. Department of Energy
Grand Junction Projects Office
Grand Junction, Colorado

Prepared by
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LIST OF ACRONYMS

Acronym	Definition
CVWRF	Central Valley Water Reclamation Facility
UMTRA	Uranium Mill Tailings Remediation Action

1.0 INTRODUCTION

Ground water elevations of the shallow unconfined aquifer have been monitored at the Uranium Mill Tailings Remedial Action (UMTRA) Project, Vitro Processing site, Salt Lake City, Utah, for the purposes of characterizing ground water flow conditions and evaluating the effects of irrigation of the golf driving range. Data collected, to date, show that the water table reached its highest level for the year during March and April 1995. From May through July 1995, the water table elevations decreased in most monitor wells due to less precipitation and higher evapotranspiration. Review and evaluation of collected data suggest that irrigation of the golf driving range will have negligible effects on water levels and ground water flow patterns if rates of irrigation do not significantly exceed future rates of evapotranspiration.

2.0 GROUND WATER ELEVATION MONITORING ACTIVITIES

The data loggers are programmed to record hourly water level measurements. Every three to four months, these data are downloaded from the data logger and entered into the UMTRA Project database. Ground water elevation data, covering the period from March 1 to July 13 1995, were downloaded from the data logger (in operation since July 1994) in monitor well, SLC01-0131 (MW 131) on 13 July 1995. Monitor well locations are shown on Figure 1. Data loggers were installed in three additional monitor wells (MW 132, MW 133, and MW 134) at that time, and the data logger in MW 131 was moved to MW 130. Ground water elevation data were downloaded from these four data loggers on 16 November 1995. On 4 March 1996, ground water elevation data were downloaded from monitor wells MW 132, MW 133, and MW 135. The data logger in monitor well 130 was inoperable at this time, and the data have not yet been retrieved from the instrument. Ground water elevation data have also been collected biweekly from five other monitor wells by the Central Valley Water Reclamation Facility (CVWRF). Daily rainfall data for the period July 1994 through July 1995 for the Salt Lake City airport were obtained from the Western Regional Climate Center in Reno, Nevada, to compare with ground water elevation data.

Surface elevations were measured at various points around the site so that elevations of surface waters and ground water could be calculated where elevation data were not previously available. These measurements included CVWRF dewatering wells and depths of excavations. Expansion of the CVWRF has required dewatering of the shallow aquifer around excavations where additional sewage treatment facilities will be installed.

3.0 RESULTS OF GROUND WATER ELEVATION MEASUREMENTS

3.1 PERIOD OF MEASUREMENT: JANUARY 1994 - JULY 1995

Ground water elevation measurements were recorded by a data logger that was installed in MW 131 located in the southeastern corner of the site. Figure 2

shows daily values of ground water elevations for the 12 months that the data logger has been in operation. These data show that there is a difference in ground water elevations of about 2.5 feet (ft) (0.8 meter [m]) between late summer, when the water table reaches its lowest level of the year, and late winter and spring, when the water table reaches its maximum elevation. Figure 2 also includes ground water elevation data from five other monitor wells at the site that are monitored biweekly by CVWRF. There is a gap in the data between December 1994 and April 1995 when CVWRF was unable to measure water levels. These wells show a similar pattern of ground water elevation changes as MW 131 except for MW 134 which has higher ground water elevations in the summer than in the winter and spring. Water levels in MW 134 are influenced by water levels in Mill Creek, which flows westward about 100 ft (30 m) north of MW 134.

Daily and monthly rainfall data indicate that this past winter and spring (1995) had considerably more precipitation than normal. Figure 3 shows monthly rainfall totals from January 1994 to July 1995, compared to the mean monthly rainfall for a period of record of 47 years. Total rainfall from October 1994 to June 1995 was about 50 percent higher than the mean rainfall for that period. Ground water elevations in monitor wells MW 130, MW 131, MW 132, MW 133 and MW 135 during this period of high precipitation were 0.4 ft (0.1 m) to 2.1 ft (0.64 m) higher in May 1995 than in March 1994 when the water table was at its seasonal high. The average difference in water levels for these two dates is 1.0 ft (0.3 m).

Figure 4 shows ground water elevation data from the data logger in monitor well MW 131 plotted against daily rainfall from a station at the Salt Lake City airport. An exact correlation between rainfall amounts and increases in ground water elevations cannot be made because the airport is about 6 miles (10 kilometers) northwest of the site and rainfall amounts are likely to vary between the airport and the site. However, it appears that in the winter and spring the shallow aquifer is very responsive to rainfall. Increases in ground water elevations of about 0.6 ft (0.2 m) to 0.9 ft (0.3 m) over several days (for example: 12 to 14 November 1994; 15 to 17 January 1995; and 11 to 13 May 1995) correspond to rainfall events measured at the airport of about 0.9 in (2.3 cm) to 1.5 in (3.8 m) over several days. The water table drops steadily starting in June when precipitation decreases and temperatures increase. Figure 4 shows that from June through September the water table changes very little in response to rainfall. Evapotranspiration is at its highest level during the summer months and very little precipitation is able to reach the water table. This suggests that the effects of irrigation of the golf course on ground water elevations are negligible, and that the irrigation rates do not significantly exceed evapotranspiration rates.

3.2 PERIOD OF MEASUREMENTS: JULY 1995 - MARCH 1996

During this period, ground water elevation data were collected by data loggers installed in monitor wells MW 130, MW 132, MW 133 and MW 135. Figures 5 through 8 show bi-hourly ground water elevation data from these wells. The differences in ground water elevation patterns from these four wells indicate considerable variability of aquifer properties in the shallow unconfined aquifer across the site. Some of the shallow wells on the site are completed in channel and splay sand deposits from which considerable ground water can be extracted. Between, above, and below these sand deposits are deposits of silt and clay that limit movement of ground water (DOE, 1996). Monitor well MW 135 and CVWRF dewatering well 139 are completed in one of these channel sand deposits. Ground water elevations monitored in MW 135 show a rise of almost 5 ft (1.5 m)when the dewatering well stopped pumping in September 1995. None of the other wells being monitored at that time showed any influence of well 139 shutting down, nor when it started pumping again.

Monitor well MW 132, located adjacent to the south side of the golf driving range, shows a general decrease in ground water elevations from July to October 1995, then a rise from October 1995 to March 1996. Within these general trends are fluctuations on the order of about one quarter to one half foot over several days or a week. These changes could be due to recharge from precipitation, irrigation, or atmospheric effects. From July through September 1995, a daily pattern of ground water elevation changes of about a tenth of a foot can be seen. Figure 9 shows these changes from August 24 through September 6. During the summer, the golf course is irrigated every night for about 8 hours (Vilven, 1995). This daily rise and fall in water levels could be due either to irrigation of the golf course or to atmospheric changes. Water levels were dropping throughout the irrigation season due to decreased rainfall and high rates of evapotranspiration. After each daily rise in water level, the water table dropped more than the amount of rise. The overall decrease in water levels in MW 132 indicates that the amount of irrigation water recharging the aquifer is minimal. It is not likely that irrigation of the golf course as it exists now or of an expanded golf course would alter ground water flow and constituent migration unless considerable overwatering took place.

4.0 SURFACE ELEVATION MEASUREMENTS

Measurements of selected points around the site were made with a surveyor's level, tripod, and stadia rod to establish reference points for measuring the elevations of surface water bodies, ground water in wells and sumps that had not previously been measured, and water encountered at the bottom of construction excavations. Elevations of the surface waters in Mill Creek and South Vitro Ditch were measured to compare to ground water elevations in nearby monitor wells. At the time of the measurements (14 July 1995) Mill Creek was 0.76 ft (0.26 m) below the elevation of ground water in MW 134,

which indicates that ground water may be discharging to Mill Creek in this area. In March 1996, the water level in Mill Creek was 1.1 ft (0.35 m) above the water level in MW 134. Because the elevation of is not likely to fluctuate significantly due to the constant discharge of effluent from CVWRF, some of the water in Mill Creek may recharge the aquifer when the water table is low.

The surface elevation of water in the northern end of South Vitro Ditch was measured at 3.5 ft (1.1 m) above the elevation of ground water in MW 136. Therefore, water in South Vitro Ditch is likely recharging the aquifer in this area.

Surface elevations were measured at the two excavations at CVWRF for reference points from which depth-to-water measurements can be made. The larger excavation at location 139 (Figure 1) is being dewatered by a construction well, less than 30 ft (10 m) deep, which was installed during construction activities (about 1980) at CVWRF. This well is extracting ground water from the shallow aquifer at a rate of about 300 gallons per minute (1140 liters per minute). The other excavation (location 141) is being dewatered by a sump pump inside a galvanized steel casing that has been buried in coarse gravel (about 25 ft (8 m) below ground level) at the northwest corner of the excavation. Ground water extracted by the construction dewatering wells is piped into the CVWRF grit tanks. The water flows through the process system and is eventually discharged into Mill Creek (Figure 10).

An inactive dewatering well (location 140) is located next to Mill Creek. The elevation of the top of casing in this well and the depth to water were measured. The elevation of ground water in this well is about 4 ft (1.2 m) lower than the surface elevation of water in Mill Creek. The reason for the low water table in this area could be either the extensive dewatering taking place for the current construction activities or additional dewatering from drains and sump pumps installed below CVWRF.

5.0 GROUND WATER CONFIGURATION

Figure 10 shows ground water table contours from December 1994, prior to the start of dewatering for the current construction activities. This figure shows that ground water flow in the shallow unconfined aquifer beneath the site is predominantly to the northwest. Figure 11 shows ground water table contours for the unconfined aquifer in July 1995. The most noticeable features on this map are the closed depressions in the water table around the dewatering wells at CVWRF and around the lift station at the railroad and Interstate 15 overpass on South 3300 Street underpass. Ground water extracted by the lift station is discharged into South Vitro Ditch, which discharges into Mill Creek. The 4230-ft and 4240-ft contour lines on Figure 10 indicate that, aside from water diverted to the surface by the various dewatering wells on and near the site, ground water flows generally to the northwest.

Ground water elevations in MW 135 indicate that there is a depression in the water table in this area, however, the cause of this depression has not been fully determined. Water

levels measured in this well since 1992 are about 5 ft (1.5 m) lower than water levels measured in this area in 1982 and 1983 (DOE, 1984). The low levels of ground water in MW 135 cannot be fully attributed to the recent dewatering activities because CVWRF dewatering started in January 1995, and water levels have been low since at least 1992. This suggests that there are other features that are draining the aquifer in this area. Possibilities for such drainage are sump pumps below the sewage treatment facility, or flow of ground water from the site along the gravel fill around pipelines that connect to other CVWRF and sewage treatment facilities, or flow into the sewer mains that discharge into CVWRF or other such facilities.

6.0 SUMMARY

Water level measurements from monitor wells, dewatering wells, surface water bodies, and excavations give a clearer picture of the water table configuration at the Vitro Processing Site than was previously available from measurements made only in monitor wells. These measurements show that a considerable amount of ground water is being extracted or drained from the shallow aquifer by dewatering wells. The ground water flow pattern induced by this extraction appears to have a significant impact on the movement of site-related constituents in the shallow aquifer. Movement of contaminated ground water off- site is diminished due to CVWRF ground water extraction, and the amount of site-related constituents in the aquifer will be reduced because of the increased ground water flow onto the site, flushing site waters toward the CVWRF extraction wells.

A comparison of ground water elevations and rainfall events shows that in the winter and spring the aquifer is very responsive to rainfall events. However, during the summer, when evapotranspiration is high, rainfall has negligible impact on ground water levels. It is not likely that irrigation of the present golf driving range on the site or an expansion to a nine-hole golf course will have any significant impact on ground water levels or constituent migration, assuming irrigation application rates are comparable to those currently being used.

7.0 RECOMMENDATIONS FOR CONTINUED WATER LEVEL MONITORING

Data collected from the three data loggers now functioning in three monitor wells at the site will provide additional information about ground water flow patterns and the impact of irrigation of the golf driving range on water levels and ground water flow. It is recommended that monitoring of ground water levels using the data loggers and other water level monitoring points continue at least until December 1996. This will allow for ground water level measurements from the more extensive monitoring network through the summer irrigation period and into the period of higher rainfall with higher water levels. Also, water levels can be monitored as the CVWRF dewatering wells are shut down when construction activities are completed in 1996. Water levels in MW 132, adjacent to the golf driving range, should be recorded and compared to irrigation records and to atmospheric data to determine if the daily patterns in water levels from this well during the

summer are due to irrigation of the driving range. A report summarizing the data should be prepared every six months and should include any new findings or activities at the site that might affect ground water levels and flow. The data logger from MW 130 should be repaired and installed in the well so that water levels on the east side of the site can be monitored. Data should be downloaded from the data loggers every four months to minimize potential loss of data due to equipment malfunction, battery failure, or memory overload. It is also recommended that CVWRF continue to monitor water levels biweekly in monitor wells on their property that do not have data loggers.

8.0 LIST OF CONTRIBUTORS

The following individuals contributed to the preparation of this report.

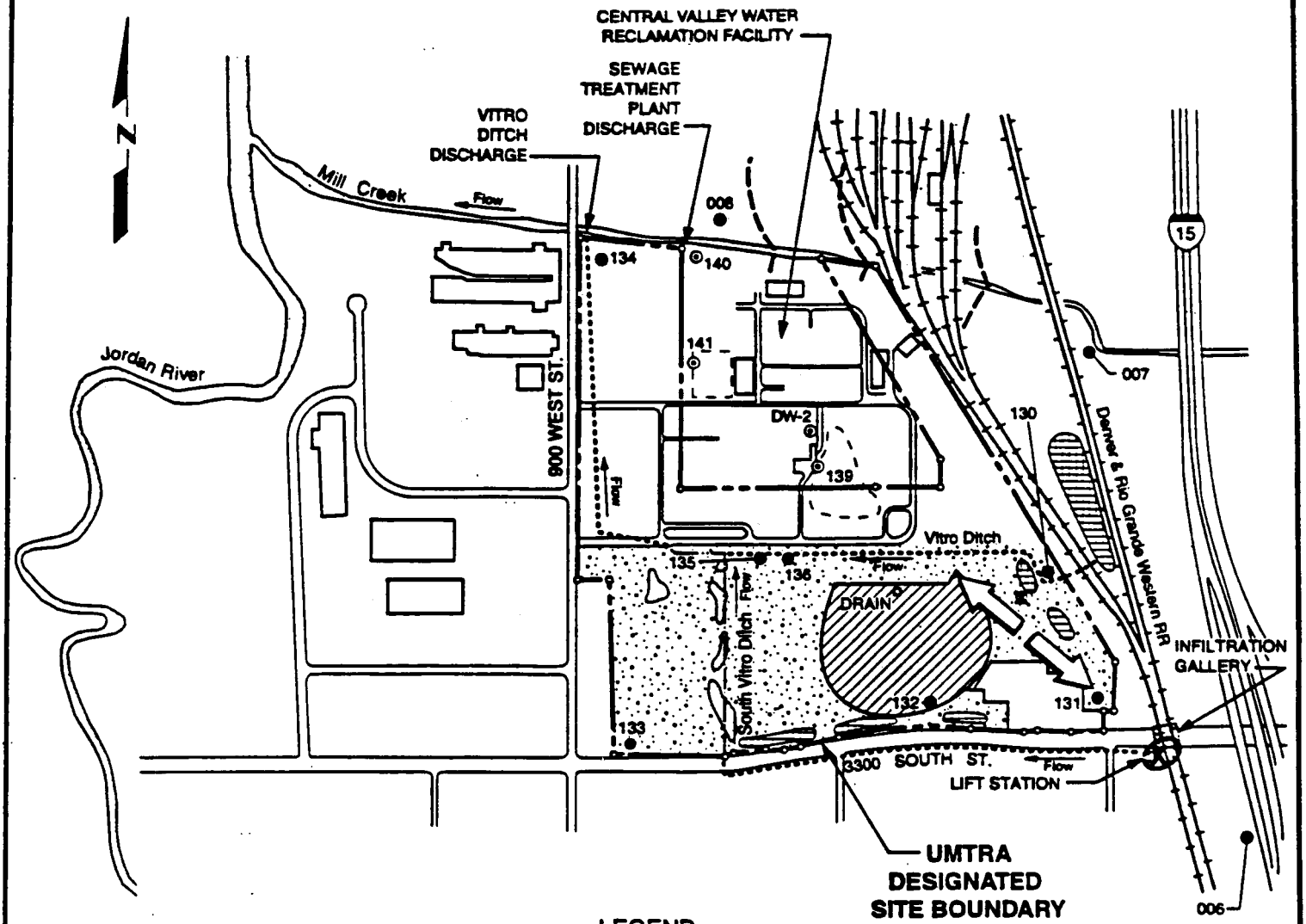
Name	Contribution
B. Smith	Document coordinator
B. Smith	Primary authors
A. Holm, S. Wright	Document review
J. Jones	Editing
D. Minchow	Text processing
K. DeGruyter	Graphic artist

9.0 REFERENCES

DOE (U.S. Department of Energy), 1996. *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*, prepared for the U.S. Department of Energy, Grand Junction Projects Office, Grand Junction, Colorado, March 1996.

DOE (U.S. Department of Energy), 1984. *Remedial Actions at the Former Vitro Chemical Company Site, South Salt Lake, Salt Lake County, Utah: Volume II (Appendices)*, prepared for the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

Vilven, D., Manager of Golf in the Round, 600 W. 3300 South, Salt Lake City, Utah 84165, 1995. Personal communication with Brian Smith, UMTRA Project, Jacobs Engineering Group Inc., PDCC #2.19.2.2.2, November 1995.



LEGEND

006	WELL NUMBER
●	MONITOR WELL LOCATION
4240	WATER TABLE ELEVATION (FT ABOVE MSL), DECEMBER 1994
ND	WATER TABLE ELEVATION NOT DETERMINED
—4231—	WATER TABLE ELEVATION (FT ABOVE MSL), DASHED WHERE INFERRED
	CLOSED DEPRESSION IN WATER TABLE
140	DEWATERING WELL, CONSTRUCTION
	SHUT-IN MUNICIPAL SUPPLY WELL
	DIRECTION OF GROUND WATER FLOW
	EXCAVATIONS
	UNDERGROUND SECTIONS OF VITRO AND SOUTH VITRO DITCHES
	BUILDING
X	STORM SEWER SUMP PUMP
	PONDED WATER
	PROPOSED GOLF COURSE
	IRRIGATED DRIVING RANGE
	PROPOSED POND
	PAVED ROAD
15	INTERSTATE HIGHWAY

500 0 500 1000 FEET

150 0 150 300 METERS

FIGURE 1
MONITOR WELL LOCATIONS
SALT LAKE CITY, UTAH, SITE

MAC: SITE/SLC/GWELEVMONREP/WATTBLE3

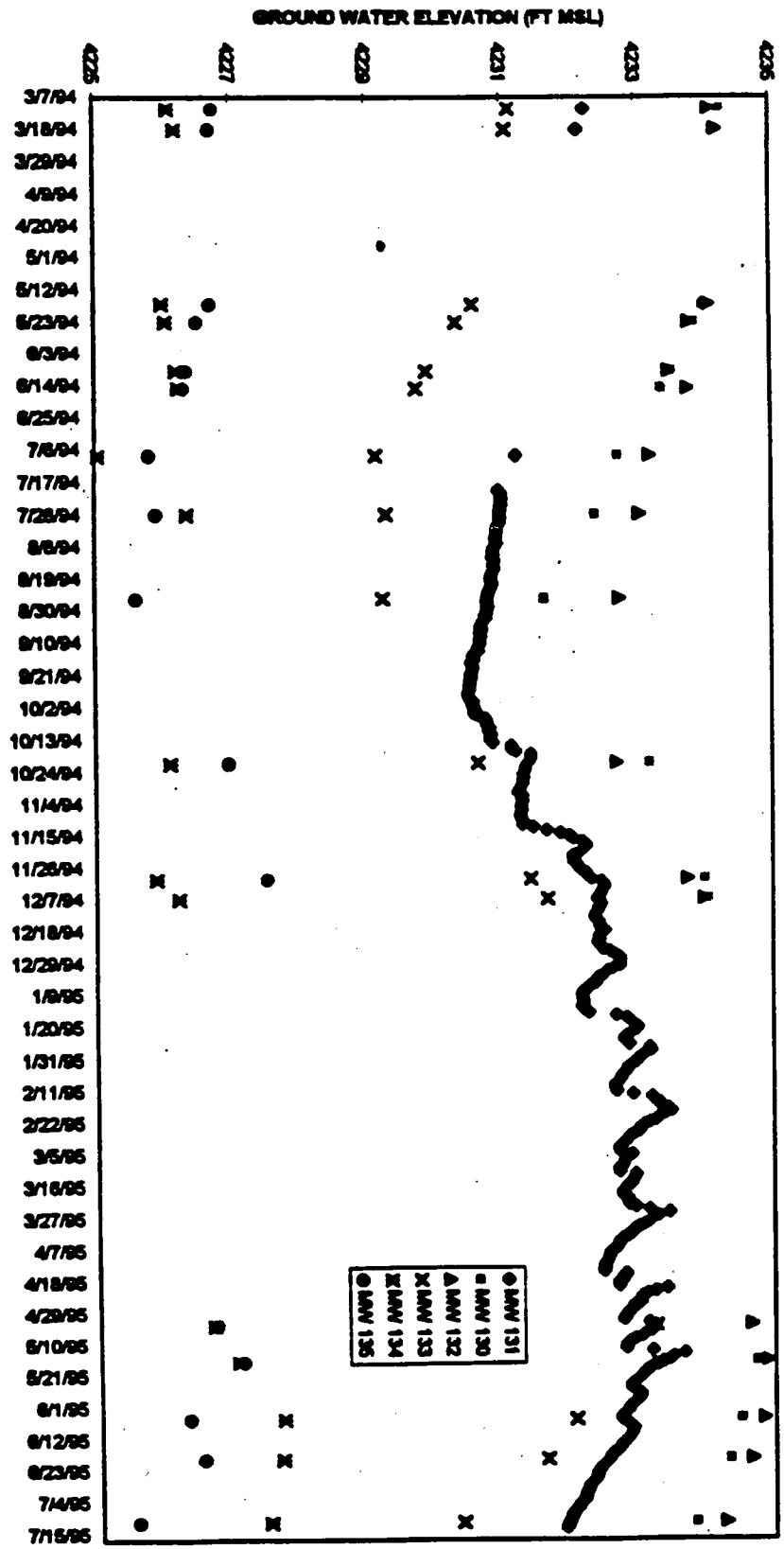


FIGURE 2
WATER LEVEL DATA, SALT LAKE CITY, VITRO PROCESSING SITE
(MARCH 1994 - JULY 1995)

