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UMTRA GROUND WATER PROJECT

Ground Water Compliance Action Plan for the Lakeview, Oregon, UMTRA Project Site

August 1999

Prepared by the

U.S. Department of Energy

Grand Junction Office

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA ·

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Grand Junction, Colorado

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1.0 Introduction

The United States Congress passed the Uranium Mill Tailings Radiation Control Act (UMTRCA) (42 USC §7901 *et seq.*) in 1978 in response to public concerns about potential health hazards from long-term exposure to uranium mill tailings. UMTRCA authorized the U.S. Department of Energy (DOE) to stabilize, dispose of, and control uranium mill tailings and other contaminated materials at inactive uranium-ore processing sites.

Three UMTRCA titles apply to uranium-ore processing sites. Title I designates 24 inactive processing sites for remediation. It directs the U.S. Environmental Protection Agency (EPA) to promulgate standards, mandates remedial action in accordance with these standards, stipulates that remedial action be selected and performed with the concurrence of the U.S. Nuclear Regulatory Commission (NRC) and in consultation with the affected states and Indian tribes, directs NRC to license the disposal sites for long-term care, and directs DOE to enter into cooperative agreements with the affected states and Indian tribes. Title II applies to active uranium mills. Title III applies only to certain uranium mills in New Mexico. The Uranium Mill Tailings Remedial Action (UMTRA) Project is responsible for administering only Title I of UMTRCA. In 1988, Congress passed the Uranium Mill Tailings Remedial Action Amendments Act (42 USC §7922 *et seq.*), authorizing DOE to extend without limitation the time needed to complete ground water remediation activities at the processing sites.

From 1986 to 1988, 736,000 tons of uranium mill tailings and other process-related solid waste were removed from the Lakeview, Oregon, processing site and moved to a disposal cell located on the Collins Ranch about 7 miles northwest of Lakeview. In some areas of the former raffinate or evaporation ponds, contaminated materials were removed from depths of more than 50 feet (ft) below ground surface. The *Remedial Action Plan and Site Design for Stabilization of the Inactive Uranium Mill Tailings Site at Lakeview, Oregon* (RAP) (DOE 1992) was issued for the Lakeview site. This Ground Water Compliance Action Plan (GCAP) will serve as a modification to Section 2.4 of the RAP and is the concurrence document to comply with Subpart B of 40 CFR 192.12.

The proposed compliance strategy for the Lakeview site is illustrated in Figure 1. This proposed action is based on information in the engineering assessment for the site (DOE 1981), the surface environmental assessment (Surface EA) (DOE 1985), the RAP, and the baseline risk assessment (BLRA) (DOE 1996b).

2.0 Ground Water Compliance

DOE is required by the *Final Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project* (PEIS) (DOE 1996a) to follow the framework presented in Figure 1 in selecting the appropriate ground water compliance strategy. The uppermost aquifer consists of a shallow zone (30 ft deep or less) and a deeper zone (60 to 75 ft deep).

DOE has determined that no remediation and the application of supplemental standards based on limited use ground water (40 CFR 192.21[g]) is the appropriate compliance strategy for the Lakeview site. Ground water in the uppermost aquifer is not a current or potential source of