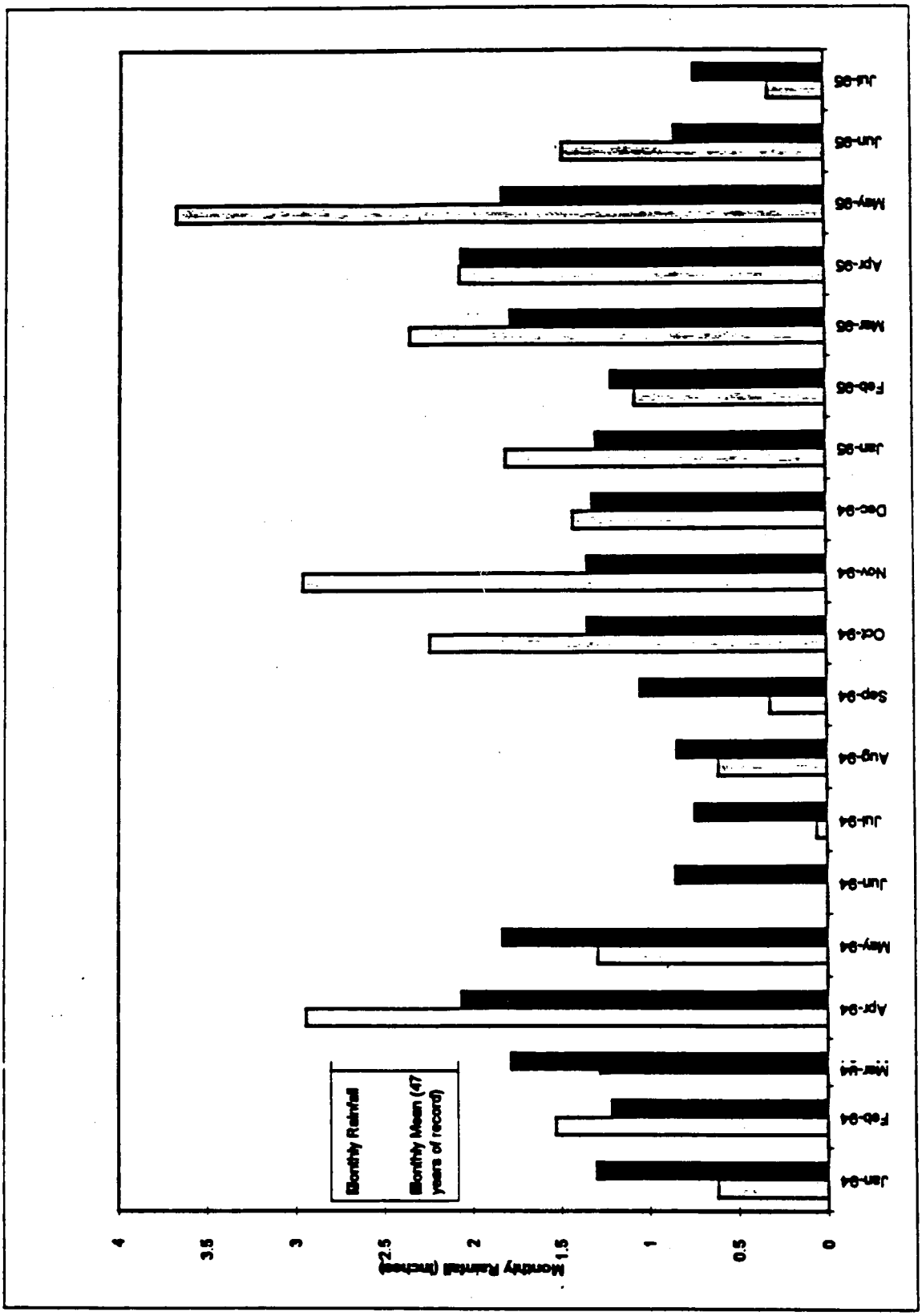


FIGURE 3
MONTHLY RAINFALL, JANUARY 1994 - JULY 1994
SALT LAKE CITY AIRPORT

MAC: SITE/SLC/VITROGWMON/FIGSHELL

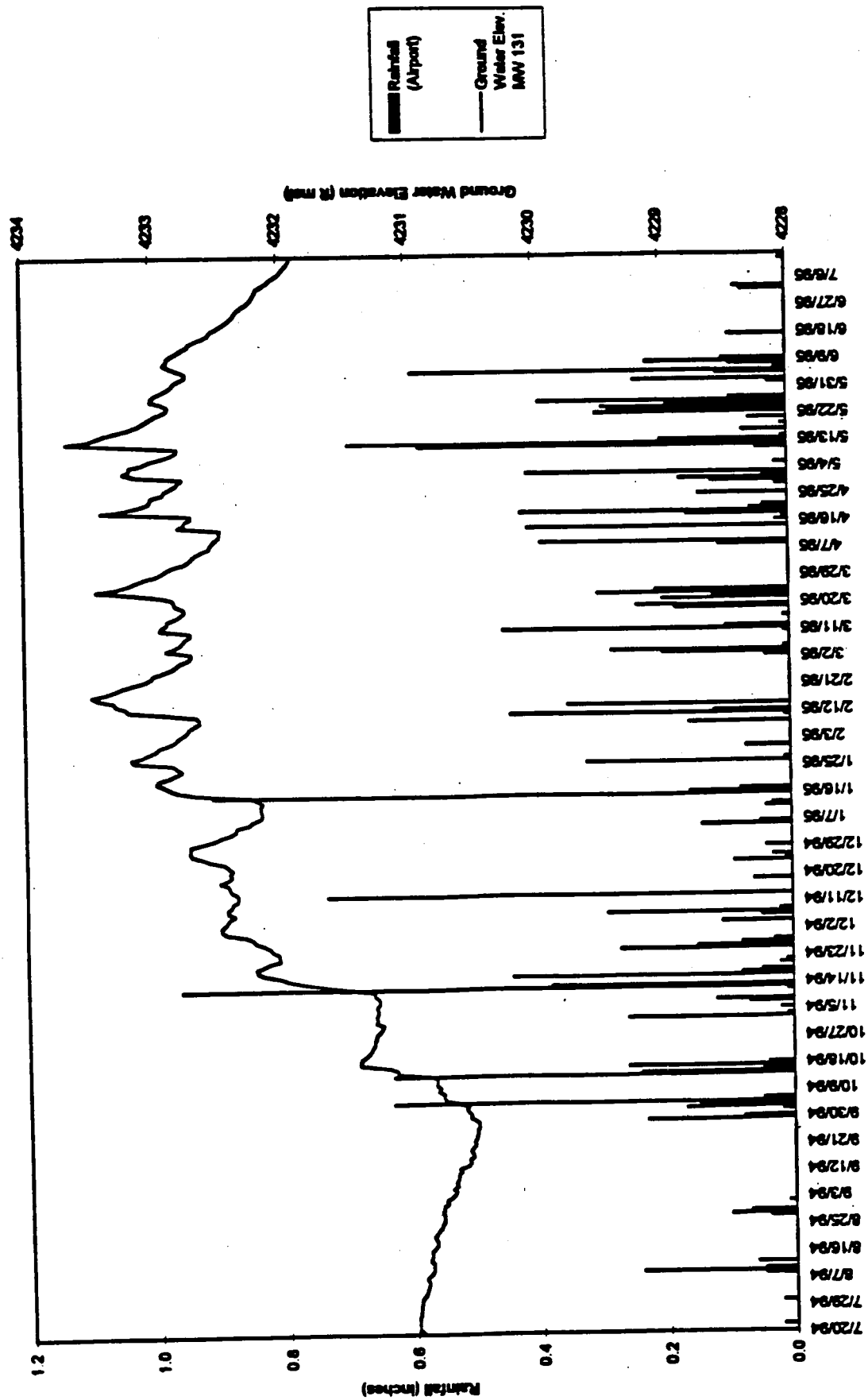


FIGURE 4
GROUND WATER ELEVATIONS AND DAILY RAINFALL AMOUNTS, SALT LAKE CITY, UTAH, VITRO PROCESSING SITE

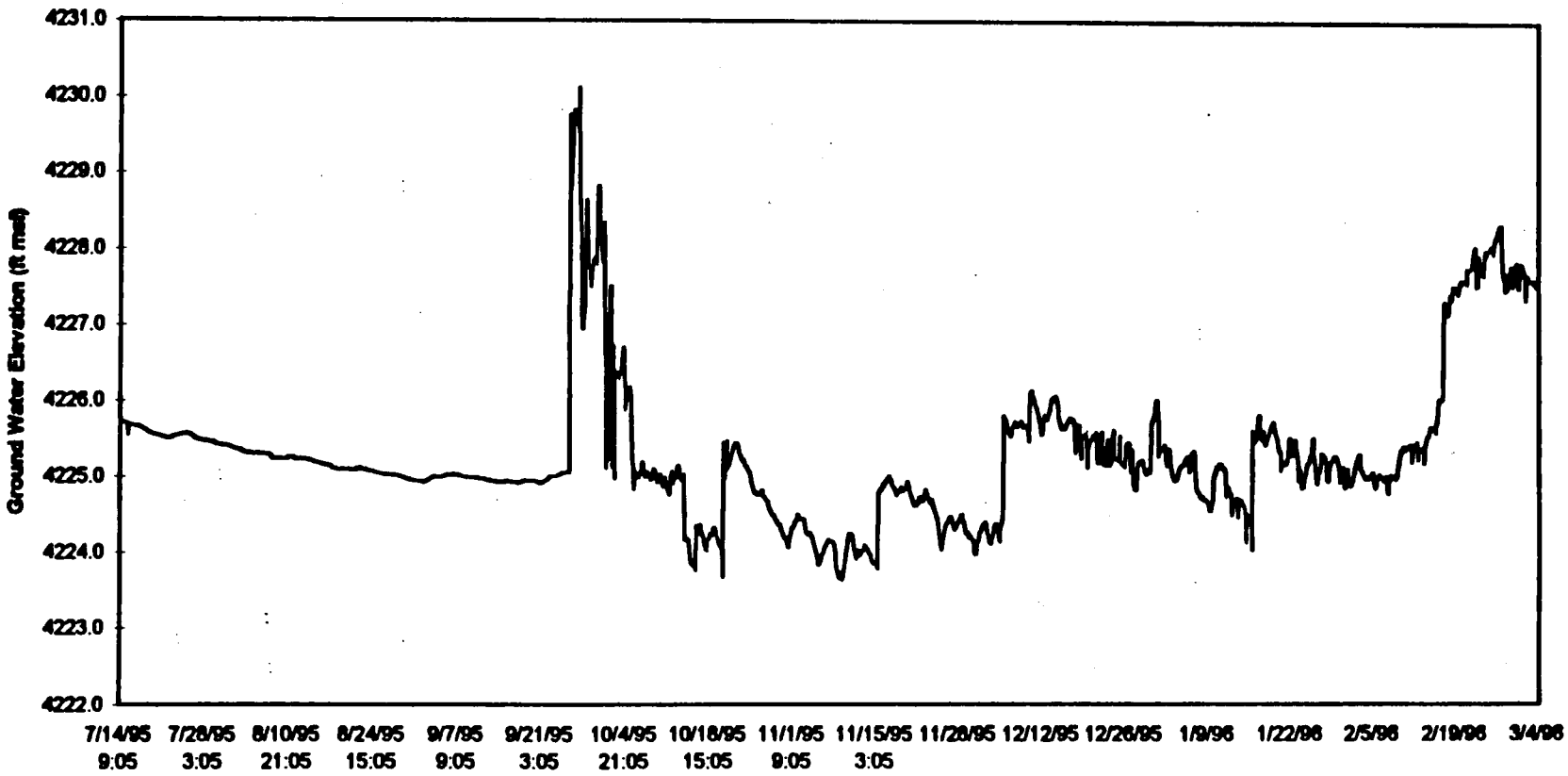


FIGURE 5
GROUND WATER ELEVATIONS IN MONITOR WELL 135
SALT LAKE CITY, UTAH, VITRO PROCESSING SITE

MAC: SITE/SLC/VITROGWMON/FIGSHELL

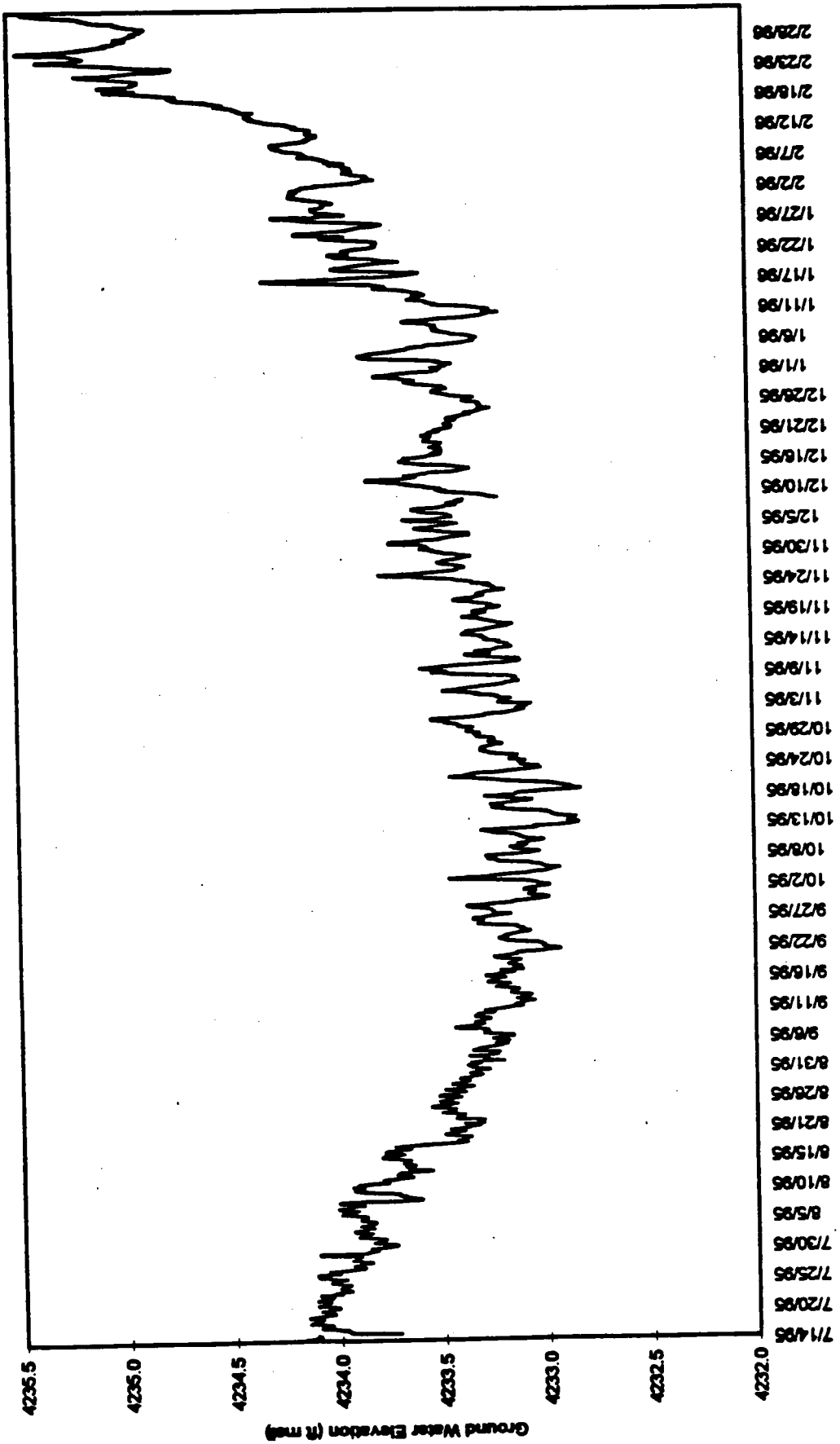


FIGURE 6
GROUND WATER ELEVATIONS IN MONITOR WELL 132
SALT LAKE CITY, UTAH, VITRO PROCESSING SITE

MAC: SITE/SLC/VITROGWMON/FIGSHELL

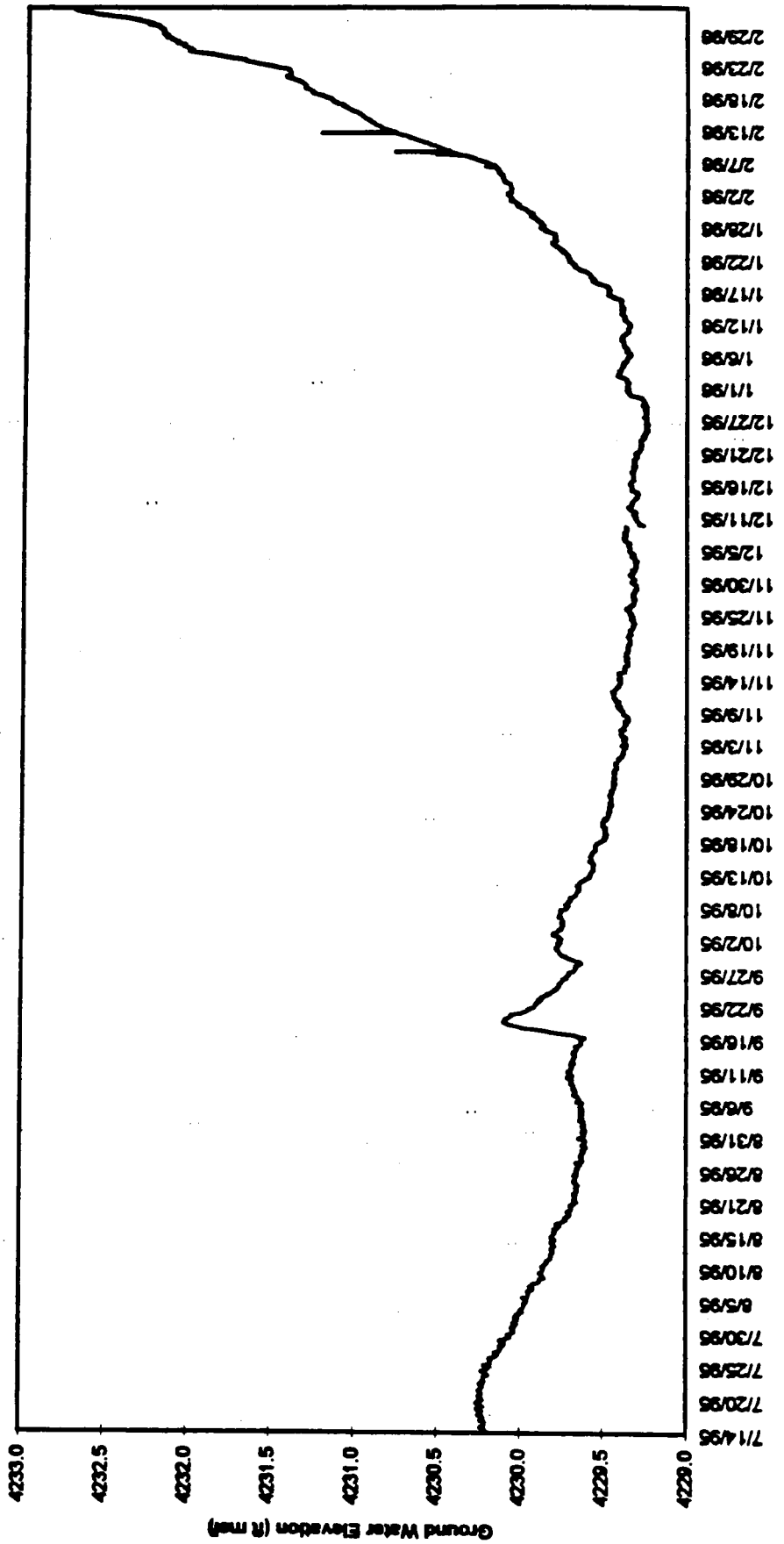


FIGURE 7
GROUND WATER ELEVATIONS IN MONITOR WELL 133
SALT LAKE CITY, UTAH, VITRO PROCESSING SITE

MAC: SITE/SLC/VITROGWMON/FIGSHELL

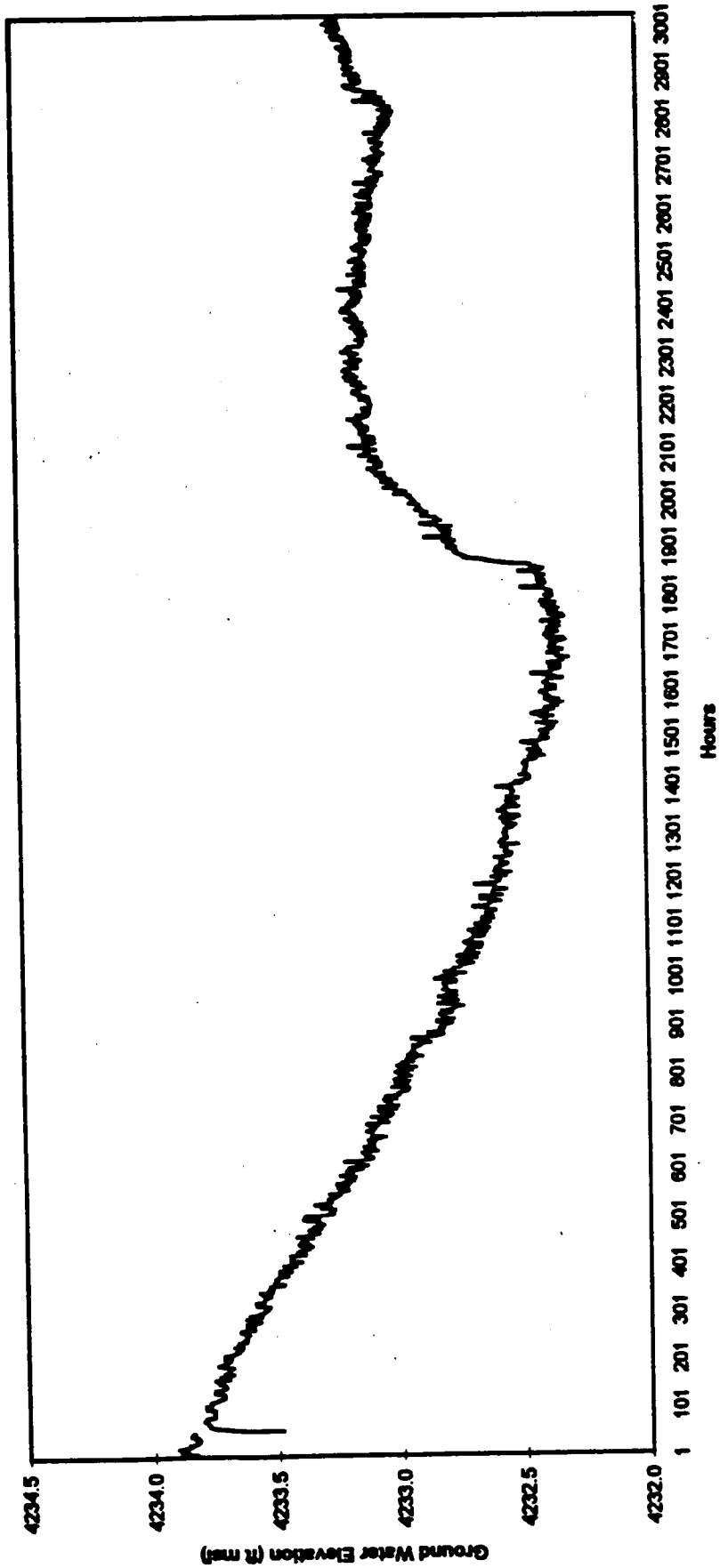


FIGURE 8
GROUND WATER ELEVATIONS IN MONITOR WELL 130
SALT LAKE CITY, UTAH, VITRO PROCESSING SITE

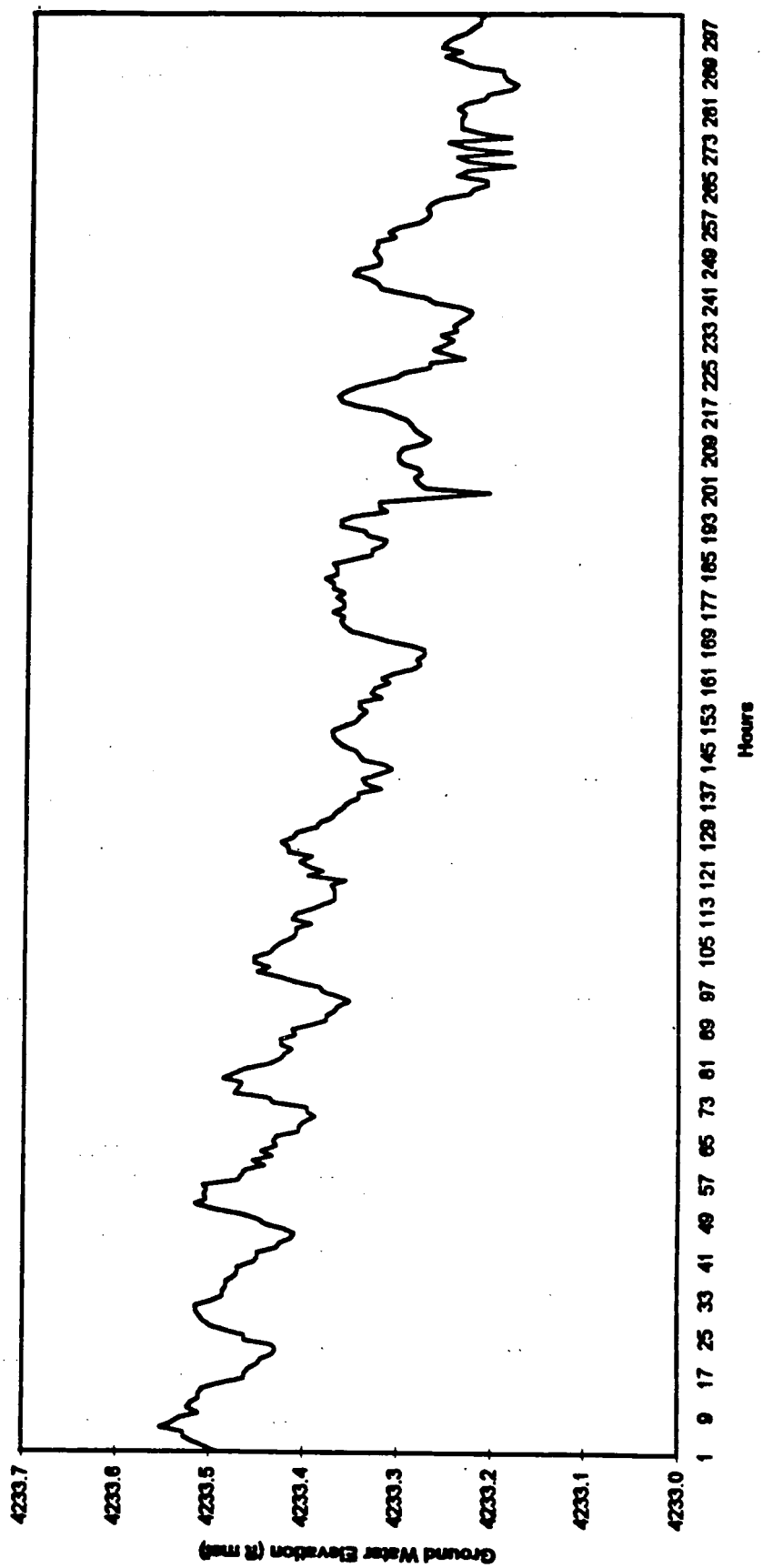
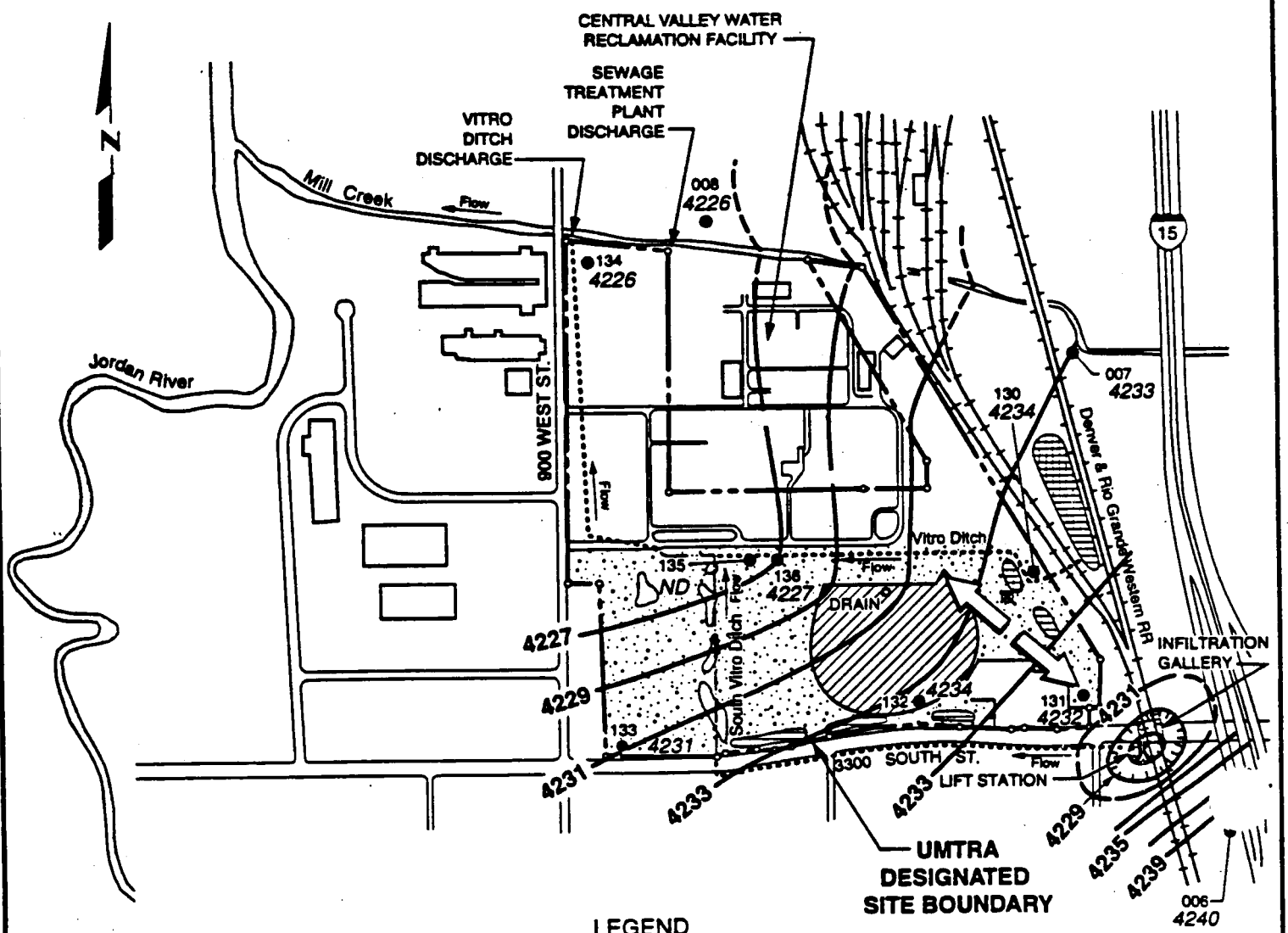


FIGURE 9
GROUND WATER ELEVATIONS IN MONITOR WELL 132
AUGUST 24 - SEPTEMBER 6, 1995
SALT LAKE CITY, UTAH, VITRO PROCESSING SITE

MAC: SITE/SLC/VITROGWMON/FIGSHELL



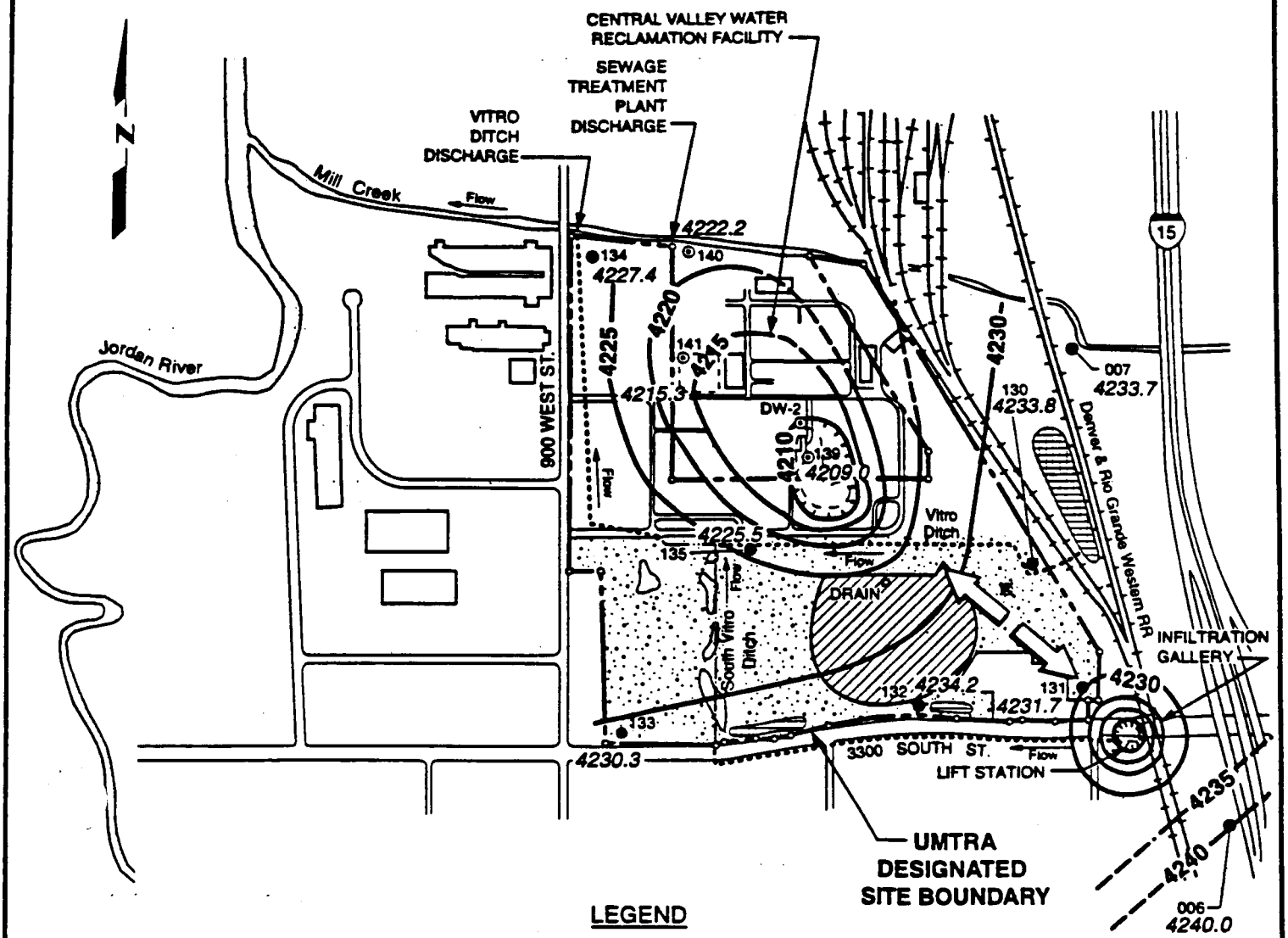
LEGEND

006	WELL NUMBER
●	MONITOR WELL LOCATION
— 4240	WATER TABLE ELEVATION (FT ABOVE MSL), DECEMBER 1994
ND	WATER TABLE ELEVATION NOT DETERMINED
—4231—	WATER TABLE ELEVATION (FT ABOVE MSL), DASHED WHERE INFERRED
	CLOSED DEPRESSION IN WATER TABLE
DW-2	DEWATERING WELL, CONSTRUCTION
	SHUT-IN MUNICIPAL SUPPLY WELL
	DIRECTION OF GROUND WATER FLOW
	PERENNIAL STREAM
	UNDERGROUND SECTIONS OF VITRO AND SOUTH VITRO DITCHES
	BUILDING
X	STORM SEWER SUMP PUMP
	PONDED WATER
	PROPOSED GOLF COURSE
	IRRIGATED DRIVING RANGE
	PROPOSED POND
	PAVED ROAD
15	INTERSTATE HIGHWAY

500 0 500 1000 FEET

150 0 150 300 METERS

FIGURE 10
GROUND WATER TABLE CONTOURS OF THE UNCONFINED AQUIFER
SALT LAKE CITY, UTAH, SITE (DECEMBER 1994)



LEGEND

134	WELL NUMBER
●	MONITOR WELL LOCATION
4227.4	WATER TABLE ELEVATION (FT ABOVE MSL), JULY 1995
—4230—	WATER TABLE ELEVATION (FT ABOVE MSL), DASHED WHERE INFERRED
	CLOSED DEPRESSION IN WATER TABLE
⊙	DEWATERING WELL, CONSTRUCTION
■	SHUT-IN MUNICIPAL SUPPLY WELL
	DIRECTION OF GROUND WATER FLOW
	PERENNIAL STREAM
	EXCAVATIONS
	UNDERGROUND SECTIONS OF VITRO AND SOUTH VITRO DITCHES
	BUILDING
	PONDED WATER
	PROPOSED GOLF COURSE
	IRRIGATED DRIVING RANGE
	PROPOSED POND
	PAVED ROAD
15	INTERSTATE HIGHWAY

NOTE: CONTOUR INTERVAL 5 FT.

500 0 500 1000 FEET

150 0 150 300 METERS

FIGURE 11
GROUND WATER TABLE CONTOURS OF THE UNCONFINED AQUIFER SALT LAKE CITY, UTAH, SITE (JULY 1995)

MAC: SITE/SLC/GWELEVMONREP/WATTBLE

Attachment F

JACOBS ENGINEERING GROUP INC., ALBUQUERQUE OPERATIONS

O: Sharon Arp, DOE Site Manager

THROUGH: Larry Pinkel, TAC Assistant Project Manager LP

FROM: Clyde Yancey, TAC Site Manager CY

DATE: August 4, 1993

SUBJECT: Salt Lake City Vitro Site - Groundwater Mound Resultant From Golf Course Irrigation
Contract No. DE-AC04-91AL62350

Attached are the results of the HELP Model analysis and the analytic model used to assess the impact of the development of the golf course on the former Vitro site. To summarize, a 3-foot mound is predicted for the Phase I development and a 5-foot mound for the Phase II development based on an average daily infiltration of 0.001 feet per day over the developed site. (See mound profiles, Figure 1).

The infiltration rate of 0.001 feet per day was used to arrive at a conservative estimate of the mound. The HELP Model gave a lower and upper bound range of 0.0015 to 0.0020 feet per day average infiltration rate. It is believed the HELP model predictions for infiltration rate are conservative for high rainfall/irrigation conditions as moisture is moved upward only within the user defined evaporation (root) zone.

The mound development does not appear to be significant until the Phase II development. It is recommended that the groundwater levels in the six on-site wells (wells 130 - 135) be continuously monitored with the use of downhole data loggers. The data collected would document the short- and long-term trends in response to the golf course development. This information is basic to understanding any potential impacts the golf course will have on the subsurface hydrology and groundwater chemistry in the site vicinity. A cost estimate for the installation and monitoring of the data loggers will be supplied upon request.

If you have any questions regarding this report, please do not hesitate to contact me.

CLY\LWP\lm
Attachment

cc w/attachment:
DMetzler, UMT PO

cc w/oattachment:
RNelson, TAC
JGibb, TAC
RBennett, TAC
RMeyers, TAC
EStorms, TAC
JSanchez, TAC
Document Control
SM File

lc-gwmo 08/03/93

JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

CALCULATION COVER SHEET

CALC NO. SLC-07-93-12-02-00 DISCIPLINE HYD NO. OF SHEETS 5

PROJECT: UMTRA

SITE: SALT LAKE CITY, UTAH
FORMER VITRO PROCESSING SITE

FEATURE: MOUND PREDICTION FROM GOLF COURSE DEVELOPMENT & ADDITIONAL IRRIGATION

SOURCES OF DATA:

1. DOE/AL-050130.0000 HYDROGEOLOGIC CHARACTERIZATION OF THE FORMER VITRO PROCESSING SITE, SALT LAKE CITY, UTAH. 1993
2. JACOBS CALC. NO. SLC-07-93-12-01-00 HELP MODEL-INFILTRATION

SOURCES OF FORMULAE & REFERENCES:

1. PHYSICAL & CHEMICAL HYDROGEOLOGY, DOMENICO, PATRICK A. SCHWARTZ, FRANKLIN W. JOHN WILEY & SONS, INC. 1990, p. 69
2. PRACTICAL ASPECTS OF GROUNDWATER MODELING, WALTON, WILLIAM C., NATIONAL WATER WELL ASSOCIATION, 1985, pp. 219, 220.

PRELIMINARY CALC. ☐ FINAL CALC. ☒ SUPERSEDES CALC. NO. _____

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
		Eric Sykes	7/16/93	[illegible]	7/19/93	RHB	7/19/93

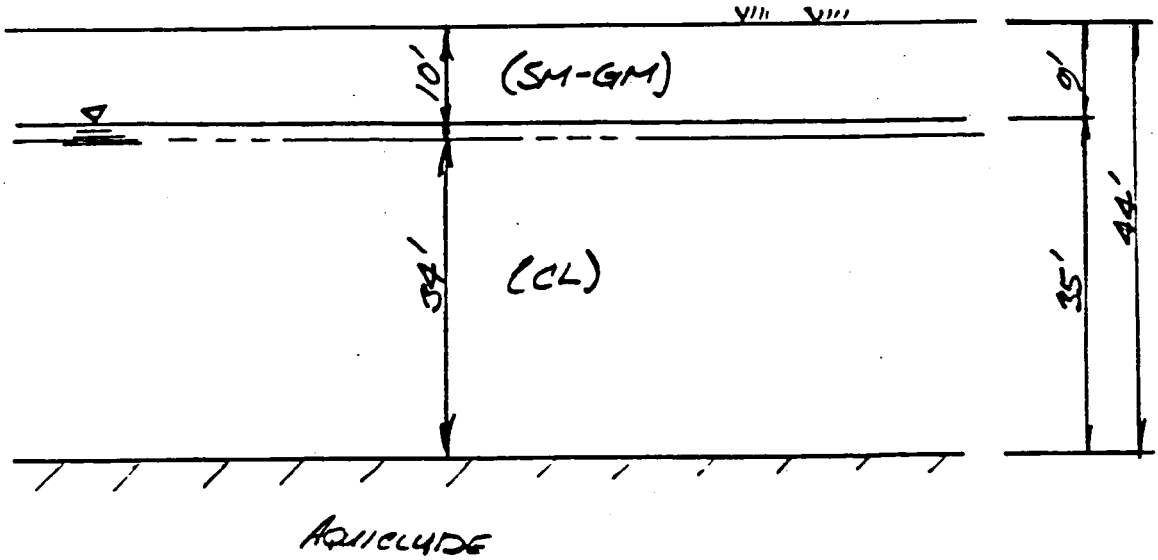
JEG-AL-ENG-51 (6/87)

JACOBS ENGINEERING

DATE 7/27/93 SUBJECT SLC-VITRO SITE SHEET NO. 1

BY RM CHKD. _____ MOUNDING OF UPPER AQUIFER JOB NO. _____

DETERMINE Kh FOR USE IN HANTUSH FORMULA



- SOLUTION BY HANTUSH ASSUMES UNIFORM MATERIAL IN AQUIFER AND ZONE OF MOUNDING
- ACTUAL CONDITION IS THAT ABOVE. LAYERED SYTEM MUST BE ACCOUNTED FOR.
- HOWEVER SINCE MOUND WILL OCCUR IN SILTY-GRAVEL LAYER, ITS CONDUCTIVITY SHOULD HAVE CONSIDERABLE, IF NOT GREATER, WEIGHT AS THE DRIVER OF THE MOUND.
- TO ACCOUNT FOR SILTY-GRAVEL LAYER USE WEIGHTED AVERAGE OF CONDUCTIVITIES. (REF. 1)

LAYER	Kh	THICK t	Kh(t)
(SM-GM)	*10 $\frac{FT}{DAY}$ ($4\times10^{-3}\frac{cm}{s}$)	10 FT	100 $\frac{FT^2}{DAY}$
(CL)	**0.5 $\frac{FT}{DAY}$ ($2\times10^{-4}\frac{cm}{s}$)	34 FT	17 $\frac{FT^2}{DAY}$

* ASSUMED VALUE - CONSISTENT w/ HELP MODEL VERTICAL CONDUCTIVITY FOR LAYER 2

** FROM PUMP TEST

Σ 117

$$\hat{K}_h = \frac{\Sigma K_h(t)}{\Sigma t} = \frac{117}{44} = 2.7 \frac{FT}{DAY}$$

Analytical solution to determine rise in the water table in response to recharge to the shallow aquifer at the Salt Lake City site.

An analytical solution was used to calculate the rise in the water table in the shallow unconfined aquifer in response to irrigation of the golf course. The rise of the water table in response to a vertically downward uniform rate of recharge is described by the following equations (Hantush, 1967)

$$\text{when } t \geq \frac{r^2 S_y}{2P_h \bar{m}} \quad \text{for } r \leq R_m$$

$$h_m = \left\{ \frac{W_m R_m^2}{2P_h} \left[W(u_o) - \left(\frac{r}{R_m}\right)^2 \exp(-u_o) + \frac{1}{u_o}(1 - e^{-u_o}) \right] + h_i^2 \right\}^{1/2}$$

$$\text{when } t \geq \frac{r^2 S_y}{2P_h \bar{m}} \quad \text{for } r \geq R_m$$

$$h_m = \left\{ \frac{W_m R_m^2}{2P_h} \left[W(u) + 0.5\, u_0 \exp(-u) \right] + h_i^2 \right\}^{1/2}$$

where

$$u_o = \frac{R_m^2 S_y}{4P_h \bar{m} t} \quad \text{(dimensionless)}$$

$$u = \frac{r_m^2 S_y}{4P_h \bar{m} t} \quad \text{(dimensionless)}$$

and

R_m = radius of circular recharge area (L)
W_m = recharge rate (LT^{-1})
$\bar{m}$ = 0.5 (h_i + h_m) (L)
h_i = initial height of the water table above the aquiclude (L)
h_m = height of the water table above aquiclude with recharge (L)
P_h = horizontal hydraulic conductivity (LT^{-1})
S_y = specific yield (dimensionless)

Analytical solution to calculate rise in watertable (hm - hi) after 2500 days of irrigation for selected distances(r) from center of golf course.

PHASE 1 INPUT PARAMETERS
Hydraulic conductivity (Ph) = 2.7 ft/day
Recharge rate (Wm) = 0.001 ft/day
Specific Yield (Sy) = 0.2
Initial water level (hi) above confining layer = 35 ft
Radius of golf course (area to be irrigated) = 630 ft (28 acres)

m (ft)	uo	u	W(u) or W(uo)	hm (ft)	r (ft)	hm - hi (ft)
36.5	0.0805		2.03	38.01	1.00	3.01
36.0	0.0817		2.00	37.42	500.00	2.42
35.9	0.0819		2.00	37.08	630.00	2.08
35.6	0.0826	0.2081	1.18	36.25	1000.00	1.25
35.4	0.0831	0.4708	0.60	35.66	1500.00	0.66
35.2	0.0835	0.8418	0.29	35.34	2000.00	0.34
35.0	0.0840	1.3228	0.14	35.19	2500.00	0.19

PHASE 2 INPUT PARAMETERS
Hydraulic conductivity (Ph) = 2.7 ft/day
Re[illegible]rge rate (Wm) = 0.001 ft/day
S[illegible]ic Yield (Sy) = 0.2
I[illegible]al water level (hi) above confining layer = 35 ft
Radius of golf course (area to be irrigated) = 940 ft (64 acres)

m (ft)	uo	u	W(u) or W(uo)	hm (ft)	r (ft)	hm - hi (ft)
37.5	0.1745		1.36	39.97	1.00	4.97
37.2	0.1759		1.33	39.42	500.00	4.42
36.5	0.1793		1.31	38.11	940.00	3.11
36.4	0.1798	0.2035	1.22	37.90	1000.00	2.90
35.8	0.1828	0.4655	0.61	36.53	1500.00	1.53
35.4	0.1849	0.8370	0.29	35.76	2000.00	0.76
35.1	0.1865	1.3190	0.14	35.38	2500.00	0.38

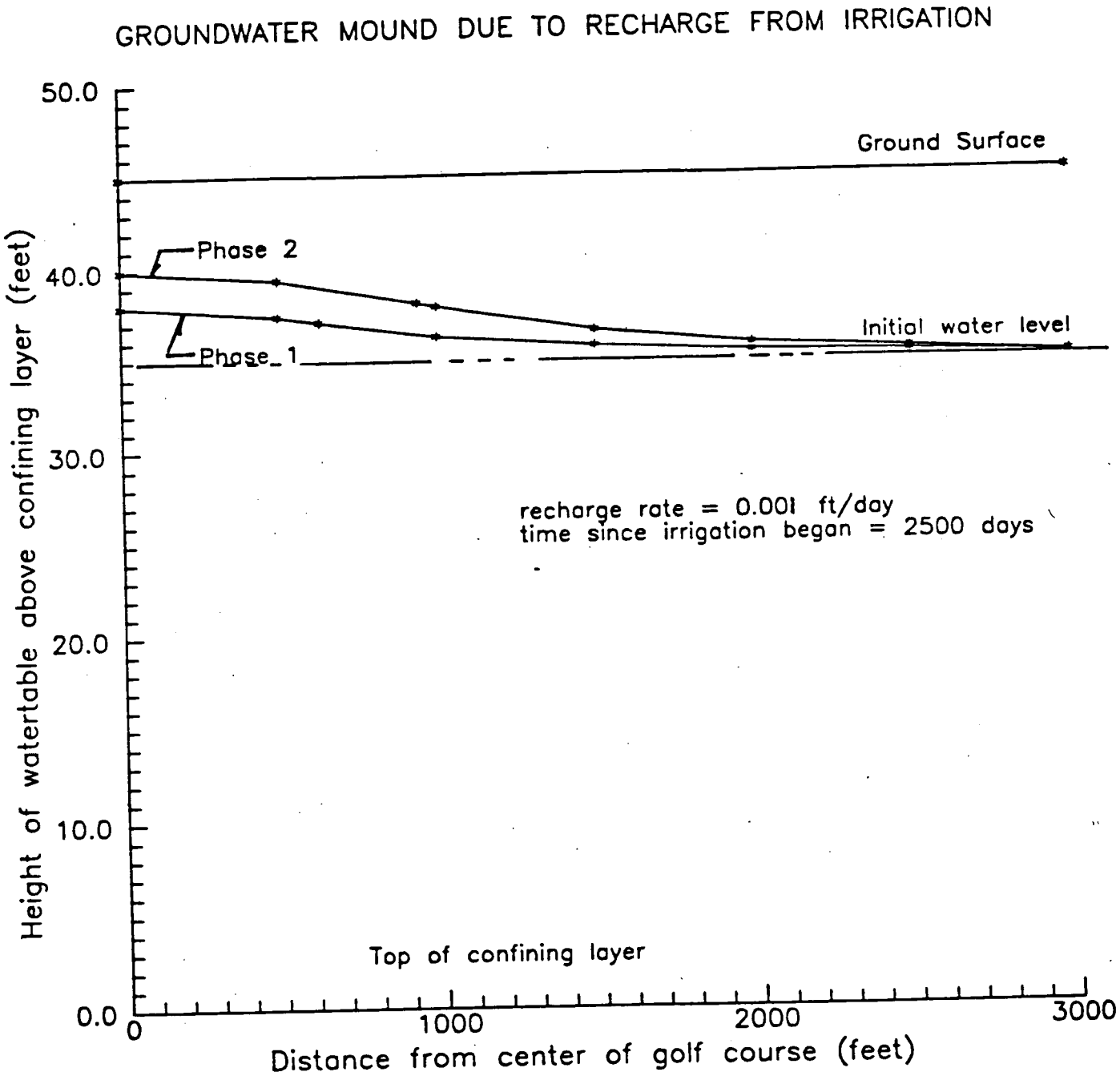

GROUNDWATER MOUND DUE TO RECHARGE FROM IRRIGATION
Ground Surface
Phase 2
Initial water level
Phase 1
recharge rate = 0.001 ft/day
time since irrigation began = 2500 days
Top of confining layer
Height of watertable above confining layer (feet)
50.0
40.0
30.0
20.0
10.0
0.0
0
1000
2000
3000
Distance from center of golf course (feet)

FIGURE 1

****

MONTHLY TOTALS FOR YEAR 76

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	0.63	1.90	1.90	5.22	8.74	8.74
	9.30	8.57	7.66	4.58	0.03	0.08
RUNOFF (INCHES)	0.000	0.000	0.000	0.074	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	1.176	2.066	1.956	3.288	7.929	9.707
(INCHES)	8.601	7.905	5.723	2.639	0.976	0.087
PERCOLATION FROM	0.6698	0.4721	0.4058	0.3241	0.3198	0.3709
LAYER 3 (INCHES)	0.3690	0.3183	0.2838	1.1466	1.4795	0.8839

****

****

ANNUAL TOTALS FOR YEAR 76

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	57.35	5973957.	100.00
RUNOFF	0.074	7697.	0.13
EVAPOTRANSPIRATION	52.051	5422019.	90.76
PERCOLATION FROM LAYER 3	7.0435	733702.	12.28
CHANGE IN WATER STORAGE	-1.819	-189459.	-3.17
SOIL WATER AT START OF YEAR	25.75	2682062.	
SOIL WATER AT END OF YEAR	24.20	2520563.	
SNOW WATER AT START OF YEAR	0.27	27960.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	-2.	0.00

****

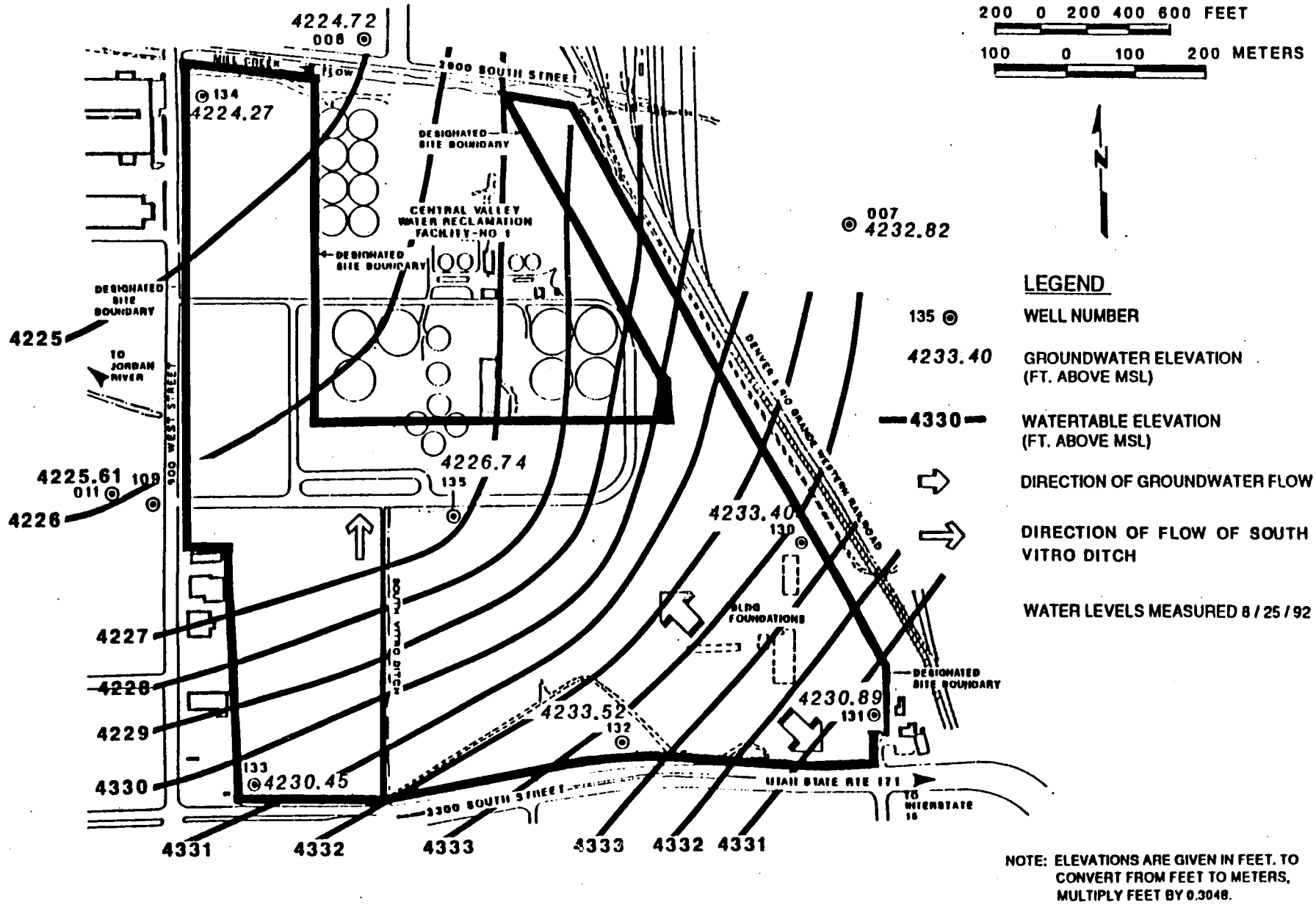


FIGURE 2
WATER TABLE SURFACE OF THE UNCONFINED AQUIFER
SALT LAKE CITY, UTAH SITE

JACOBS ENGINEERING GROUP INC.
ALBUQUERQUE OPERATIONS

CALCULATION COVER SHEET

CALC NO. SLC-07-93-12-01 00 - DISCIPLINE CIVIL/GEOTECH NO. OF SHEETS _____

PROJECT: UMTRA

SITE: SALT LAKE CITY, UTAH
FORMER VITRO PROCESSING SITE

FEATURE: HELP MODEL - INFILTRATION ANALYSIS

SOURCES OF DATA:

1. DOE/AL-050130.0000
   HYDROGEOLOGIC CHARACTERIZATION OF THE FORMER VITRO PROCESSING SITE, SALT LAKE CITY, UTAH. 1993
2. THE SEAR-BROWN GROUP, SALT LAKE CITY, UTAH

SOURCES OF FORMULAE & REFERENCES:

1. EPA THE HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE (HELP), VOL. II, JUNE 1984

PRELIMINARY CALC. ☐ FINAL CALC. ☒ SUPERSEDES CALC. NO. _____

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
		Bob Meyers	7/6/93	[illegible]	7/14/93	[illegible]	7/16/93

Salt Lake City - Former Vitro Processing Site
Infiltration Analysis Utilizing HELP Model

1. Background

Reference is made to the "Hydrogeologic Characterization of the Former Vitro Processing Site" dated January 1993 (Reference 1) for background concerning the hydrogeology, hydraulic and soil properties, and groundwater quality at the site.

The remedial action at the Vitro site was completed in 1987. The owner of the site, the CVWRF, is currently proceeding with development of the southern end of the site in two phases with a golf practice range being developed in phase I and a separate par 3 golf course in phase II. The phase I development will result in approximately 28 acres of irrigated grass cover. Phase II will add another 36 acres of irrigated grass cover.

2. Problem Statement

A contaminant plume remains in the upper unconfined aquifer due to the uranium processing activity and tailings leachates and is migrating in a west-northwestern direction from the site along the hydraulic gradient of the upper aquifer. The location of the proposed golf courses are hydraulically upgradient of the contaminant plume at the southern end of the processing site. Therefore an evaluation of the increased infiltration into the upper aquifer due to the irrigation of the courses is required to assess the potential influence of the increased infiltration on the contaminant plume.

The Hydrologic Evaluation of Landfill Performance (HELP) one dimensional model, developed specifically by the Waterways Experiment Station of the Army Corps of Engineers for use at RCRA sites, is useful as a general model for simulating the hydrologic performance at waste disposal sites. The HELP model was utilized for the estimation of increased infiltration to the upper aquifer due to the development of the irrigated golf courses.

3. Model Development

For the former Vitro processing site, models were developed for both the undeveloped and developed conditions. A three layer system was assumed based on the soil boring profiles reported in reference 1 and the description of the soil improvement for the establishment of the turf provided by the developer's course design professional, The Sear-Brown Group of Salt Lake City. In the vicinity of the phase I golf course, the depth to the phreatic surface of the upper unconfined aquifer is approximately 10 feet.

The typical section used in the HELP model is shown in Figure 1. The upper layer (Layer 1) of the model is defined as the vegetative layer and is assumed 6 inches thick for both the developed and undeveloped site. This vegetative layer was assigned different soil, evapotranspiration and hydraulic properties for the two conditions. Layer 2 below the vegetative layer is 96 inches thick and consists of the silty sand and

gravel fill material that was placed during the remediation activities. All properties for this layer remained constant for the comparison between the developed and undeveloped site. Layer 3 directly above the phreatic surface of the aquifer is a native silty clay and is the same layer contacting the aquifer. A depth of 20 inches was assumed and again all properties of this layer remained constant for the developed and undeveloped site comparisons.

A parameter study was also performed on the developed site model to evaluate the sensitivity of the model to the possible ranges of saturated hydraulic conductivity, evaporative zone depths and leaf area indices. The rational behind selection of input parameters are described below.

Soil Properties

Since no soil lab testing was performed on the boring samples during the 1992 characterization (reference 1), soil classifications in the Uniform Soil Classification System (USCS) were determined by visual assessment. Soil properties utilized were taken from default values in the HELP model based on the soil classification assigned. The developer's design professional reported that the soil preparation for the soil would involve blading in 3 inches of dried sludge from the CVWRF treatment plant. For the prepared soil, Layer 1 was assumed a high plasticity silt (MH). Layer 2 is reported as a silty sand and gravel (GM) in reference 1. In the HELP model, default values are provided for soils ranging from a poorly graded gravel (GP), well graded sand (SW) and silty sand (SM). The silty sand parameters were selected with upper bound values for a silty sand (very coarse silty sand). Layer 3 is reported as a silty clay (CL) and the default parameters form the HELP program were used for this classification. These default values for the soil properties are as shown in the individual computer runs in Appendix B.

Parameter sensitivity was performed by varying the saturated hydraulic conductivities of layers 2 and 3. Layer 3, the silty clay was varied by assuming a more stiff clay than the default values. This was accomplished by assigning the clay as being compacted which decreases the hydraulic conductivity by a factor of 20 and the drainable water (porosity minus wilting point or residual water content) are reduced by 25 percent. Layer 2 was varied by increasing the hydraulic conductivity by a factor of 2 which would represent a more gravelly silty sand.

Climatological Data

Climatological data includes daily rainfall records, normal mean monthly temperatures, solar radiation, leaf area indices and winter cover factors. Default weather data for Salt Lake City provided in the HELP code was utilized. Default weather data are from record years 1974 through 1978. The evaporative zone depth (EZD) is a function of the quality of the vegetative cover and the leaf area index (LAI). For the developed site, the irrigated grass cover will allow use of the maximum EZD recommended for the assumed vegetative cover. The default parameters are as shown in the individual computer runs in Appendix B.

6.0 References

DOE (U.S. Department of Energy), 1993. Hydrogeologic Characterization of the Former Vitro Processing Site, Salt Lake City, Utah, Report No. DOE/AL-050130.0000, prepared by the U.S. Department of Energy UMTRA Office, Albuquerque Operations Office, Albuquerque, New Mexico.

EPA (U.S. Environmental Protection Agency), 1984. The Hydrologic Evaluation of Landfill Performance (HELP), Vol II, June 1984.

The irrigation of the developed site was modeled by superimposing the projected irrigation schedule as provided by the developer's design professional over the record rainfall data for Salt Lake City. The projected irrigation schedule is specified at 1 3/4 inches per week which is applied at a uniform application of 1/4 inches per day. The irrigation rate of 1/4 inch per day was begun on day 111 of each yearly rainfall record and ended on day 290, which corresponds closely to the growing season for Salt Lake City.

Parameter sensitivity was performed by varying the LAI corresponding to the quality of the grass cover for the developed site. The default values for the LAI for an excellent grass cover and a good grass cover were used. The EZD was varied to a minimum of 18 inches for the two cases of grass cover used in the parameter sensitivity analysis.

Surface Runoff

The surface runoff coefficient is based on Soil Conservation Service Number method. Default values in the HELP code are based on the vegetative cover and the leaf area index.

Parameter sensitivity corresponded to the variation in the assumption in the quality of the grass cover.

4. Summary of Results

For comparison purposes of individual runs of the HELP model for the developed and undeveloped site as well as the parameter sensitivity analysis, the average annual infiltration total for the five year record was used. The HELP model analysis using the initial default parameters for the developed site as described above (default soil parameters, excellent grass cover, EZD of 48 inches, LAI of 5), resulted in an average annual infiltration of 7.35 inches over the five year record.

The sensitivity analysis was performed for the parameters described above. The lower bound of the sensitivity analysis resulted in an average annual infiltration of 7.25 inches over the five year record for the case where all parameters are as in the initial run except the layer 3 silty clay was input as a stiff clay. The upper bound of the sensitivity analysis resulted in an average annual infiltration of 9.39 inches over the five year record for the case where all parameters are as in the initial run except the layer 2 was treated as a silty sand with more gravel and the EZD was defined as 18 inches. All other combinations of the parameter variations resulted in average annual values between the 7.25 inches and 9.39 inches.

Results are presented graphically in Figures 2 through 8 in Appendix A. The upper bound parameter output file was used to generate these figures. Figures 2 and 3 compare the infiltration rate in inches per day over a one year period for the developed and undeveloped sites respectively. The record year of 1977 gave the peak infiltration

rate per day of close to 1/8 inch per day (Figure 2). There is a 6 month lag between the initiation of the irrigation period and the time to peak of the infiltration rate. The overall annual infiltration is 11.70 inches for the developed site. This infiltration is close to 20 percent of the total rainfall and irrigation of 62.67 inches. Figure 3 compares the same record year for the undeveloped site. The infiltration rate per day is an order of magnitude lower than for the developed site at less than 0.005 inches per day. The net increase in infiltration over the record year of 1977 is 10.94 inches, (the difference between the developed and undeveloped site). This net increase value is reported in Figure 8 along with the remaining four record years.

Figures 4 and 5 compare the developed and undeveloped site respectively on a monthly basis over the entire five year record period. Specific values of the monthly rainfall and/or irrigation monthly rates may be found in the output file in Appendix B for the upper bound parameter result. Again, the lag in the peak infiltration into the aquifer can be seen as well as an order of magnitude increase in the infiltration into the aquifer as a result of the development.

Figures 6 and 7 provide the yearly totals for both rainfall and/or irrigation with the yearly totals for the resulting infiltration for all five record years. The differences between the developed and undeveloped site of the infiltration totals provide the net increase in infiltration per year and are reported in Figure 8.

5. Conclusion and Recommendations

On the basis of the HELP model results, there is a significant increase in the infiltration to the upper aquifer over the areas of the planned phase I and phase II developments due to the scheduled irrigation reported by the developer's designer. The increase in infiltration rate to the upper aquifer is predicted to be an order of magnitude higher than the existing undeveloped conditions of the site. Total net increase in infiltration to the upper aquifer on an annual basis ranges from 6 to 11 inches per year. Over the surface area of the developed site, this may result in a localized slug of water upgradient of the vitro contaminant plume on the order of 50 acre-feet per year for the fully developed site.

These results may be used in estimating the influence of the increased infiltration on the plume by analytic means or for future groundwater model development. Results should be verified through additional site characterization after development is complete. Such characterization must be accompanied by accurate rainfall and irrigation records.

Results presented in this HELP model development are sensitive to input parameters. Observational results may vary significantly due to variations in actual soil parameters, climatological conditions and irrigation application schedules.

Salt Lake City - Vitro Site

Infiltration Undeveloped Site

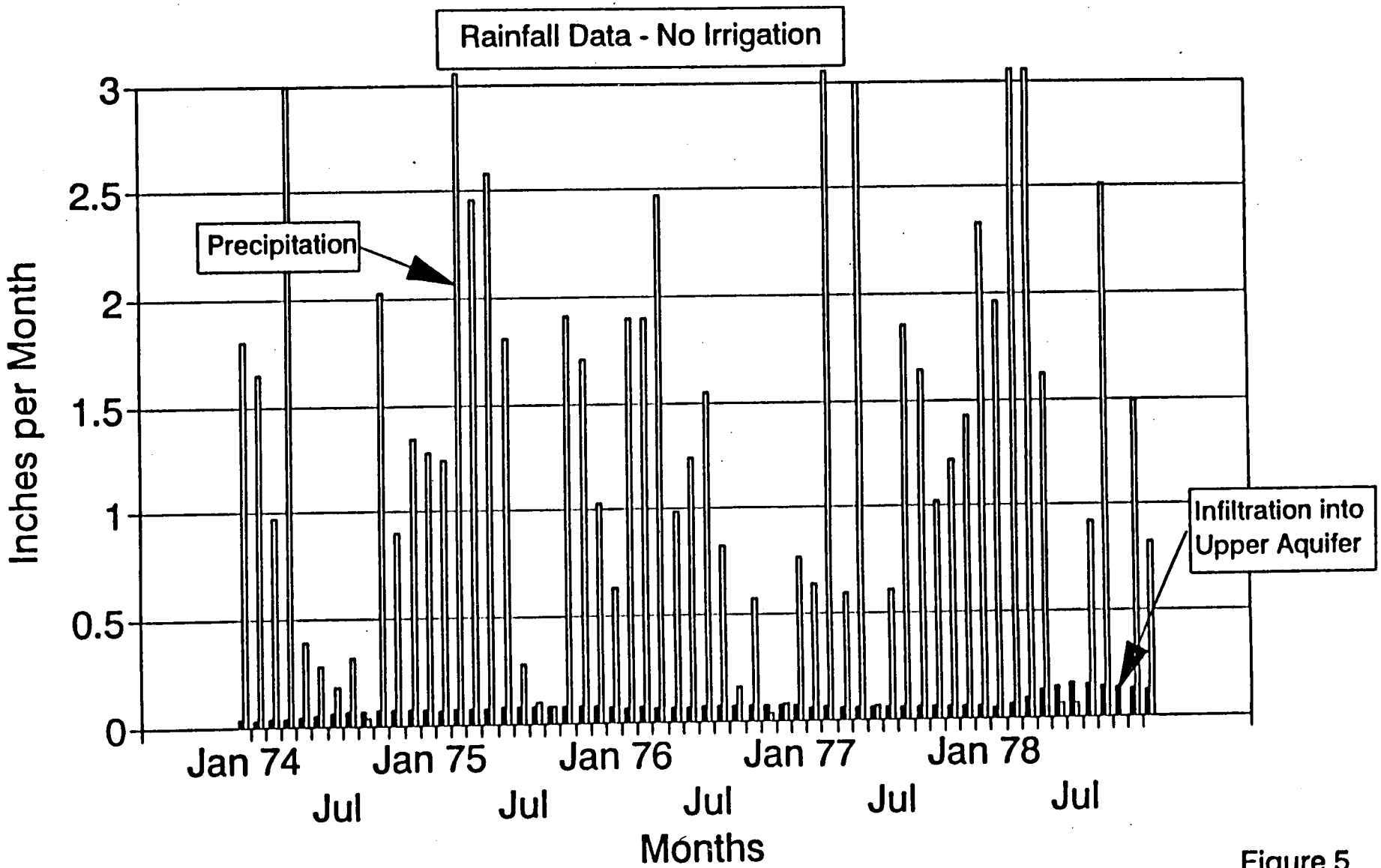


Figure 5

C:\DAT\HELP\BAR5NR.WQ1

Salt Lake City - Vitro Site

Infiltration w/ Golf Course Irrigation

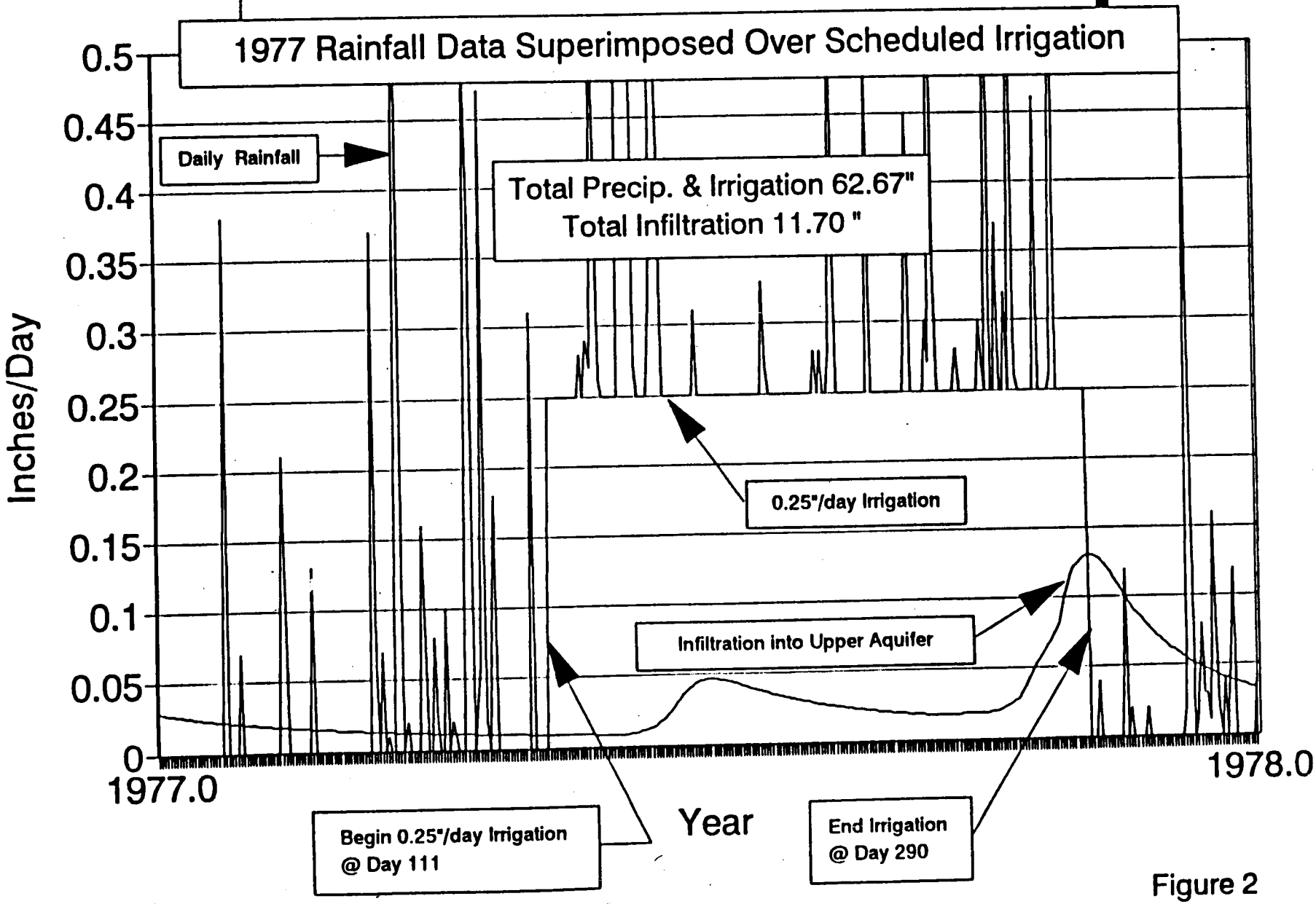


Figure 2

T\HELP\SL1Y.WQ1

Appendix A

Salt Lake City - Vitro Site

Infiltration w/ Golf Course Irrigation

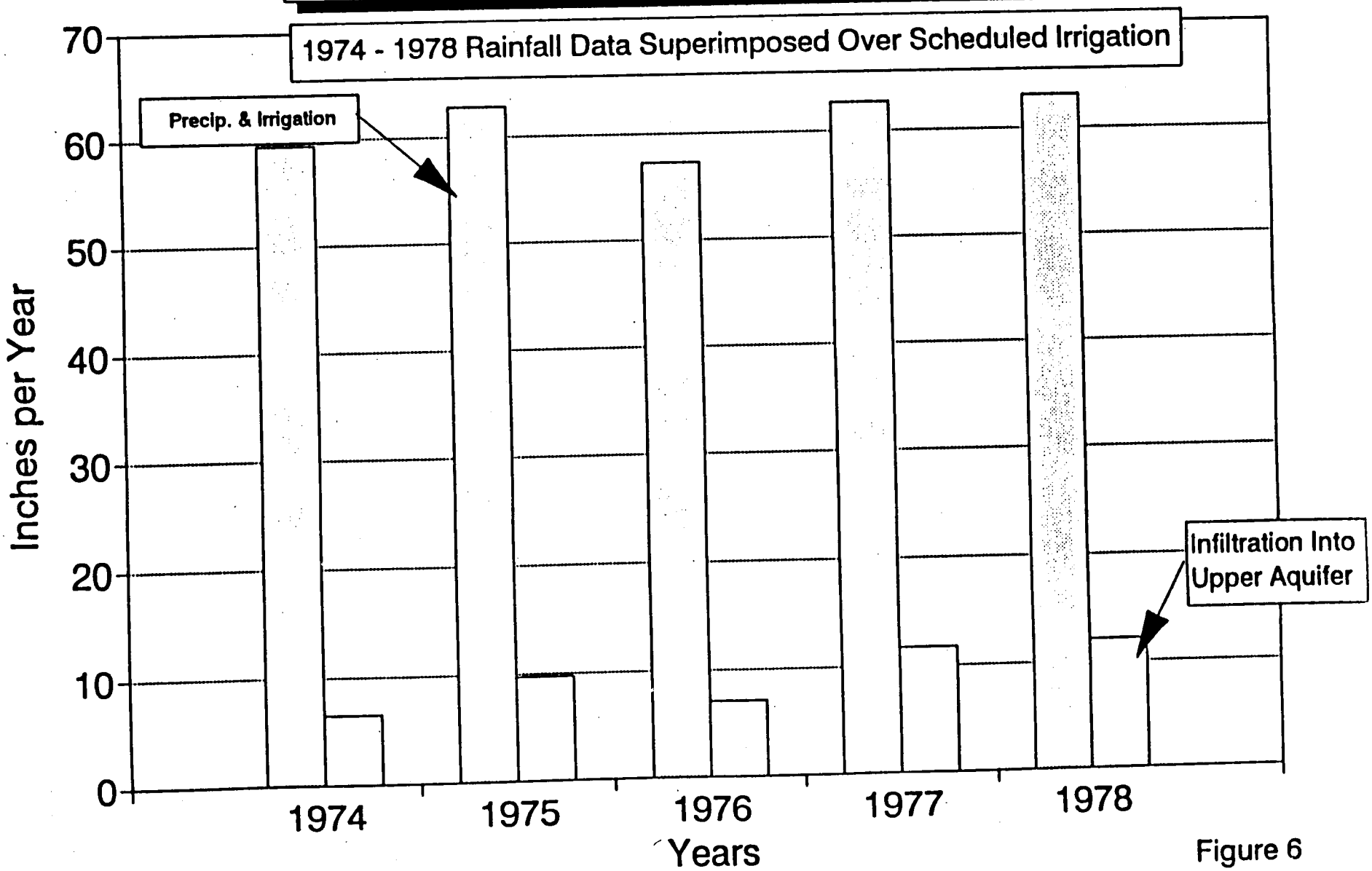


Figure 6

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Salt Lake City - Vitro Site

Soil Layer Lithology in HELP Model

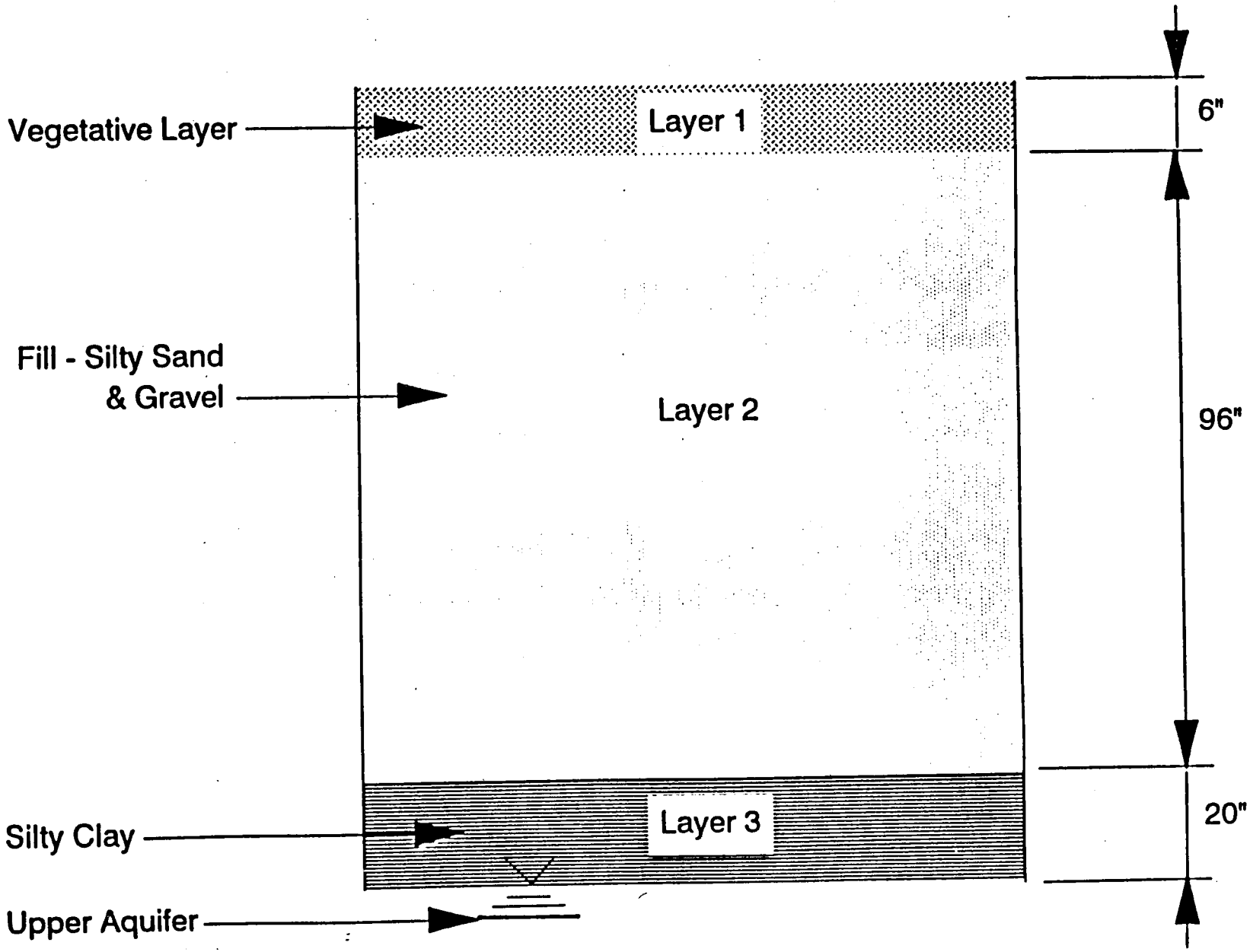


Figure 1

Salt Lake City - Vitro Site

Infiltration w/ No Irrigation

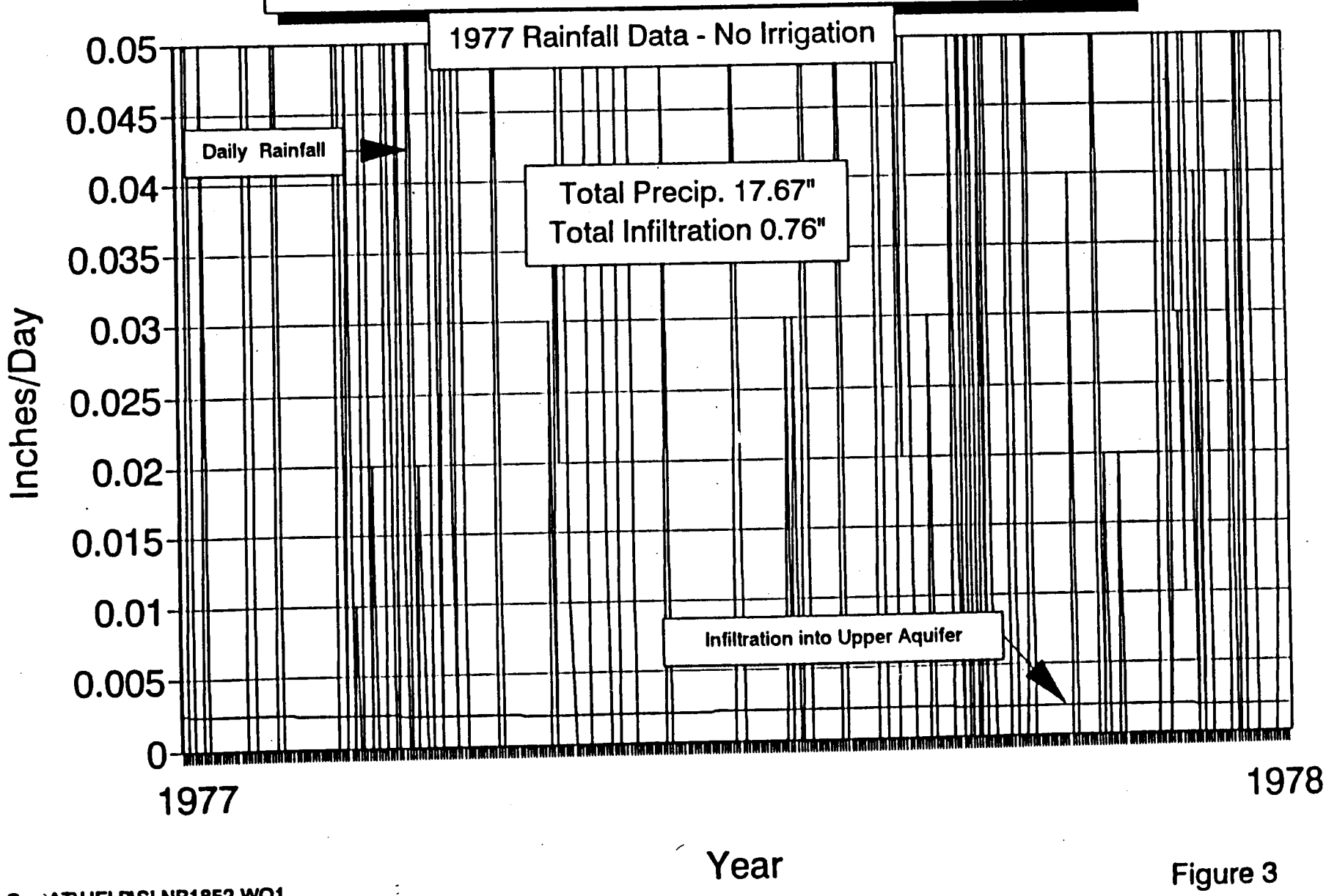


Figure 3

AT\HELP\SLNR1852.WQ1

Salt Lake City - Vitro Site

Infiltration w/ Golf Course Irrigation

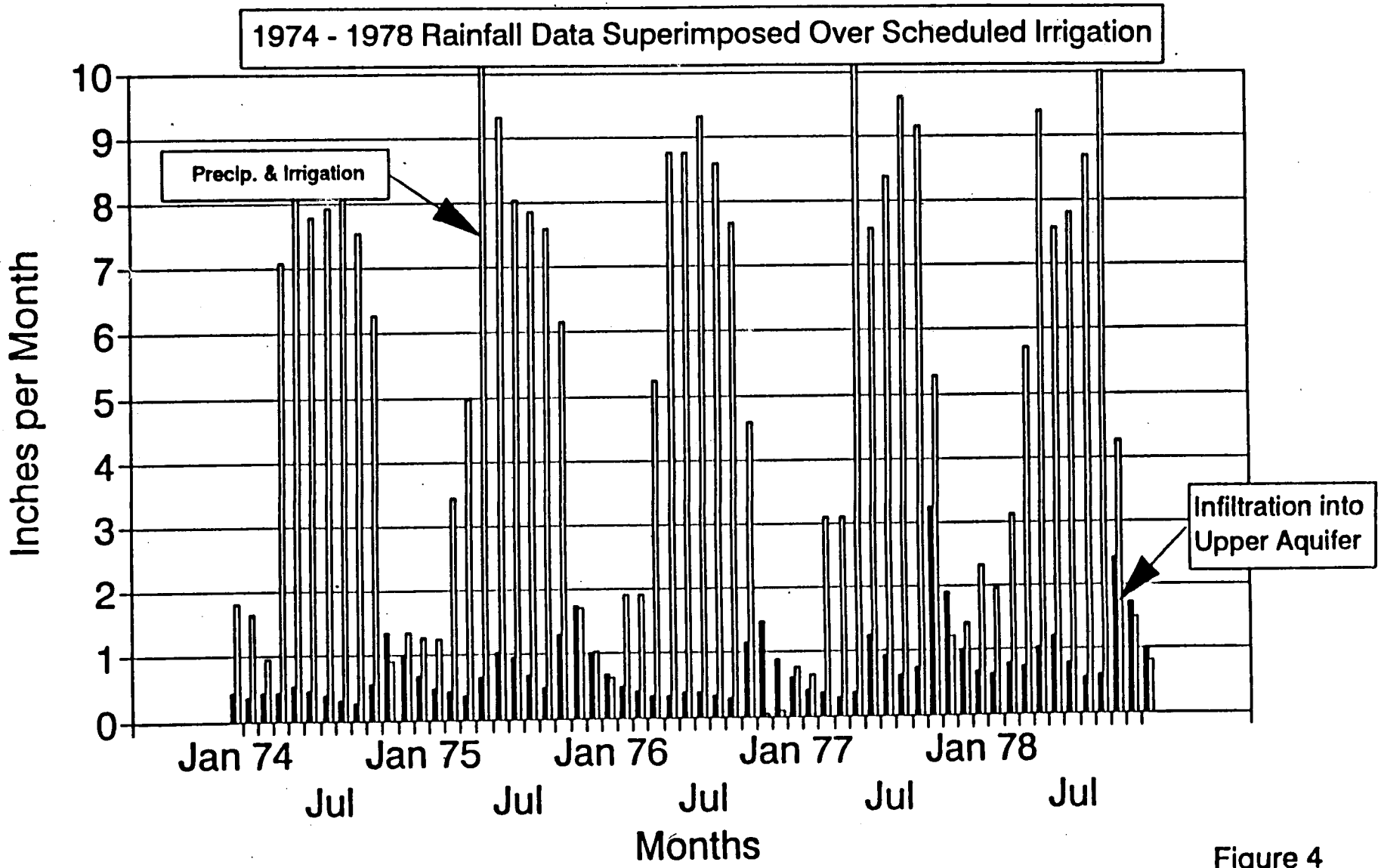


Figure 4

C:\DAT\HELP\BAR5.WQ1

Salt Lake City - Vitro Site

Infiltration Undeveloped Site

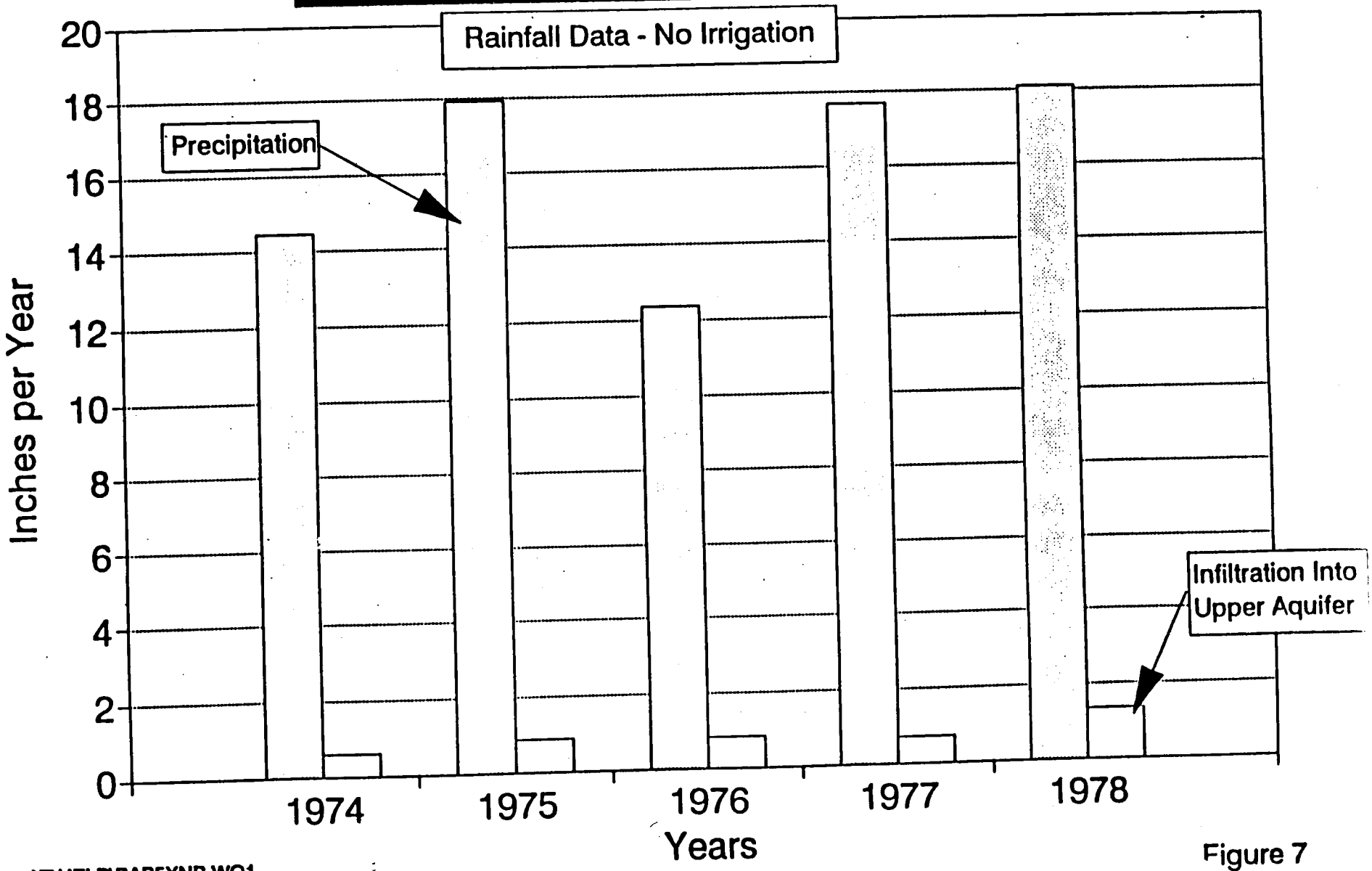
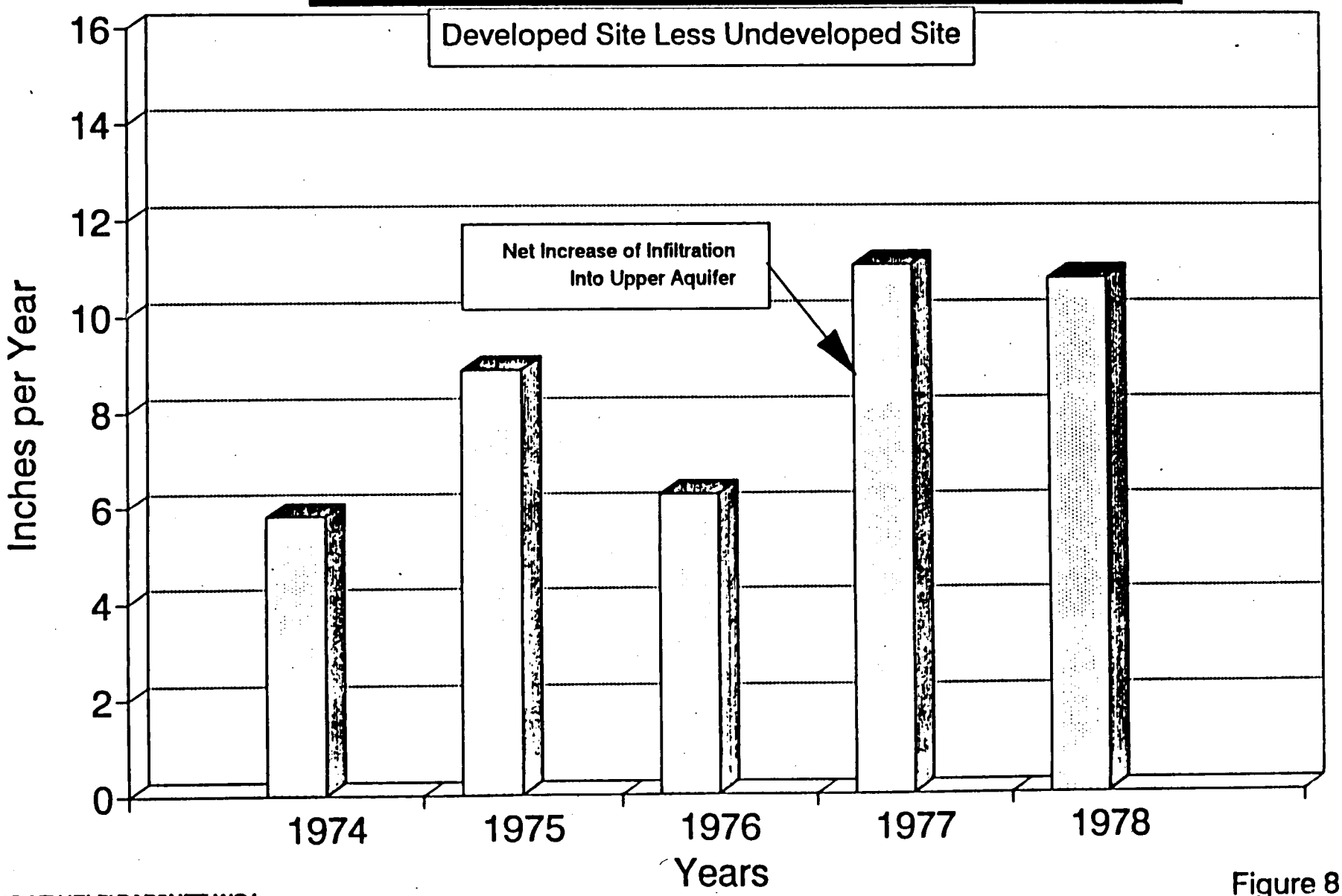


Figure 7

\T\HELP\BAR5YNR.WQ1

Salt Lake City - Vitro Site

Net Increase of Infiltration



C:\DAT\HELP\BAR5NET.WQ1

Figure 8

Appendix B

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SALT LAKE CITY
VITRO - PH I GOLF COURSE (3 LAYERS)
06-10-93
EXCELLENT GRASS EZD-18 LAI-5
DEFAULT SOIL PARAMETERS EXCEPT LAYER 2 K_{sat} 2 TIMES GREATER

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EXCELLENT GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.3980 VOL/VOL
FIELD CAPACITY	=	0.2443 VOL/VOL
WILTING POINT	=	0.1361 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1932 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000599999970 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	96.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.1053 VOL/VOL
WILTING POINT	=	0.0466 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1666 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.003400000045 CM/SEC

LAYER 3

VERTICAL PERCOLATION LAYER

THICKNESS	=	20.00 INCHES
POROSITY	=	0.4790 VOL/VOL
FIELD CAPACITY	=	0.3714 VOL/VOL
WILTING POINT	=	0.2505 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3949 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000024999998 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	78.09
TOTAL AREA OF COVER	=	1250000. SQ FT
EVAPORATIVE ZONE DEPTH	=	18.00 INCHES
UPPER LIMIT VEG. STORAGE	=	7.6320 INCHES
INITIAL VEG. STORAGE	=	2.7384 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

USER SPECIFIED RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND SOLAR RADIATION FOR SALT LAKE CITY UTAH

MAXIMUM LEAF AREA INDEX	=	5.00
START OF GROWING SEASON (JULIAN DATE)	=	122
END OF GROWING SEASON (JULIAN DATE)	=	285

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.60	34.10	40.70	49.20	58.80	68.30
77.50	74.90	65.00	53.00	39.70	30.30

MONTHLY TOTALS FOR YEAR 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	2.33	1.96	3.11	5.71	9.37	7.56
	7.81	8.67	10.01	4.25	1.49	0.82
RUNOFF (INCHES)	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.077	0.000	0.000	0.000
EVAPOTRANSPIRATION (INCHES)	1.166	1.790	3.145	3.325	7.691	8.518
	7.679	7.764	5.229	3.151	1.441	0.767
PERCOLATION FROM LAYER 3 (INCHES)	0.6658	0.6069	0.7911	0.7471	1.0378	1.2000
	0.7785	0.5452	0.3866	2.4204	1.7324	0.9779

ANNUAL TOTALS FOR YEAR 78

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	63.09	6571874.	100.00
RUNOFF	0.077	8007.	0.12
EVAPOTRANSPIRATION	51.667	5381987.	81.89
PERCOLATION FROM LAYER 3	12.0896	1259338.	19.16
CHANGE IN WATER STORAGE	-0.744	-77458.	-1.18
SOIL WATER AT START OF YEAR	25.93	2701098.	
SOIL WATER AT END OF YEAR	25.34	2639908.	
SNOW WATER AT START OF YEAR	0.16	16268.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.36	1.48	2.50	5.21	9.82	8.19
	8.29	8.55	8.38	5.31	1.07	0.94
STD. DEVIATIONS	0.71	0.55	1.04	1.44	1.71	0.79
	0.60	0.68	1.13	0.91	0.66	0.54
RUNOFF						
TOTALS	0.000	0.000	0.000	0.040	0.009	0.000
	0.000	0.003	0.015	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.054	0.020	0.000
	0.000	0.006	0.034	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.917	1.603	2.352	3.482	8.001	8.677
	8.206	7.796	5.558	2.919	1.313	0.757
STD. DEVIATIONS	0.350	0.718	0.544	0.542	0.545	0.778
	0.584	0.070	0.195	0.369	0.362	0.400
PERCOLATION FROM LAYER 3						
TOTALS	0.6054	0.4624	0.4814	0.4262	0.5737	0.8636
	0.6847	0.4932	0.4709	1.7314	1.6296	0.9702
STD. DEVIATIONS	0.1022	0.0932	0.1751	0.1852	0.2898	0.4201
	0.2907	0.1671	0.2072	1.0821	0.2348	0.0498

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	61.10	(2.573)	6364374.	100.00
RUNOFF	0.068	(0.039)	7041.	0.11
EVAPOTRANSPIRATION	51.580	(1.499)	5372931.	84.42
PERCOLATION FROM LAYER 3	9.3926	(2.6060)	978398.	15.37
CHANGE IN WATER STORAGE	0.058	(1.413)	6006.	0.09

PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	1.87	194791.7
RUNOFF	0.119	12361.1
PERCOLATION FROM LAYER 3	0.1305	13590.8
SNOW WATER	1.04	107844.9

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.2713

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0764

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	1.04	0.1736
2	16.20	0.1687
3	8.10	0.4051
SNOW WATER	0.00	

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MONTHLY TOTALS FOR YEAR 75

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	1.28	1.24	3.44	4.96	10.33	9.31
	8.03	7.85	7.58	6.16	1.71	1.03
RUNOFF (INCHES)	0.000	0.000	0.000	0.009	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION (INCHES)	1.094	1.555	2.562	3.511	8.043	8.537
	9.033	7.724	5.547	2.816	1.363	1.142
PERCOLATION FROM LAYER 3 (INCHES)	0.6641	0.4669	0.4317	0.3562	0.6313	1.0388
	0.9694	0.6338	0.4758	1.2952	1.7339	1.0015

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ANNUAL TOTALS FOR YEAR 75

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	62.92	6554166.	100.00
RUNOFF	0.009	985.	0.02
EVAPOTRANSPIRATION	52.927	5513180.	84.12
PERCOLATION FROM LAYER 3	9.7337	1013932.	15.47
CHANGE IN WATER STORAGE	0.250	26072.	0.40
SOIL WATER AT START OF YEAR	25.77	2683951.	
SOIL WATER AT END OF YEAR	25.75	2682062.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.27	27960.	
ANNUAL WATER BUDGET BALANCE	0.00	-3.	0.00

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SALT LAKE CITY
VITRO - PH I GOLF COURSE (3 LAYERS)
06-10-93
EXCELLENT GRASS  EZD-48   LAI-5
DEFAULT SOIL PARAMETERS EXCEPT LAYER 3 COMPACT

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EXCELLENT GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.3980 VOL/VOL
FIELD CAPACITY	=	0.2443 VOL/VOL
WILTING POINT	=	0.1361 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1891 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000599999970 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	96.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.1053 VOL/VOL
WILTING POINT	=	0.0466 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1657 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.001700000023 CM/SEC

LAYER 3

VERTICAL PERCOLATION LAYER

THICKNESS	=	20.00 INCHES
POROSITY	=	0.4219 VOL/VOL
FIELD CAPACITY	=	0.3412 VOL/VOL
WILTING POINT	=	0.2505 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3443 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000001250000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	78.09
TOTAL AREA OF COVER	=	1250000. SQ FT
EVAPORATIVE ZONE DEPTH	=	48.00 INCHES
UPPER LIMIT VEG. STORAGE	=	20.7420 INCHES
INITIAL VEG. STORAGE	=	8.5229 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

USER SPECIFIED RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND SOLAR RADIATION FOR SALT LAKE CITY UTAH

MAXIMUM LEAF AREA INDEX	=	5.00
START OF GROWING SEASON (JULIAN DATE)	=	122
END OF GROWING SEASON (JULIAN DATE)	=	285

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.60	34.10	40.70	49.20	58.80	68.30
77.50	74.90	65.00	53.00	39.70	30.30

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MONTHLY TOTALS FOR YEAR 74

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	1.80	1.65	0.97	7.07	8.14	7.78
	7.93	8.07	7.53	6.28	0.90	1.34
RUNOFF (INCHES)	0.000	0.000	0.000	0.034	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION (INCHES)	0.772	2.062	1.513	4.479	8.826	9.006
	9.330	7.703	5.361	2.429	1.560	0.849
PERCOLATION FROM LAYER 3 (INCHES)	0.0074	0.0100	0.0186	0.0368	0.1082	0.2435
	0.3000	0.2687	0.2208	0.1979	0.3301	0.6605

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ANNUAL TOTALS FOR YEAR 74

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	59.46	6193750.	100.00
RUNOFF	0.034	3497.	0.06
EVAPOTRANSPIRATION	53.889	5613487.	90.63
PERCOLATION FROM LAYER 3	2.4025	250260.	4.04
CHANGE IN WATER STORAGE	3.134	326505.	5.27
SOIL WATER AT START OF YEAR	23.92	2492080.	
SOIL WATER AT END OF YEAR	27.06	2818585.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 75

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	1.28	1.24	3.44	4.96	10.33	9.31
	8.03	7.85	7.58	6.16	1.71	1.03
RUNOFF (INCHES)	0.000	0.000	0.000	0.007	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	1.024	1.480	2.378	3.257	7.983	8.537
(INCHES)	10.066	8.933	5.670	2.679	1.213	1.015
PERCOLATION FROM	0.6337	0.4742	0.4571	0.3916	0.6054	1.1400
LAYER 3 (INCHES)	0.9490	0.4458	0.4274	0.4188	1.1971	1.0229

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ANNUAL TOTALS FOR YEAR 75

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	62.92	6554166.	100.00
RUNOFF	0.007	718.	0.01
EVAPOTRANSPIRATION	54.237	5649723.	86.20
PERCOLATION FROM LAYER 3	8.3630	871150.	13.29
CHANGE IN WATER STORAGE	0.313	32580.	0.50
SOIL WATER AT START OF YEAR	27.06	2818585.	
SOIL WATER AT END OF YEAR	27.10	2823204.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.27	27960.	
ANNUAL WATER BUDGET BALANCE	0.00	-5.	0.00

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MONTHLY TOTALS FOR YEAR 76

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	0.63	1.90	1.90	5.22	8.74	8.74
	9.30	8.57	7.66	4.58	0.03	0.08
RUNOFF (INCHES)	0.000	0.000	0.000	0.058	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION (INCHES)	1.081	1.949	1.801	3.347	7.870	9.707
	10.183	8.233	5.699	2.502	0.764	0.222
PERCOLATION FROM LAYER 3 (INCHES)	0.7114	0.5112	0.4490	0.3695	0.3310	0.2985
	0.2817	0.2408	0.1981	0.3180	1.2002	0.9899

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ANNUAL TOTALS FOR YEAR 76

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	57.35	5973957.	100.00
RUNOFF	0.058	6074.	0.10
EVAPOTRANSPIRATION	53.359	5558193.	93.04
PERCOLATION FROM LAYER 3	5.8993	614508.	10.29
CHANGE IN WATER STORAGE	-1.966	-204818.	-3.43
SOIL WATER AT START OF YEAR	27.10	2823204.	
SOIL WATER AT END OF YEAR	25.40	2646346.	
SNOW WATER AT START OF YEAR	0.27	27960.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	-1.	0.00

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MONTHLY TOTALS FOR YEAR 77

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	0.76	0.64	3.10	3.09	12.51	7.56
	8.36	9.60	9.14	5.27	1.22	1.42
RUNOFF (INCHES)	0.000	0.000	0.000	0.000	0.042	0.000
	0.000	0.010	0.001	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.352	0.356	2.585	2.872	7.509	9.272
(INCHES)	9.308	8.229	5.649	3.316	0.756	0.792
PERCOLATION FROM	0.6739	0.4552	0.3998	0.3164	0.2807	0.6703
LAYER 3 (INCHES)	0.7450	0.4979	0.3529	1.0205	1.2756	1.3181

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ANNUAL TOTALS FOR YEAR 77

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	62.67	6528123.	100.00
RUNOFF	0.053	5511.	0.08
EVAPOTRANSPIRATION	50.996	5312127.	81.37
PERCOLATION FROM LAYER 3	8.0062	833983.	12.78
CHANGE IN WATER STORAGE	3.614	376507.	5.77
SOIL WATER AT START OF YEAR	25.40	2646346.	
SOIL WATER AT END OF YEAR	28.86	3006585.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.16	16268.	
ANNUAL WATER BUDGET BALANCE	0.00	-5.	0.00

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MONTHLY TOTALS FOR YEAR 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	2.33	1.96	3.11	5.71	9.37	7.56
	7.81	8.67	10.01	4.25	1.49	0.82
RUNOFF (INCHES)	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.085	0.000	0.000	0.000
EVAPOTRANSPIRATION (INCHES)	1.135	1.711	2.887	3.374	7.654	10.216
	9.162	7.348	5.011	2.939	1.277	0.679
PERCOLATION FROM LAYER 3 (INCHES)	1.3111	0.9665	0.9927	0.9927	1.0311	1.2451
	0.8443	0.5198	0.3596	0.7403	1.2756	1.2785

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ANNUAL TOTALS FOR YEAR 78

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	63.09	6571874.	100.00
RUNOFF	0.085	8840.	0.13
EVAPOTRANSPIRATION	53.394	5561878.	84.63
PERCOLATION FROM LAYER 3	11.5573	1203881.	18.32
CHANGE IN WATER STORAGE	-1.946	-202727.	-3.08
SOIL WATER AT START OF YEAR	28.86	3006585.	
SOIL WATER AT END OF YEAR	27.07	2820126.	
SNOW WATER AT START OF YEAR	0.16	16268.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	1.	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.36	1.48	2.50	5.21	9.82	8.19
	8.29	8.55	8.38	5.31	1.07	0.94
STD. DEVIATIONS	0.71	0.55	1.04	1.44	1.71	0.79
	0.60	0.68	1.13	0.91	0.66	0.54
RUNOFF						
TOTALS	0.000	0.000	0.000	0.020	0.008	0.000
	0.000	0.002	0.017	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.026	0.019	0.000
	0.000	0.004	0.038	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.873	1.512	2.233	3.433	7.968	9.347
	9.610	8.089	5.478	2.773	1.114	0.712
STD. DEVIATIONS	0.323	0.684	0.565	0.601	0.514	0.645
	0.476	0.602	0.294	0.362	0.349	0.299
PERCOLATION FROM LAYER 3						
TOTALS	0.6675	0.4834	0.4634	0.4214	0.4713	0.7195
	0.6240	0.4346	0.3118	0.5391	1.0557	1.0540
STD. DEVIATIONS	0.4618	0.3388	0.3472	0.3496	0.3603	0.4635
	0.3126	0.1739	0.0982	0.3361	0.4075	0.2646

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	61.10	(2.573)	6364374.	100.00
RUNOFF	0.047	(0.029)	4928.	0.08
EVAPOTRANSPIRATION	53.175	(1.272)	5539082.	87.03
PERCOLATION FROM LAYER 3	7.2457	(3.3796)	754757.	11.86
CHANGE IN WATER STORAGE	0.630	(2.677)	65609.	1.03

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	1.87	194791.7
RUNOFF	0.085	8820.9
PERCOLATION FROM LAYER 3	0.0425	4429.1
SNOW WATER	1.04	107848.1

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2483
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1035

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	1.01	0.1683
2	17.68	0.1842
3	8.38	0.4191
SNOW WATER	0.00	

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Undeveloped

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SALT LAKE CITY
VITRO - NO DEVELOPMENT (3 LAYERS)
06-16-93
POOR GRASS EZD-18 LAI-1
DEFAULT SOIL PARAMETERS EXCEPT LAYER 2 K_{sat} 2 TIMES GREATER

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POOR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.3394 VOL/VOL
FIELD CAPACITY	=	0.0906 VOL/VOL
WILTING POINT	=	0.0466 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1428 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000152999986 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	96.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.1053 VOL/VOL
WILTING POINT	=	0.0466 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1214 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.003400000045 CM/SEC

LAYER 3

VERTICAL PERCOLATION LAYER

THICKNESS	=	20.00 INCHES
POROSITY	=	0.4790 VOL/VOL
FIELD CAPACITY	=	0.3714 VOL/VOL
WILTING POINT	=	0.2505 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3508 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000024999998 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	73.68
TOTAL AREA OF COVER	=	1250000. SQ FT
EVAPORATIVE ZONE DEPTH	=	18.00 INCHES
UPPER LIMIT VEG. STORAGE	=	7.2804 INCHES
INITIAL VEG. STORAGE	=	1.7412 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

USER SPECIFIED RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND SOLAR RADIATION FOR SALT LAKE CITY UTAH

MAXIMUM LEAF AREA INDEX	=	1.00
START OF GROWING SEASON (JULIAN DATE)	=	122
END OF GROWING SEASON (JULIAN DATE)	=	285

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.60	34.10	40.70	49.20	58.80	68.30
77.50	74.90	65.00	53.00	39.70	30.30

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MONTHLY TOTALS FOR YEAR 74

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	1.80	1.65	0.97	4.57	0.39	0.28
	0.18	0.32	0.03	2.03	0.90	1.34
RUNOFF (INCHES)	0.000	0.000	0.000	0.056	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION (INCHES)	0.808	2.047	1.250	2.360	0.504	0.979
	0.607	0.320	0.030	0.851	1.601	0.846
PERCOLATION FROM LAYER 3 (INCHES)	0.0325	0.0283	0.0305	0.0299	0.0374	0.0446
	0.0547	0.0618	0.0648	0.0702	0.0695	0.0722

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ANNUAL TOTALS FOR YEAR 74

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	14.46	1506251.	100.00
RUNOFF	0.056	5808.	0.39
EVAPOTRANSPIRATION	12.202	1271081.	84.39
PERCOLATION FROM LAYER 3	0.5965	62133.	4.13
CHANGE IN WATER STORAGE	1.605	167227.	11.10
SOIL WATER AT START OF YEAR	19.53	2034536.	
SOIL WATER AT END OF YEAR	21.14	2201762.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 75

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	1.28	1.24	3.44	2.46	2.58	1.81
	0.28	0.10	0.08	1.91	1.71	1.03
RUNOFF (INCHES)	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	1.116	1.523	2.090	2.466	3.165	2.251
(INCHES)	0.594	0.229	0.080	1.036	0.938	1.225
PERCOLATION FROM	0.0717	0.0637	0.0690	0.0666	0.0721	0.0732
LAYER 3 (INCHES)	0.0783	0.0793	0.0763	0.0776	0.0732	0.0735

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ANNUAL TOTALS FOR YEAR 75

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	17.92	1866667.	100.00
RUNOFF	0.000	0.	0.00
EVAPOTRANSPIRATION	16.711	1740707.	93.25
PERCOLATION FROM LAYER 3	0.8744	91081.	4.88
CHANGE IN WATER STORAGE	0.335	34879.	1.87
SOIL WATER AT START OF YEAR	21.14	2201762.	
SOIL WATER AT END OF YEAR	21.21	2209055.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.26	27587.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 76

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	0.63 1.55	1.90 0.82	1.90 0.16	2.47 0.57	0.99 0.03	1.24 0.08
RUNOFF (INCHES)	0.000 0.000	0.000 0.000	0.000 0.000	0.039 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION (INCHES)	1.097 1.234	1.692 1.386	1.739 0.160	1.799 0.570	0.899 0.030	2.352 0.080
PERCOLATION FROM LAYER 3 (INCHES)	0.0710 0.0697	0.0642 0.0711	0.0662 0.0690	0.0618 0.0706	0.0640 0.0671	0.0649 0.0677

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ANNUAL TOTALS FOR YEAR 76

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	12.34	1285417.	100.00
RUNOFF	0.039	4058.	0.32
EVAPOTRANSPIRATION	13.038	1358106.	105.65
PERCOLATION FROM LAYER 3	0.8072	84087.	6.54
CHANGE IN WATER STORAGE	-1.544	-160834.	-12.51
SOIL WATER AT START OF YEAR	21.21	2209055.	
SOIL WATER AT END OF YEAR	19.93	2075808.	
SNOW WATER AT START OF YEAR	0.26	27587.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 77

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	0.76	0.64	3.10	0.59	4.76	0.06
	0.61	1.85	1.64	1.02	1.22	1.42
RUNOFF (INCHES)	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.226	0.280	2.358	1.491	3.707	1.319
(INCHES)	0.558	1.836	1.657	1.138	0.416	0.861
PERCOLATION FROM	0.0658	0.0577	0.0620	0.0580	0.0580	0.0554
LAYER 3 (INCHES)	0.0578	0.0579	0.0557	0.0568	0.0540	0.0546

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ANNUAL TOTALS FOR YEAR 77

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	17.67	1840626.	100.00
RUNOFF	0.000	0.	0.00
EVAPOTRANSPIRATION	15.848	1650840.	89.69
PERCOLATION FROM LAYER 3	0.6937	72261.	3.93
CHANGE IN WATER STORAGE	1.128	117523.	6.38
SOIL WATER AT START OF YEAR	19.93	2075808.	
SOIL WATER AT END OF YEAR	20.90	2177063.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.16	16268.	
ANNUAL WATER BUDGET BALANCE	0.00	1.	0.00

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MONTHLY TOTALS FOR YEAR 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	2.33	1.96	3.11	3.21	1.62	0.06
	0.06	0.92	2.51	0.00	1.49	0.82
RUNOFF (INCHES)	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION (INCHES)	1.157	1.658	2.549	2.997	2.159	0.809
	0.060	0.642	1.842	0.462	0.534	0.840
PERCOLATION FROM LAYER 3 (INCHES)	0.0534	0.0487	0.0645	0.0921	0.1266	0.1426
	0.1549	0.1528	0.1413	0.1374	0.1244	0.1201

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ANNUAL TOTALS FOR YEAR 78

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	18.09	1884376.	100.00
RUNOFF	0.000	0.	0.00
EVAPOTRANSPIRATION	15.706	1636062.	86.82
PERCOLATION FROM LAYER 3	1.3587	141528.	7.51
CHANGE IN WATER STORAGE	1.025	106785.	5.67
SOIL WATER AT START OF YEAR	20.90	2177063.	
SOIL WATER AT END OF YEAR	22.08	2300116.	
SNOW WATER AT START OF YEAR	0.16	16268.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	1.	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.36	1.48	2.50	2.66	2.07	0.69
	0.54	0.80	0.88	1.11	1.07	0.94
STD. DEVIATIONS	0.71	0.55	1.04	1.44	1.71	0.79
	0.60	0.68	1.13	0.87	0.66	0.54
RUNOFF						
TOTALS	0.000	0.000	0.000	0.019	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.027	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.881	1.440	1.997	2.223	2.087	1.542
	0.611	0.883	0.754	0.811	0.704	0.770
STD. DEVIATIONS	0.391	0.677	0.517	0.590	1.388	0.718
	0.417	0.701	0.912	0.291	0.597	0.419
PERCOLATION FROM LAYER 3						
TOTALS	0.0589	0.0525	0.0584	0.0617	0.0716	0.0761
	0.0831	0.0846	0.0814	0.0825	0.0777	0.0776
STD. DEVIATIONS	0.0165	0.0149	0.0158	0.0222	0.0333	0.0386
	0.0412	0.0390	0.0343	0.0316	0.0271	0.0249

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	16.10	(2.577)	1676667.	100.00
RUNOFF	0.019	(0.027)	1973.	0.12
EVAPOTRANSPIRATION	14.701	(1.961)	1531359.	91.33
PERCOLATION FROM LAYER 3	0.8661	(0.2952)	90218.	5.38
CHANGE IN WATER STORAGE	0.510	(1.235)	53116.	3.17

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	1.62	168750.0
RUNOFF	0.056	5808.3
PERCOLATION FROM LAYER 3	0.0050	522.3
SNOW WATER	1.04	107840.7

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.2356

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0463

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	0.67	0.1124
2	13.98	0.1456
3	7.42	0.3712
SNOW WATER	0.00	

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MONTHLY TOTALS FOR YEAR 77

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	0.76	0.64	3.10	3.09	12.51	7.56
	8.36	9.60	9.14	5.27	1.22	1.42
RUNOFF (INCHES)	0.000	0.000	0.000	0.000	0.044	0.000
	0.000	0.014	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION (INCHES)	0.355	0.398	2.337	2.914	7.454	9.037
	7.804	7.824	5.665	3.437	0.955	0.845
PERCOLATION FROM LAYER 3 (INCHES)	0.5962	0.4076	0.3618	0.2894	0.3479	1.2535
	0.9240	0.6188	0.7503	3.2430	1.8969	1.0062

ANNUAL TOTALS FOR YEAR 77

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	62.67	6528123.	100.00
RUNOFF	0.059	6156.	0.09
EVAPOTRANSPIRATION	49.026	5106875.	78.23
PERCOLATION FROM LAYER 3	11.6956	1218294.	18.66
CHANGE IN WATER STORAGE	1.889	196803.	3.01
SOIL WATER AT START OF YEAR	24.20	2520563.	
SOIL WATER AT END OF YEAR	25.93	2701098.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.16	16268.	
ANNUAL WATER BUDGET BALANCE	0.00	-4.	0.00

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MONTHLY TOTALS FOR YEAR 74

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	1.80	1.65	0.97	7.07	8.14	7.78
	7.93	8.07	7.53	6.28	0.90	1.34
RUNOFF (INCHES)	0.000	0.000	0.000	0.119	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION	0.795	2.204	1.759	4.371	8.887	7.587
(INCHES)	7.911	7.766	5.626	2.553	1.828	0.943
PERCOLATION FROM	0.4309	0.3587	0.4166	0.4140	0.5315	0.4545
LAYER 3 (INCHES)	0.3825	0.3151	0.2531	0.5517	1.3054	0.9816

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ANNUAL TOTALS FOR YEAR 74

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	59.46	6193750.	100.00
RUNOFF	0.119	12361.	0.20
EVAPOTRANSPIRATION	52.230	5440591.	87.84
PERCOLATION FROM LAYER 3	6.4005	666724.	10.76
CHANGE IN WATER STORAGE	0.711	74074.	1.20
SOIL WATER AT START OF YEAR	25.05	2609877.	
SOIL WATER AT END OF YEAR	25.77	2683951.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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Attachment G

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE SLC01, SALT LAKE CITY
REPORT DATE: 1/28/2000 4:16 p

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	SAMPLE: ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	QUALIFIERS: DATA	QUALIFIERS: QA	DETECTION LIMIT	UN-CERTAINTY
Arsenic	mg/L	0130	07/23/1992	0001	LU	O	0.0266			#	0.005	-
	mg/L	0130	10/09/1992	0001	LU	O	0.0236			#	0.005	-
	mg/L	0130	10/29/1993	0001	LU	O	0.023	S		#	0.005	-
	mg/L	0130	02/10/1994	0001	LU	O	0.026	S		#	0.005	-
	mg/L	0130	12/11/1994	0001	LU	O	0.085	S		#	0.005	-
	mg/L	0130	12/11/1994	N001	LU	O	0.077			#	0.005	-
	mg/L	0130	07/15/1995	0001	LU	O	0.035			#	0.005	-
	mg/L	0130	07/15/1995	N001	LU	O	0.030			#	0.005	-
	mg/L	0130	12/09/1995	0001	LU	O	0.025			#	0.005	-
	mg/L	0130	12/09/1995	N001	LU	O	0.026	S		#	0.005	-
	mg/L	0130	03/26/1997	0001	LU	O	0.0330			#	-	-
	mg/L	0131	10/10/1992	0001	LU	U	0.0465			#	0.005	-
	mg/L	0131	10/29/1993	0001	LU	U	0.080	S		#	0.005	-
	mg/L	0131	02/10/1994	0001	LU	U	0.055	S		#	0.005	-
	mg/L	0131	02/10/1994	0002	LU	U	0.058	S		#	0.005	-
	mg/L	0131	12/11/1994	0001	LU	U	0.145			#	0.005	-
	mg/L	0131	12/11/1994	N001	LU	U	0.140			#	0.005	-
	mg/L	0131	07/15/1995	0001	LU	U	0.111			#	0.005	-
	mg/L	0131	07/15/1995	0002	LU	U	0.112			#	0.005	-
	mg/L	0131	07/15/1995	N001	LU	U	0.116			#	0.005	-
	mg/L	0131	07/15/1995	N002	LU	U	0.112			#	0.005	-
	mg/L	0131	12/09/1995	0001	LU	U	0.078			#	0.005	-
	mg/L	0131	12/09/1995	0002	LU	U	0.083			#	0.005	-
	mg/L	0131	12/09/1995	N001	LU	U	0.070			#	0.005	-
	mg/L	0131	12/09/1995	N002	LU	U	0.073	S		#	0.005	-
	mg/L	0131	03/26/1997	0001	LU	U	0.0869			#	-	-
	mg/L	0131	08/06/1998	0001	LU	U	0.0448			#	-	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE SLC01, SALT LAKE CITY
REPORT DATE: 1/28/2000 4:16 p

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	SAMPLE: ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	QUALIFIERS: DATA	QUALIFIERS: QA	DETECTION LIMIT	UN-CERTAINTY
Arsenic	mg/L	0132	07/23/1992	0001	LU	O	0.0566			#	0.005	-
	mg/L	0132	10/10/1992	0001	LU	O	0.0342			#	0.005	-
	mg/L	0132	10/29/1993	0001	LU	O	0.027	S		#	0.005	-
	mg/L	0132	02/10/1994	0001	LU	O	0.042	S		#	0.005	-
	mg/L	0132	12/09/1994	0001	LU	O	0.105			#	0.005	-
	mg/L	0132	12/09/1994	N001	LU	O	0.100	S		#	0.005	-
	mg/L	0132	07/15/1995	0001	LU	O	0.080			#	0.005	-
	mg/L	0132	07/15/1995	N001	LU	O	0.077			#	0.005	-
	mg/L	0132	12/09/1995	0001	LU	O	0.049	S		#	0.005	-
	mg/L	0132	12/09/1995	N001	LU	O	0.057	S		#	0.005	-
	mg/L	0132	03/26/1997	0001	LU	O	0.0437			#	-	-
	mg/L	0132	08/06/1998	0001	LU	O	0.0259			#	-	-
	mg/L	0133	07/23/1992	0001	LU	O	0.126		F	#	0.005	-
	mg/L	0133	10/10/1992	0001	LU	O	0.114			#	0.005	-
	mg/L	0133	10/29/1993	0001	LU	O	0.025	+		#	0.005	-
	mg/L	0133	02/10/1994	0001	LU	O	0.123	S		#	0.005	-
	mg/L	0133	12/11/1994	0001	LU	O	0.090	S		#	0.005	-
	mg/L	0133	12/11/1994	N001	LU	O	0.088			#	0.005	-
	mg/L	0133	07/14/1995	0001	LU	O	0.081			#	0.005	-
	mg/L	0133	07/14/1995	N001	LU	O	0.083			#	0.005	-
	mg/L	0133	12/09/1995	0001	LU	O	0.106			#	0.005	-
	mg/L	0133	12/09/1995	N001	LU	O	0.107			#	0.005	-
	mg/L	0133	03/25/1997	0001	LU	O	0.108			#	-	-
	mg/L	0133	08/06/1998	0001	LU	O	0.0845			#	-	-
	mg/L	0134	07/22/1992	0001	LU	D	0.0477	S		#	0.005	-
	mg/L	0134	10/09/1992	0001	LU	D	0.0398			#	0.005	-
	mg/L	0134	10/29/1993	0001	LU	D	0.029	S		#	0.005	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE SLC01, SALT LAKE CITY
REPORT DATE: 1/28/2000 4:16 p

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	SAMPLE: ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	QUALIFIERS: DATA	QUALIFIERS: QA	DETECTION LIMIT	UN-CERTAINTY
Arsenic	mg/L	0134	02/11/1994	0001	LU	D	0.133	S		#	0.005	-
	mg/L	0134	12/11/1994	0001	LU	D	0.048			#	0.005	-
	mg/L	0134	12/11/1994	N001	LU	D	0.057			#	0.005	-
	mg/L	0134	07/15/1995	0001	LU	D	0.039	S		#	0.005	-
	mg/L	0134	07/15/1995	N001	LU	D	0.042	S		#	0.005	-
	mg/L	0134	12/08/1995	0001	LU	D	0.012	S		#	0.005	-
	mg/L	0134	12/08/1995	N001	LU	D	0.046	S		#	0.005	-
	mg/L	0134	03/25/1997	0001	LU	D	0.0450			#	-	-
	mg/L	0134	08/04/1998	0001	LU	D	0.0518			#	-	-
	mg/L	0134	10/27/1999	0001	LU	D	0.391			#	-	-
	mg/L	0134	10/27/1999	0002	LU	D	0.368			#	-	-
	mg/L	0136	02/11/1994	0001	LU	O	0.022	S		#	0.005	-
	mg/L	0136	12/11/1994	0001	LU	O	0.012			#	0.005	-
	mg/L	0136	12/11/1994	0002	LU	O	0.012			#	0.005	-
	mg/L	0136	12/11/1994	N001	LU	O	0.015			#	0.005	-
	mg/L	0136	12/11/1994	N002	LU	O	0.013			#	0.005	-
	mg/L	0136	07/15/1995	0001	LU	O	0.014			#	0.005	-
	mg/L	0136	07/15/1995	N001	LU	O	0.015	S		#	0.005	-
	mg/L	0136	12/10/1995	0001	LU	O	0.009	+	J	#	0.005	-
	mg/L	0136	12/10/1995	N001	LU	O	0.011	S		#	0.005	-
	mg/L	0136	03/26/1997	0001	LU	O	0.0072			#	-	-
	mg/L	0136	08/05/1998	0001	LU	O	0.0082			#	-	-
	mg/L	0143	10/27/1999	0001	LC		0.00095	B		#	-	-
	mg/L	0144	10/26/1999	0001	LU		0.112			#	-	-
	mg/L	0145	10/26/1999	0001	LC		0.00040	U		#	0.0004	-
Molybdenum	mg/L	0130	07/23/1992	0001	LU	O	0.01	U		#	0.01	-
	mg/L	0130	10/09/1992	0001	LU	O	0.01	U		#	0.01	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE SLC01, SALT LAKE CITY
REPORT DATE: 1/28/2000 4:16 p

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	SAMPLE: ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	QUALIFIERS: DATA	QUALIFIERS: QA	DETECTION LIMIT	UN-CERTAINTY
Molybdenum	mg/L	0130	10/29/1993	0001	LU	O	0.01	U		#	0.01	-
	mg/L	0130	02/10/1994	0001	LU	O	0.01	U		#	0.01	-
	mg/L	0130	12/11/1994	0001	LU	O	0.19			#	0.01	-
	mg/L	0130	07/15/1995	0001	LU	O	0.01	U		#	0.01	-
	mg/L	0130	07/15/1995	N001	LU	O	0.01	U		#	0.01	-
	mg/L	0130	12/09/1995	0001	LU	O	0.01	U		#	0.01	-
	mg/L	0130	12/09/1995	N001	LU	O	0.01	U		#	0.01	-
	mg/L	0130	03/26/1997	0001	LU	O	0.0010	U		#	0.001	-
	mg/L	0131	10/10/1992	0001	LU	U	0.01	U		#	0.01	-
	mg/L	0131	10/29/1993	0001	LU	U	0.94			#	0.01	-
	mg/L	0131	02/10/1994	0001	LU	U	0.88			#	0.01	-
	mg/L	0131	02/10/1994	0002	LU	U	0.88			#	0.01	-
	mg/L	0131	12/11/1994	0001	LU	U	1.39			#	0.01	-
	mg/L	0131	07/15/1995	0001	LU	U	0.42			#	0.01	-
	mg/L	0131	07/15/1995	0002	LU	U	0.42			#	0.01	-
	mg/L	0131	07/15/1995	N001	LU	U	0.31			#	0.01	-
	mg/L	0131	07/15/1995	N002	LU	U	0.30			#	0.01	-
	mg/L	0131	12/09/1995	0001	LU	U	0.95			#	0.01	-
	mg/L	0131	12/09/1995	0002	LU	U	0.97			#	0.01	-
	mg/L	0131	12/09/1995	N001	LU	U	1.02			#	0.01	-
	mg/L	0131	12/09/1995	N002	LU	U	1.02			#	0.01	-
	mg/L	0131	03/26/1997	0001	LU	U	0.654			#	-	-
	mg/L	0131	08/06/1998	0001	LU	U	0.0440			#	-	-
	mg/L	0132	07/23/1992	0001	LU	O	0.01	U		#	0.01	-
	mg/L	0132	10/10/1992	0001	LU	O	0.01	U		#	0.01	-
	mg/L	0132	10/29/1993	0001	LU	O	0.01	U		#	0.01	-
	mg/L	0132	02/10/1994	0001	LU	O	0.01	U		#	0.01	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE SLC01, SALT LAKE CITY
REPORT DATE: 1/28/2000 4:16 p

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	SAMPLE: ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	QUALIFIERS: DATA	QUALIFIERS: QA	DETECTION LIMIT	UN-CERTAINTY
Molybdenum	mg/L	0132	12/09/1994	0001	LU	O	0.72			#	0.01	-
	mg/L	0132	07/15/1995	0001	LU	O	0.08			#	0.01	-
	mg/L	0132	07/15/1995	N001	LU	O	0.08			#	0.01	-
	mg/L	0132	12/09/1995	0001	LU	O	0.01			#	0.01	-
	mg/L	0132	12/09/1995	N001	LU	O	0.01	U		#	0.01	-
	mg/L	0132	03/26/1997	0001	LU	O	0.0010	U		#	0.001	-
	mg/L	0132	08/06/1998	0001	LU	O	0.0017	B		#	-	-
	mg/L	0133	07/23/1992	0001	LU	O	0.01	U	F	#	0.01	-
	mg/L	0133	10/10/1992	0001	LU	O	0.01	U		#	0.01	-
	mg/L	0133	10/29/1993	0001	LU	O	0.01	U		#	0.01	-
	mg/L	0133	02/10/1994	0001	LU	O	0.01	U		#	0.01	-
	mg/L	0133	12/11/1994	0001	LU	O	0.02			#	0.01	-
	mg/L	0133	07/14/1995	0001	LU	O	0.01	U		#	0.01	-
	mg/L	0133	07/14/1995	N001	LU	O	0.01	U		#	0.01	-
	mg/L	0133	12/09/1995	0001	LU	O	0.01	U		#	0.01	-
	mg/L	0133	12/09/1995	N001	LU	O	0.01	U		#	0.01	-
	mg/L	0133	03/25/1997	0001	LU	O	0.0010	U		#	0.001	-
	mg/L	0133	08/06/1998	0001	LU	O	0.0011	B		#	-	-
	mg/L	0134	07/22/1992	0001	LU	D	0.02			#	0.01	-
	mg/L	0134	10/09/1992	0001	LU	D	0.0121			#	0.01	-
	mg/L	0134	10/29/1993	0001	LU	D	0.02			#	0.01	-
	mg/L	0134	02/11/1994	0001	LU	D	0.02			#	0.01	-
	mg/L	0134	12/11/1994	0001	LU	D	0.02			#	0.01	-
	mg/L	0134	07/15/1995	0001	LU	D	0.03			#	0.01	-
	mg/L	0134	07/15/1995	N001	LU	D	0.03			#	0.01	-
	mg/L	0134	12/08/1995	0001	LU	D	0.01			#	0.01	-
	mg/L	0134	12/08/1995	N001	LU	D	0.01			#	0.01	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE SLC01, SALT LAKE CITY
REPORT DATE: 1/28/2000 4:16 p

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	SAMPLE: ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	QUALIFIERS: DATA	QUALIFIERS: QA	DETECTION LIMIT	UN-CERTAINTY
Molybdenum	mg/L	0134	03/25/1997	0001	LU	D	0.0122			#	-	-
	mg/L	0134	08/04/1998	0001	LU	D	0.0311			#	-	-
	mg/L	0134	10/27/1999	0001	LU	D	0.0352			#	-	-
	mg/L	0134	10/27/1999	0002	LU	D	0.0340			#	-	-
	mg/L	0136	02/11/1994	0001	LU	O	0.09			#	0.01	-
	mg/L	0136	12/11/1994	0001	LU	O	0.07			#	0.01	-
	mg/L	0136	12/11/1994	0002	LU	O	0.07			#	0.01	-
	mg/L	0136	07/15/1995	0001	LU	O	0.06			#	0.01	-
	mg/L	0136	07/15/1995	N001	LU	O	0.06			#	0.01	-
	mg/L	0136	12/10/1995	0001	LU	O	0.04			#	0.01	-
	mg/L	0136	12/10/1995	N001	LU	O	0.04			#	0.01	-
	mg/L	0136	03/26/1997	0001	LU	O	0.0321			#	-	-
	mg/L	0136	08/05/1998	0001	LU	O	0.0583			#	-	-
	mg/L	0143	10/27/1999	0001	LC		0.0012	B		#	-	-
	mg/L	0144	10/26/1999	0001	LU		0.137			#	-	-
	mg/L	0145	10/26/1999	0001	LC		0.0016	B		#	-	-
Uranium	mg/L	0130	07/23/1992	0001	LU	O	0.001	U		#	0.001	-
	mg/L	0130	10/09/1992	0001	LU	O	0.0001	UI		#	0.0001	-
	mg/L	0130	10/29/1993	0001	LU	O	0.001	U		#	0.001	-
	mg/L	0130	10/29/1993	N001	LU	O	0.001	U		#	0.001	-
	mg/L	0130	02/10/1994	0001	LU	O	0.001	U		#	0.001	-
	mg/L	0130	12/11/1994	0001	LU	O	0.002		J	#	0.001	-
	mg/L	0130	07/15/1995	0001	LU	O	0.001	U		#	0.001	-
	mg/L	0130	07/15/1995	N001	LU	O	0.001	U		#	0.001	-
	mg/L	0130	12/09/1995	0001	LU	O	0.001	U		#	0.001	-
	mg/L	0130	12/09/1995	N001	LU	O	0.003			#	0.001	-
	mg/L	0130	03/26/1997	0001	LU	O	0.0010	U		#	0.001	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE SLC01, SALT LAKE CITY
REPORT DATE: 1/28/2000 4:16 p

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	SAMPLE: ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	QUALIFIERS: DATA	QUALIFIERS: QA	DETECTION LIMIT	UN-CERTAINTY
Uranium	mg/L	0131	10/10/1992	0001	LU	U	0.0001	UI		#	0.0001	-
	mg/L	0131	10/29/1993	0001	LU	U	0.080			#	0.001	-
	mg/L	0131	10/29/1993	N001	LU	U	0.083			#	0.001	-
	mg/L	0131	02/10/1994	0001	LU	U	0.064			#	0.001	-
	mg/L	0131	02/10/1994	0002	LU	U	0.063			#	0.001	-
	mg/L	0131	12/11/1994	0001	LU	U	0.067			#	0.001	-
	mg/L	0131	07/15/1995	0001	LU	U	0.014			#	0.001	-
	mg/L	0131	07/15/1995	0002	LU	U	0.014			#	0.001	-
	mg/L	0131	07/15/1995	N001	LU	U	0.009			#	0.001	-
	mg/L	0131	07/15/1995	N002	LU	U	0.008			#	0.001	-
	mg/L	0131	12/09/1995	0001	LU	U	0.056			#	0.001	-
	mg/L	0131	12/09/1995	0002	LU	U	0.060			#	0.001	-
	mg/L	0131	12/09/1995	N001	LU	U	0.061			#	0.001	-
	mg/L	0131	12/09/1995	N002	LU	U	0.059			#	0.001	-
	mg/L	0131	03/26/1997	0001	LU	U	0.0292			#	-	-
	mg/L	0131	08/06/1998	0001	LU	U	0.0011			#	-	-
	mg/L	0132	07/23/1992	0001	LU	O	0.001	U		#	0.001	-
	mg/L	0132	10/10/1992	0001	LU	O	0.0001	UI		#	0.0001	-
	mg/L	0132	10/29/1993	0001	LU	O	0.001	U		#	0.001	-
	mg/L	0132	10/29/1993	N001	LU	O	0.001	U		#	0.001	-
	mg/L	0132	02/10/1994	0001	LU	O	0.001	U		#	0.001	-
	mg/L	0132	12/09/1994	0001	LU	O	0.001		J	#	0.001	-
	mg/L	0132	07/15/1995	0001	LU	O	0.001	U		#	0.001	-
	mg/L	0132	07/15/1995	N001	LU	O	0.001	U		#	0.001	-
	mg/L	0132	12/09/1995	0001	LU	O	0.001	U		#	0.001	-
	mg/L	0132	12/09/1995	N001	LU	O	0.001	U		#	0.001	-
	mg/L	0132	03/26/1997	0001	LU	O	0.0010	U		#	0.001	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE SLC01, SALT LAKE CITY
REPORT DATE: 1/28/2000 4:16 p

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	SAMPLE: ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	QUALIFIERS: DATA	QUALIFIERS: QA	DETECTION LIMIT	UN-CERTAINTY
Uranium	mg/L	0132	08/06/1998	0001	LU	O	0.0010	U		#	0.001	-
	mg/L	0133	07/22/1992	0001	LU	O	0.001		F	#	0.001	-
	mg/L	0133	10/10/1992	0001	LU	O	0.0050	I		#	0.0001	-
	mg/L	0133	10/29/1993	0001	LU	O	0.002			#	0.001	-
	mg/L	0133	10/29/1993	N001	LU	O	0.002			#	0.001	-
	mg/L	0133	02/10/1994	0001	LU	O	0.001	U		#	0.001	-
	mg/L	0133	12/11/1994	0001	LU	O	0.101			#	0.001	-
	mg/L	0133	07/14/1995	0001	LU	O	0.054			#	0.001	-
	mg/L	0133	07/14/1995	N001	LU	O	0.055			#	0.001	-
	mg/L	0133	12/09/1995	0001	LU	O	0.011			#	0.001	-
	mg/L	0133	12/09/1995	N001	LU	O	0.014			#	0.001	-
	mg/L	0133	03/25/1997	0001	LU	O	0.0053			#	-	-
	mg/L	0133	08/06/1998	0001	LU	O	0.0119			#	-	-
	mg/L	0134	07/22/1992	0001	LU	D	0.057			#	0.001	-
	mg/L	0134	10/09/1992	0001	LU	D	0.0360	I		#	0.0001	-
	mg/L	0134	10/29/1993	0001	LU	D	0.134			#	0.001	-
	mg/L	0134	10/29/1993	N001	LU	D	0.137			#	0.001	-
	mg/L	0134	02/11/1994	0001	LU	D	0.089			#	0.001	-
	mg/L	0134	12/11/1994	0001	LU	D	0.049			#	0.001	-
	mg/L	0134	07/15/1995	0001	LU	D	0.060			#	0.001	-
	mg/L	0134	07/15/1995	N001	LU	D	0.062			#	0.001	-
	mg/L	0134	12/08/1995	0001	LU	D	0.019			#	0.001	-
	mg/L	0134	12/08/1995	N001	LU	D	0.017			#	0.001	-
	mg/L	0134	03/25/1997	0001	LU	D	0.0239			#	-	-
	mg/L	0134	08/04/1998	0001	LU	D	0.0554			#	-	-
	mg/L	0134	10/27/1999	0001	LU	D	0.0456			#	-	-
	mg/L	0134	10/27/1999	0002	LU	D	0.0441			#	-	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE SLC01, SALT LAKE CITY
REPORT DATE: 1/28/2000 4:16 p

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	SAMPLE: ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	QUALIFIERS: DATA	QUALIFIERS: QA	DETECTION LIMIT	UN-CERTAINTY
Uranium	mg/L	0136	02/11/1994	0001	LU	O	0.089			#	0.001	-
	mg/L	0136	12/11/1994	0001	LU	O	0.057			#	0.001	-
	mg/L	0136	12/11/1994	0002	LU	O	0.051			#	0.001	-
	mg/L	0136	07/15/1995	0001	LU	O	0.078			#	0.001	-
	mg/L	0136	07/15/1995	N001	LU	O	0.076			#	0.001	-
	mg/L	0136	12/10/1995	0001	LU	O	0.056			#	0.001	-
	mg/L	0136	12/10/1995	N001	LU	O	0.061			#	0.001	-
	mg/L	0136	03/26/1997	0001	LU	O	0.0461			#	-	-
	mg/L	0136	08/05/1998	0001	LU	O	0.0781			#	-	-
	mg/L	0143	10/27/1999	0001	LC		0.00020	U		#	0.0002	-
	mg/L	0144	10/26/1999	0001	LU		0.0380			#	-	-
	mg/L	0145	10/26/1999	0001	LC		0.00020	U		#	0.0002	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE SLC01, SALT LAKE CITY
REPORT DATE: 1/28/2000 4:16 p

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	SAMPLE: ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	QUALIFIERS: DATA	QUALIFIERS: QA	DETECTION LIMIT	UN-CERTAINTY

RECORDS: SELECTED FROM USEE200 WHERE site_code='SLC01' AND location_code in('0130','0131','0132','0133','0134','0136','0143','0144','0145') AND quality_assurance = TRUE AND (NOT (data_validation_qualifiers LIKE '*R*' OR data_validation_qualifiers LIKE '*X*') OR IsNull(data_validation_qualifiers)) AND cas in('07440-38-2 ','07439-98-7 ','07440-61-1 ')

SAMPLE ID CODES: 000X = Filtered sample (0.45 µm). N00X = Unfiltered sample. X = replicate number.

LAB QUALIFIERS:

- * Replicate analysis not within control limits.
- + Correlation coefficient for MSA < 0.995.
- A TIC is a suspected aldol-condensation product.
- B Inorganic: Result is between the IDL and CRDL. Organic: Analyte also found in method blank.
- E Inorganic: Estimate value because of interference, see case narrative. Organic: Analyte exceeded calibration range of the GC-MS.
- Z Laboratory defined (USEPA CLP organic) qualifier, see case narrative.
- H Holding time expired, value suspect.
- I Increased detection limit due to required dilution.
- C Pesticide result confirmed by GC-MS.
- M GFAA duplicate injection precision not met.
- N Inorganic or radiochemical: Spike sample recovery not within control limits. Organic: Tentatively identified compund (TIC).
- S Result determined by method of standard addition (MSA).
- U Analytical result below detection limit.
- W Post-digestion spike outside control limits while sample absorbance < 50% of analytical spike absorbance.
- D Analyte determined in diluted sample.
- P > 25% difference in detected pesticide or Arochlor concentrations between 2 columns.
- X Laboratory defined (USEPA CLP organic) qualifier, see case narrative.
- Y Laboratory defined (USEPA CLP organic) qualifier, see case narrative.
- > Result above upper detection limit.

DATA QUALIFIERS:

- J Estimated value.
- L Less than 3 bore volumes purged prior to sampling.
- U Parameter analyzed for but was not detected.
- F Low flow sampling method used.
- R Unusable result.
- G Possible grout contamination, pH > 9.
- X Location is undefined.

QA QUALIFIER: # = validated according to Quality Assurance guidelines.

Attachment H

MACTEC-ERS
2597 B 3/4 Road
Grand Junction, Colorado 81503

Borehole Summary

F y Salt Lake City UMTRA Site Salt Lake City Project Umtra Groundwater

Boring/Well No. 143 Location (N) _____ (E) _____

Ground Elev. (Ft.) _____ Bit/Auger Size 8 5/8-65', Diameter (inch I. D.) Hole Depth (Ft) 140

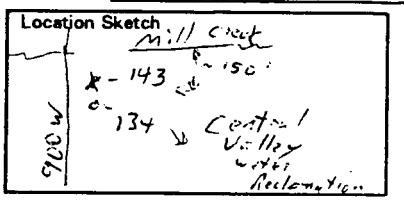
No. of Completions 1

Stick-Up Height (Ft) _____

Slot Size 0.020

	TYPE	Vol. (cf. gal)	Interval (Ft.)
Blank Casing	Sed. 40 pvc	2"	0 to 125.75
Screen	Machine Slotted	2"	125.75 to 135.75
Sump/End Cap	Sed. 40 pvc	2"	135.75 to 136.0
Sand Pack	20-40 / 10-20 Co. S. lica		140.0 to 122.5 / 122.5 to 119.0
Sealant	Bentonite pellets	3/8"	119.0 to 112.0
Grout	30% solids bentonite		112.0 to 1.0

Location Sketch



Locking Cover Installed Y / N Padlock No. _____

Drilling Method Reverse Circ. 8 5/8, Rotary 65-135, 5 7/8" Sampling Method 5 ft. interval grab

Date Drilled 9/27-10-1/99 Date Developed _____ Fluid Level/Date Artesian

Sampler(s) Traub / Spencer Remarks Low carbon steel casing from 0 - to 65 bgl.

Depth[a] (FT)	Blows/ 6"	PID ppm	Sample No.; Interval	WELL CONSTRUCTION	GRAPHIC LOG	DESCRIPTION
						Drilled by Layne, SLC, Scott Copley
						Required Information: Typical name; Munsell color; percentage sand and gravel; sorting (poor to well); grain angularity; induration or plasticity; moisture content (moist to saturated).
0				Flush	GW	0-5', Sandy gravel, well graded, subangular pebbles to 1", brown, Sl. moist
5					GC	5-10, clayey gravel, ~~m~~moist, grey, subangular pebbles to 1", well
10					ML	10-15 - Silt, sl clayey, sl sandy, v low plas., greyish brown, 2.5Y 5/2, moist-wet
15						15-20, Silty Sand, saturated, dk grey, 2.5Y 5/1 no pebbles, fine to v. fine 0942
20						~18', drilling caused water to flow out of 134, 10' to south
25						20-25, sandy Silt, dark blueish grey, Gley 2-3/1, 10B saturated, fine to ~~f~~ very fine gr. sl clayey, low plas. - Really blowing water from 134 as discharge line clogs up.
30						25-30 1050
35						~35-50 - Mixed recovery due to clays/silts clogging discharg.
40						clayey silt, dk gray, wet, firm at 50' scattered lenses of clay, (silty, plastic, firm.
50						

a - All depths measured from ground level.

Completed By D. Traub / L. Spencer Verified By _____

MACTEC-ERS
2597 B 3/4 Road
Grand Junction, Colorado 81503

Borehole No. SLC-143 Date 9-28-99

Depth (FT)	Blows/ 6"	PID ppm	Sample No.: Interval	Well Construction	Graphic Log	DESCRIPTION
						Poor recovery this interval
50					ML	50 - Clayey silt, grey, saturated, firm
55						55-60, Clayey Silt, dk gray, low plas. sl sandy Very fine gr. wet ~ firm to ~ 63 then easier drilling
60						60-65 - Silty sands, moist, not saturated (Flowing) dk grey, fine to very fine, no clay, Clay 1 4/N No more discharge from 134 while cleaning out boring 1128
70					SM	
80						- Rotary drill to 135'. 5 7/8" Tricone
90						
100						95 - silty sand, very fine grained, grey, saturated, sl clayey, no plas. Sl. sticky
						98' - Driller reports formation change, softer drilling. Sand is coarser, fine to med gr.
110						
120						127 - silty clay / clayey silt, ~ 20% very fine sand, low plas, dk. grey.
130						
140						

All depths measured from ground level.

Completed By D.T / L.S. Verified By

Well No. 143 Date 10-1-99 Time 1300 hr.

Casing diameter	2"
casing stickup	
Top of grout	1.0 ft
Grout type	Aquagard - 30% solids bentonite
Top of pellets	112.0
Size of pellets	3/8"
Water added to pellets	NONE
Top of fine sand	119
Sand size	10-20
Top of filter sand	122.5
Filter sand size	20-40
Top of screen section	125.75
Top of slots	126.08
Type of screen	Johnson
Slot size	0.020
Bottom of slots	135.42
Top of sump	135.75
Bottom of sump	136.0

Total depth of well

MACTEC-ERS
2597 B 3/4 Road
Grand Junction, Colorado 81502

Borehole Summary

Fa: Grand Junction Operations Site Salt Lake City WELL NUMBER 144

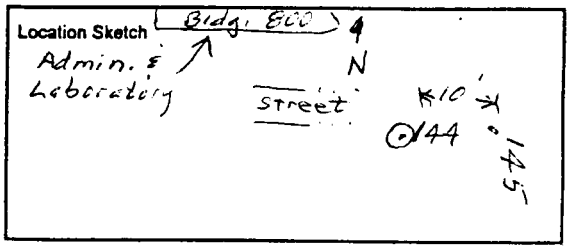
Ground Elev. (Ft.) _____ Bit / Auger Size 8 1/4" OD 6" ID. Location (N) _____ (E) _____

Drilling Contractor Layne

Hole Depth (Ft) 40.5
Well Depth (Ft) 40.0
No. of Completions 1
Stick-Up Height (Ft) Flush
Slot Size 0.020

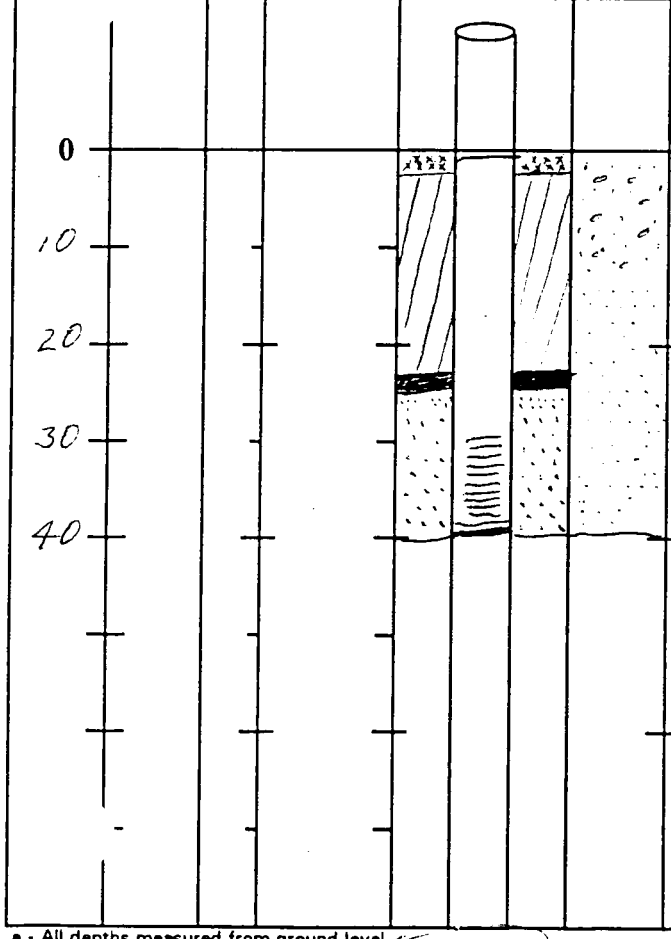
	TYPE	Vol. (ft³ / gal)	Interval (Ft.)
Surface Casing			to
Blank Well Casing	Sch. 40 pvc	2"	0 to 30
Well Screen	Machine Slotted	2"	29.7 to 39.7
Sump/End Cap	Sch. 40 pvc	2"	39.7 to 40.0
Lower Sand Pack	Co. Silica	20-40 0.7 ft³	40.5 to 27.6
Upper Sand Pack	Co. Silica	10-20 0.25 ft³	27.6 to 25.6
Bentonite Seal	Bentonite pellets	3/8" 0.5 ft³	25.6 to 23.7
Grout	Cement/bentonite ~~30% solids bentonite~~	6.5 ft³	23.7 to 1.0
Concrete	Sackrete	0.25 ft³	1.0 to 0.5

Location Sketch



Locking Cover Installed (Y) / N Padlock No. 3359
Drilling Method Auger Mobil B-57 Sampling Method None
Date Drilled 10-1-99 Date Developed _____ Fluid Level / Date 10.11 t.o.c. 10-4-99
Sampler(s) _____ Remarks _____

Depth[a] (FT)	Blows / 6"	PID ppm	Sample No.; Interval	WELL CONSTRUCTION	GRAPHIC LOG	DESCRIPTION
						Required Information: Typical name; Unified Soil Classification, Munsell color; percentage sand and gravel; sorting (poor to well); grain angularity; induration or plasticity; moisture content (moist to saturated).
0						Lithologic Log
10						See well # 145
20						
30						
40						



a - All depths measured from ground level

Completed By Patrick Spencer Verified By _____

WELL NO. 144 DATE 10-1-99 TIME 1330 hr.

PLANNED INSTALLATION		FINAL INSTALLATION
CASING DIAMETER 2"		
CASING STICKUP HEIGHT Flush		CASING STICKUP HEIGHT
TOP OF GROUT 3.0 Cement w/10% bentonite mix		TOP OF GROUT
GROUT TYPE 30% solids bentonite (Aquaguard)		
TOP OF PELLETS 23.7		TOP OF PELLETS
SIZE OF PELLETS 3/8 sphere		
WATER ADDED TO PELLETS (Gallons) None		
TOP OF FINE SAND 25.6		TOP OF FINE SAND
SAND SIZE 0.020		
TOP OF FILTER SAND 27.6		TOP OF FILTER SAND
FILTER SAND SIZE 10-20		
TOP OF SCREEN SECTION 29.7		TOP OF SCREEN
TOP OF SLOTS 30.0		
TYPE OF SCREEN Johnson machine slot		
SLOT SIZE 0.020		
BOTTOM OF SLOTS 59.4		
TOP OF SUMP/END CAP 39.7		TOP OF SUMP/END CAP
BOTTOM OF SUMP/END CAP ~~39.7~~ 40.0		BOTTOM OF SUMP/END CAP

TOTAL DEPTH 40.5

MACTEC-ERS
2597 B 3/4 Road
Grand Junction, Colorado 81503

Borehole Summary
Page 1 of 2

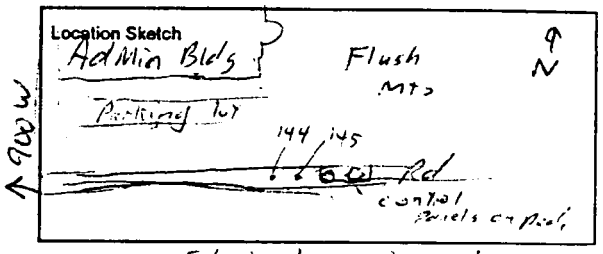
Facility Salt Lake City UMTRA Site Central Valley Water Reclamation WELL NUMBER 145

Ground Elev. (Ft.) _____ Bit / Auger Size 8 1/4" Auger Location (N) _____ (E) _____

Drilling Contractor Layne Christensen, SLC, Scott Copley

Hole Depth (Ft) 140.0
Well Depth (Ft) 135.0
Well Diameter 2"
No. of Completions 1
Stick-Up Height (Ft) Flush
Slot Size 0.020

	TYPE	Vol. (ft³ / gal)	Interval (Ft.)
Surface Casing	Steel	6"	-0.3 to 55'
Blank Well Casing	Sch. 40 pvc	2"	0 to 124.7
Well Screen	Machine Slotted	2"	124.7 to 134.7
Sump/End Cap	Sch. 40 pvc	2"	134.7 to 135.0
Lower Sand Pack	Colo. Silica	20-40 1.7 ft³	140.0 to 120.0
Upper Sand Pack	Co. Silica	10-20 0.25 ft³	120. to 118.0
Bentonite Seal	Bent. Pellets	3/8" 0.25 ft³	118.0 to 116.0
Grout	30% solids bent.	11.0 ft³	116.0 to 1.5
Concrete	Sackrete	1.7 ft³	1.5 to 0.5

Location Sketch


Locking Cover Installed Y / N Padlock No. _____
Drilling Method Reverse Circ. / Mobile B57
Date Drilled 9-29-97 Date Developed -0-
Sampler(s) _____

Sampling Method 10 ft. interval grab
Fluid Level / Date Artesian
Remarks Drilled w/ODEX changed to auger

Low carbon steel casing to 55 bgl.

Depth[a] (FT)	Blows / 6"	PID ppm	Sample No.; Interval	WELL CONSTRUCTION	GRAPHIC LOG	DESCRIPTION
				Flush		**Required Information:** Typical name; Munsell color; percentage sand and gravel; sorting (poor to well); grain angularity; induration or plasticity; moisture content (moist to saturated); Unified Soil Classification.
0					GM	Silty gravel, sl clayey, olive brown, 2.5Y 4/4, well sorted, ~~Subangular~~ rounded pebbles to 3/4", moist 10:36 start casing hole
5					GC	5-10' clayey gravel, subrounded pebbles, well sorted. wet, low plasticity, ~~silty~~ sl silty
10					CL	10-15. sl clayey silt, very dark grey, Gley 1 3/N clogs up discharge hoses. sandy, with small subrounded pebbles
15					CL	15-20, clayey silt, 5% subrounded pebbles to 1/2", grey casing pretty much dropping on its own weight
20						20-25. clayey silt / silty Clay, dark grey G 1 4/N very little fine to very fine sand. Saturated. Most of cuttings staying down hole 11:54
25						
30					SP	30-35: Poor recovery, most returns are going into formation. Sand, fine gr, no pebbles minor silt. Saturated, grey. Gley 1 5/N. Subangular grains, ~75% are thin ~~green~~ granite mineral fragments
40						

a - All depths measured from ground level.

11/3/98

Completed By L. Spencer / D. Traub Verified By _____

MACTEC-ERS
2597 B 3/4 Road
Grand Junction, Colorado 81503

Borehole No. 145

Date 9/29/99

Borehole Summ
Page 2 of 2

Depth (FT)	Blows/ 6"	PID ppm	Sample No.; Interval	Well Construction	Graphic Log	DESCRIPTION
40						- Flowing sands ~~to~~ locked edex bit i ODEX casing. Had to pull entire string to wash it out. Layne brought in auger rig to set casing with 10" augers.
45						
50						Drilling stiffened up at 50'; will set casing at 55'
55						55-79 silty sand, gray (10YR 5/1) a few intervals up to 2ft thick very slightly sticky; saturated, fn. gr. sands silt w/ a trace of cla
65						poorly graded, subangular to subrounded SM/
						79-89 Silty sand, gray (10YR 5/1) 95% fn to very fn gr. subangular to subrounded sand, 5% silt, non sticky, poorly graded, saturated SM
75						
						89-99 Same as above but slightly sticky
85						99-109 Silty sand, med. to fn. gr., gray (10YR 5/1) non sticky, poorly graded, sat. SM
95						109-129 Sand, gray (10YR 5/1). 95% fn. to coarse gr. subrounded to subangular sand, 5% silt and clay, slightly sticky, well graded, sat.
105						low plasticity ML Note: Sand consists of qtz grains, dark mineral grains, y white chert grains, green, red, orange, b mineral grains and some pyrite? - Has somewhat of swampy odor.
115						
125						129-139 Silty sand, gray (10YR 5/1) same as above but fn. to med. grained, very slightly sticky 95% sand, 5% silt, poorly graded.
135						
TD. 140						

All depths measured from ground level.

Completed By L.S / D.T

Verified By

WELL NO. 145 DATE 10-2-99 TIME 1500

PLANNED INSTALLATION		FINAL INSTALLATION
CASING DIAMETER 2		
CASING STICKUP HEIGHT flush		CASING STICKUP HEIGHT _____
TOP OF GROUT 1.5		TOP OF GROUT _____
GROUT TYPE 30% solids bentonite Aquaguard		
TOP OF PELLETS 116		TOP OF PELLETS _____
SIZE OF PELLETS 3/8" sphere		
WATER ADDED TO PELLETS (Gallons) None		
TOP OF FINE SAND 118		TOP OF FINE SAND _____
SAND SIZE 10-20		
TOP OF FILTER SAND 120		TOP OF FILTER SAND _____
FILTER SAND SIZE 20-40		
TOP OF SCREEN SECTION 124.7		TOP OF SCREEN _____
TOP OF SLOTS 125.0		
TYPE OF SCREEN Johnson Machine Slotted		
SLOT SIZE 0.020		
BOTTOM OF SLOTS 134.7		
TOP OF SUMP/END CAP 134.7		TOP OF SUMP/END CAP _____
BOTTOM OF SUMP/END CAP 135.0		BOTTOM OF SUMP/END CAP _____

TOTAL DEPTH 140.0

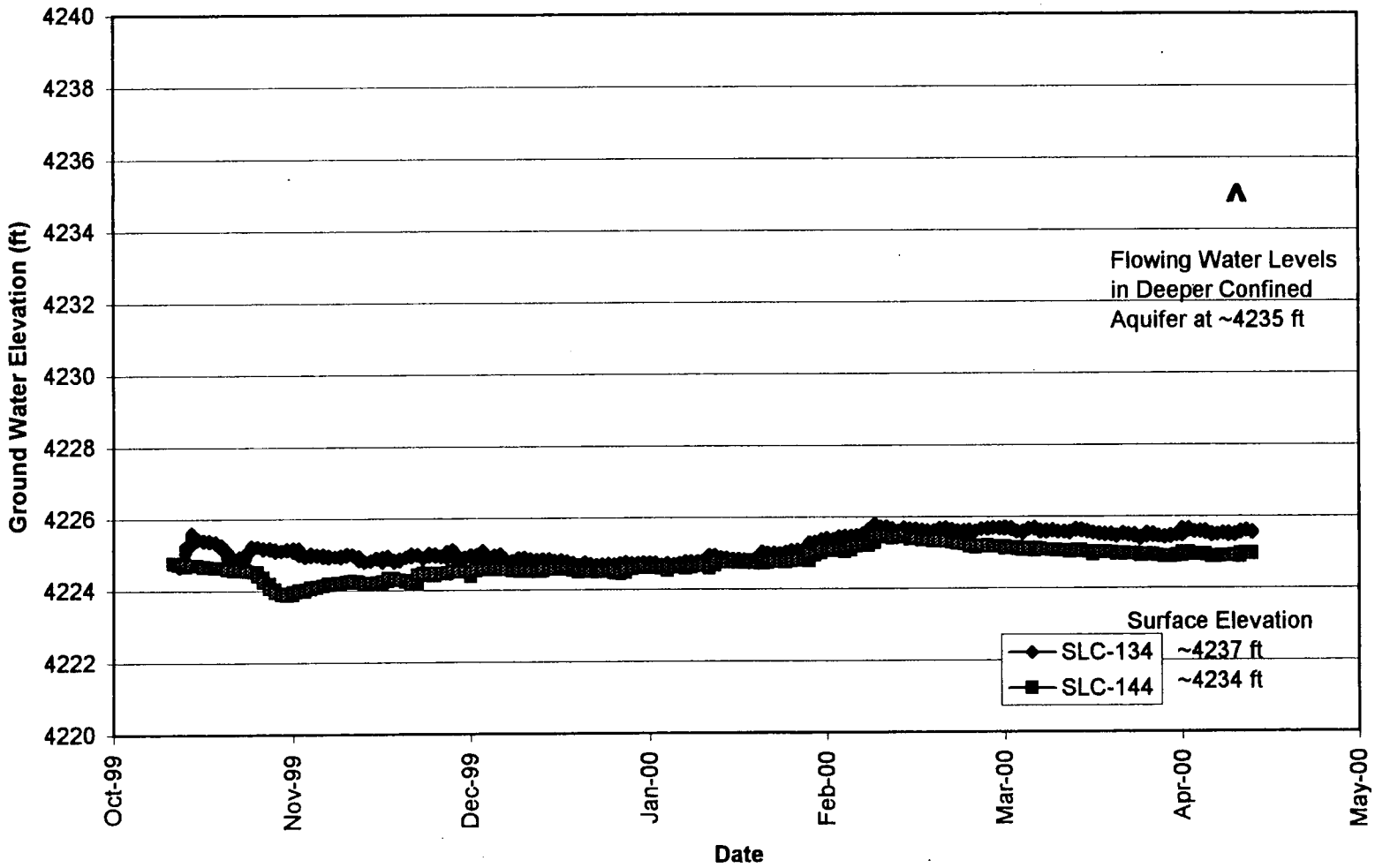
STATIC GROUND WATER LEVELS (USEE700) FOR SITE SLC01, SALT LAKE CITY
REPORT DATE: 1/28/2000 4:21 pm

LOCATION CODE	FLOW CODE	TOP OF CASING ELEVATION (FT NGVD)	MEASUREMENT		DEPTH FROM TOP OF CASING (FT)	GROUND WATER ELEVATION (FT NGVD)
			DATE	TIME		
0134	D	4239.50	07/22/1992	15:35	14.65	4224.85
		4239.50	10/09/1992	09:48	15.27	4224.23
		4239.50	10/27/1993	12:33	13.23	4226.27
		4239.50	02/11/1994	10:02	13.92	4225.58
		4239.50	12/07/1994	10:31	13.29	4226.21
		4239.50	07/11/1995	16:03	12.02	4227.48
		4239.50	12/06/1995	09:47	14.78	4224.72
		4239.50	08/04/1998	10:35	11.52	4227.98
		4239.50	08/04/1998	13:48	11.52	4227.98
		4239.50	10/27/1999	08:17	14.78	4224.72
0143		-	10/27/1999	10:00	0.00	flowing
0144		-	10/26/1999	14:40	9.19	-9.19
0145		-	10/26/1999	15:00	0.00	flowing

RECORDS: SELECTED FROM USEE700 WHERE site_code='SLC01' AND location_code in('0134','0143','0144','0145')

FLOW CODES:
D DOWN GRADIENT

Salt Lake City, UT
Ground Water Elevations
in Shallow Unconfined Aquifer



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08 May

SSL
CITY OF SOUTH SALT LAKE
OFFICE OF THE MAYOR

PHONE (801) 483-6000
FAX (801) 483-6001

RANDY G. FITTS
MAYOR

220 EAST MORRIS AVENUE • SOUTH SALT LAKE CITY, UTAH
84115-3284

July 28, 1999

Donald Metzler, Program Manager
United States Department of Energy
2597 B. 3/4 Road
Grand Junction, Colorado 81503

Re: Decommissioning of Vitro Well

Dear Mr. Metzler,

Please consider this as the official request of the City of South Salt Lake to decommission the culinary well located on the old vitro tailing site located at approximately 3300 South 500 West, Salt Lake City, Utah.

It is our understanding that the Department of Energy will cause this work to be completed and to pay for the same.

If you have any questions concerning this matter, please feel free to contact me.

Sincerely,

Randy G. Fitts
Mayor

RGF/HCH/rpf

cc: Rob Herbert, Utah Division of Radiation Control

WELL ABANDONMENT REPORT
State of Utah
Division of Water Rights

1. Well Identification

UNIDENTIFIED ABANDONMENT ID # SSL - 8

2. Owner *Note any changes*

VITRO SITE
Salt Lake City UT

Contact Person/Engineer: DICK HEIDENBURG / MACTEC - ERS

3. Well Location *Note any changes*

POD:

Location Description: (address, proximity to buildings, landmarks, ground elevation, local well #) SSL - 8

4. Existing Well Details Is a Well Driller's Report Available? ☐ Yes ☒ No

Well Depth 867 feet Well Diameter 10 inches

Nature of Use: ☐ Dom. ☐ Irr. ☐ Stock ☒ Industrial ☐ Commercial ☐ Municipal ☐ Provisional ☐ Monitor ☐ Other

Casing Type: ☒ Steel ☐ Stainless Steel ☐ PVC ☐ Fiberglass ☐ ABS ☐ SR ☐ Other

☐ Screen ☒ Perforations ☐ Open Pipe Screen/Perforation Interval 575' TO 848'

Filter Pack ☐ Yes ☐ No UNKNOWN Depth of Surface Seal UNKNOWN

Static Water Level 15 feet Flowing Well? ☐ Yes ☒ No

Other details (if known)

5. Abandonment Details Date of Abandonment 9/28/99

Reason for Abandonment OLD WELL, NO LONGER UTILIZED

Method of Abandonment (Include a description of seal placement and procedures, amount of casing/screen removed, pump/piping removal, termination of casing at the surface, problems encountered, and other pertinent information)

TREMIE GROUT CEMENT AND CUT 2' BELOW GRADE

Abandonment Material Details:

DEPTH (feet)

From	To	ABANDONMENT MATERIAL	QUANTITY (e.g., cubic yards, lbs)	GROUT WEIGHT (e.g. lbs/gal.#bag mix, gal/sack)
0	867	CEMENT BENTONITE MIXTURE	16 YARDS	13 BAG MIX

☐ Abandoned well replaced with a new well.

If yes, the location of the new well is _____ ft north/south and _____ ft east/west from the abandoned well.

6. Well Driller Statement This well was abandoned under my supervision, according to applicable rules and regulations, and this report is complete and correct to the best of my knowledge and belief.

Name LAYNE CHRISTENSEN COMPANY License No. 6262
(Person, Firm, or Corporation – Print or Type)

Signature _____ Date 11/8/99
(Licensed Well Driller)

Note: All abandonment work shall be performed in accordance with the provisions of the State of Utah Administrative Rules of Water Well Drillers Section R655-4-12.

Attachment I

NOTICE OF RESIDUAL RADIOACTIVE CONTAMINATION

THIS NOTICE IS TO ALERT BUYERS OR DEVELOPERS THAT RESIDUAL RADIOACTIVE CONTAMINATION EXITS ON THE PROPERTY HEREIN DESCRIBED.

RECITALS

A. WHEREAS, the current owner of the property known as the Salt Lake Vitro Site situated in the county of Salt Lake, Salt Lake City, Utah, and more particularly described on Exhibit 1 attached hereto is Central Valley Water Reclamation Facility Board located at 800 West Central Valley Road, Salt Lake City, Utah, 84119;

Received Division Of Radiation Control

B. WHEREAS, the Salt Lake Vitro Site was used by the Vitro Chemical Company to process uranium ore from 1951 to 1964 and to process vanadium ore from 1964 to 1968;

C. WHEREAS, when milling operations were discontinued in 1968, more than four million tons of uranium mill tailing waste remained on the Salt Lake Vitro Site;

D. WHEREAS, under the Uranium Mill Tailings Radiation Control Act of 1978 (Public Law 95-604), which requires the remediation of the identified uranium mill tailing sites, the United States Department of Energy and the state of Utah entered into Cooperative Agreement Number DE-FC04-81AL616309, dated March 30, 1983, for the remediation of the Salt Lake Vitro Site; between 1985 and 1987 excavation and disposal of the uranium mill tailings and site restoration were performed;

E. WHEREAS, not all residual radioactive materials were removed during remedial action, isolated areas of the radioactive contamination remain, examples of which are shown on the map attached hereto as Exhibit 2;

F. WHEREAS, the cleanup of the Salt Lake Vitro Site is documented in the *Completion Report for the UMTRA Project Vitro Processing Site Salt Lake City, Utah*, ("Completion Report") dated June 1997 which provides a discussion of the known contaminated areas, including an estimate of the amount of contamination present, the approximate location of the radioactive contamination, and a health assessment resulting from exposure to the contaminants; and

G. WHEREAS, the Completion Report may be examined at and copies obtained from the following:

State of Utah
Department of Environmental Quality
Division of Radiation Control
168 North 1950 West, Building #2
Salt Lake City, UT 84114-4850
(801) 536-4250

Department Of Energy
Grand Junction Office
2597 B 3/4 Road
Grand Junction, CO 81503
(970) 248-6000

Department of Commerce
National Technical Information Services
5232 Port Royal Road
Springfield, VA 22161
(703) 487-4650

H. NOW THEREFORE the United States Department of Energy, the state of Utah, and the Central Valley Water Reclamation Facility Board hereby recommend to prospective purchasers or developers of part or all of the Salt Lake Vitro Site that the following actions be taken:

1. Verify that future construction plans do not occur in contaminated areas. If there is a possibility of encountering contaminated material, contact the Utah Department of Environmental Quality, Division of Radiation Control.

2. Prior to construction, conduct appropriate radiological surveys to determine whether radioactive elements are present, and their identity, concentration, and distribution.

3. If radioactive materials are encountered during construction, the materials may be; (a) dispensed of as radioactive waste in an appropriate waste facility; or (b) buried into the deepest part of the excavation during back filling.

4. Regardless of the results of the radiological surveys, if there are construction plans for habitable structures (e.g., residential, institutional, commercial, or industrial buildings and the like), consider installing a passive sub-slab radon ventilation system that will vent radon soil gas to the atmosphere.

Dated this 26th day of August, 1997

UNITED STATES DEPARTMENT OF ENERGY

By: George J. Rael
George Rael
Director
Environmental Restoration Division

STATE OF NEW MEXICO)
) ss.
COUNTY OF BERNALILLO)

Before me, a Notary Public qualified for Bernalillo County, personally appeared George Rael, who by me duly swore did say that he is the Director of the Environmental Restoration Division and he further acknowledged to me that the above NOTICE OF RESIDUAL RADIOACTIVE CONTAMINATION document was duly executed by him on behalf of the United States Department of Energy.

WITNESS my hand and Notarial Seal on this 26th day of August, 1997.

Michele S Montoya
Notary Public

Residing at: Albuquerque NM

My Commission Expires: 5/25/2001

Dated this 3rd day of September, 1997

STATE OF UTAH
DEPARTMENT OF ENVIRONMENTAL QUALITY

By: William J. Sinclair
William Sinclair
Director
Division of Radiation Control

STATE OF UTAH)
) ss.
COUNTY OF SALT LAKE)

Before me, a Notary Public qualified for Salt Lake County, personally appeared William Sinclair, who by me duly swore did say that he is the Director of the Division of Radiation Control and he further acknowledged to me that the above NOTICE OF RESIDUAL RADIOACTIVE CONTAMINATION document was duly executed by him on behalf of the state of Utah.

WITNESS my hand and Notarial Seal on this 3rd day of Sept., 1997.

Mary Charlene Lamph
Notary Public

NOTARY PUBLIC
Mary Charlene Lamph
168 North 1950 West
Salt Lake City, Utah 84116
My Commission Expires
September 9, 1999
STATE OF UTAH

Residing at: Salt Lake City

My Commission Expires: Sept. 9, 1999

Dated this 11 day of Sept., 1997

CENTRAL VALLEY WATER RECLAMATION FACILITY BOARD

By: Reed Fisher
Reed Fisher
General Manager

STATE OF UTAH)
) ss.
COUNTY OF SALT LAKE)

Before me, a Notary Public qualified for Salt Lake County, personally appeared Reed Fisher, who by me duly swore did say that he is the General Manager of the Central Valley Reclamation Facility and he further acknowledged to me that the above NOTICE OF RESIDUAL RADIOACTIVE CONTAMINATION document was duly executed by him on behalf of the Central Valley Water Reclamation Facility Board.

WITNESS my hand and Notarial Seal on this 11th day of September 1997.

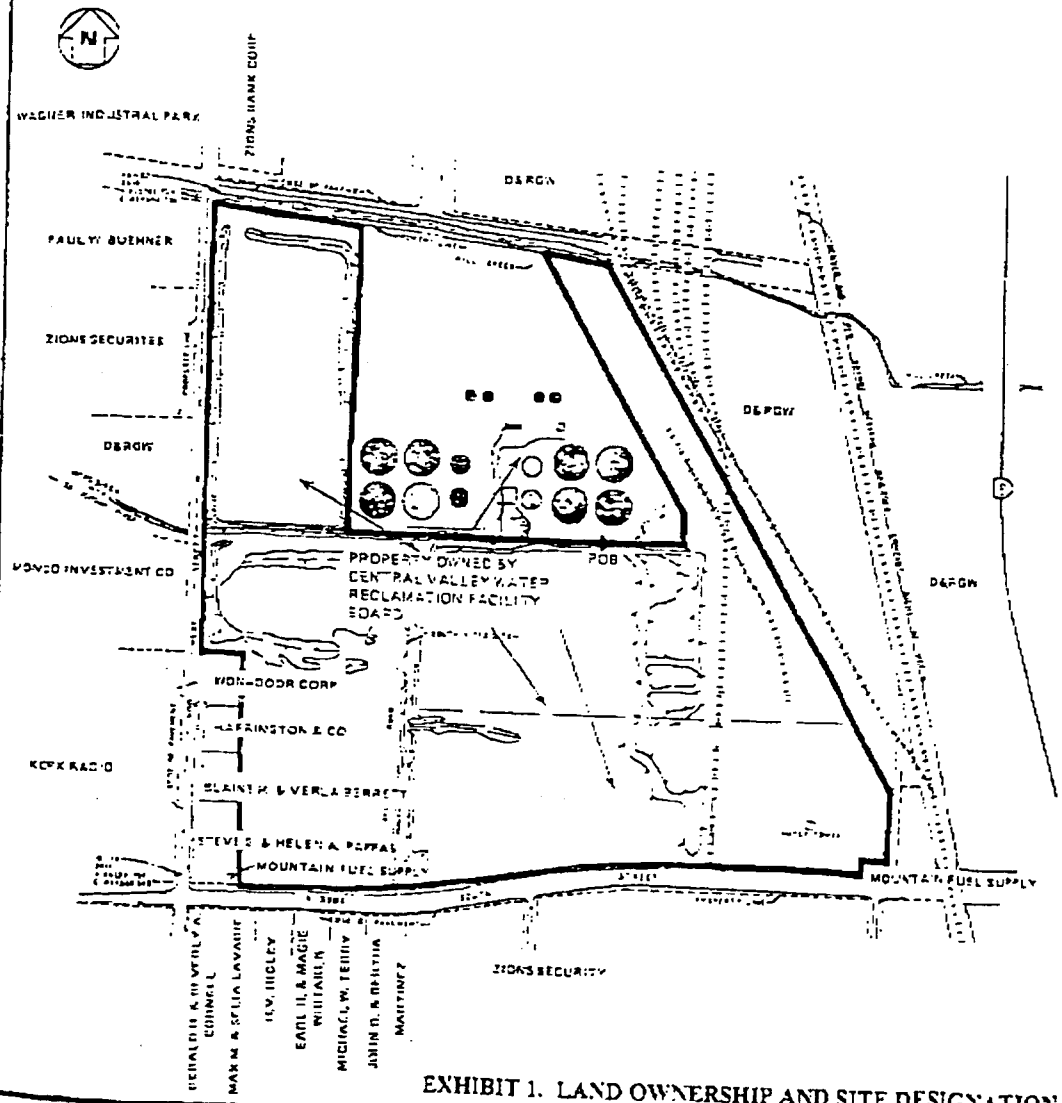
Beverly N. Bell
Notary Public

NOTARY PUBLIC
BEVERLY N. BELL
800 W. Central Valley Rd.
So. Salt Lake, Utah 84119
My Commission Expires
September 30, 1997
STATE OF UTAH

Residing at: Salt Lake City, UT

My Commission Expires: 09/30/97

Ford, Bacon & Davis Utah, Inc.



SALT LAKE VITRO SITE

BEGINNING AT THE EAST QUARTER CORNER OF SECTION 26, T1S, R1W, SALT LAKE BASE AND MERIDIAN, AND RUNNING THENCE WEST 1154.5 FT, THENCE N 0°18'E, 1440.79 FT, THENCE N 83°16'W, 851.84 FT, THENCE S 0°03'14"W, 2078.59 FT, THENCE S 85°50'E, 179.5 FT, THENCE S 1°57'E, 1062.87 FT, THENCE N 89°43'47"E, 506.52 FT, THENCE N 85°50'27"E, 195.77 FT, THENCE N 80°45'E, 473.05 FT, THENCE N 81°32'32"E, 168 FT, THENCE N 80°44'E, 489.21 FT, THENCE N 89°55'16"E, 958.8 FT, THENCE N 75 FT, THENCE E 150 FT, THENCE N 0°01'E, 302.88 FT, THENCE N 29°59'W, 2721.01 FT, THENCE N 85°48'W, 295.88 FT, THENCE S 29°54'30"E, 1265.21 FT, THENCE S 170.75 FEET, THENCE W 379.39 FT TO THE POINT OF BEGINNING

CONTAINS 127.9 ACRES (MORE OR LESS)

REFERENCE 3

EXHIBIT 1. LAND OWNERSHIP AND SITE DESIGNATION MAP

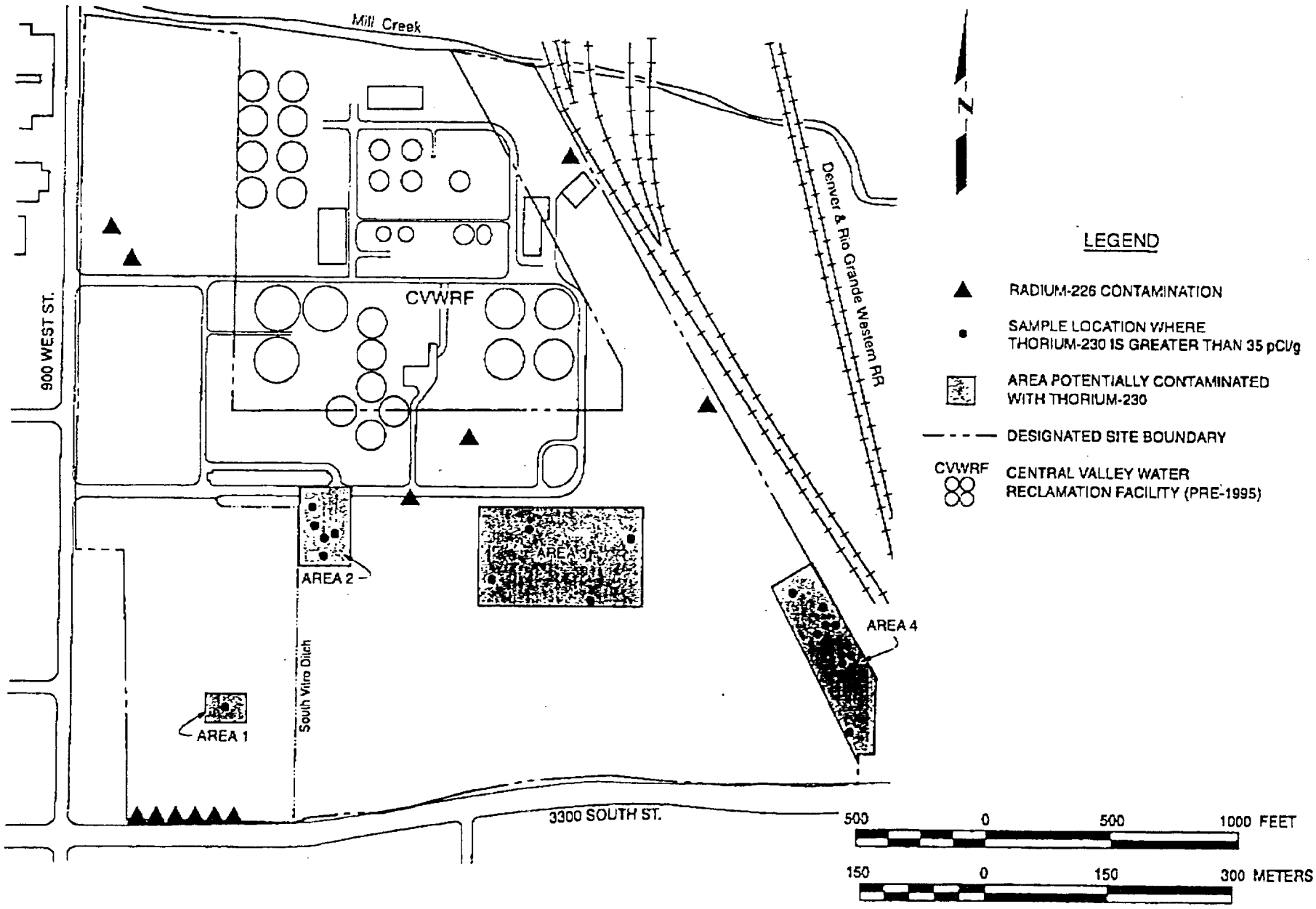


EXHIBIT 2
POST-REMEDIATION RADIOACTIVE CONTAMINATION AREAS
SALT LAKE CITY, UTAH, VITRO PROCESSING SITE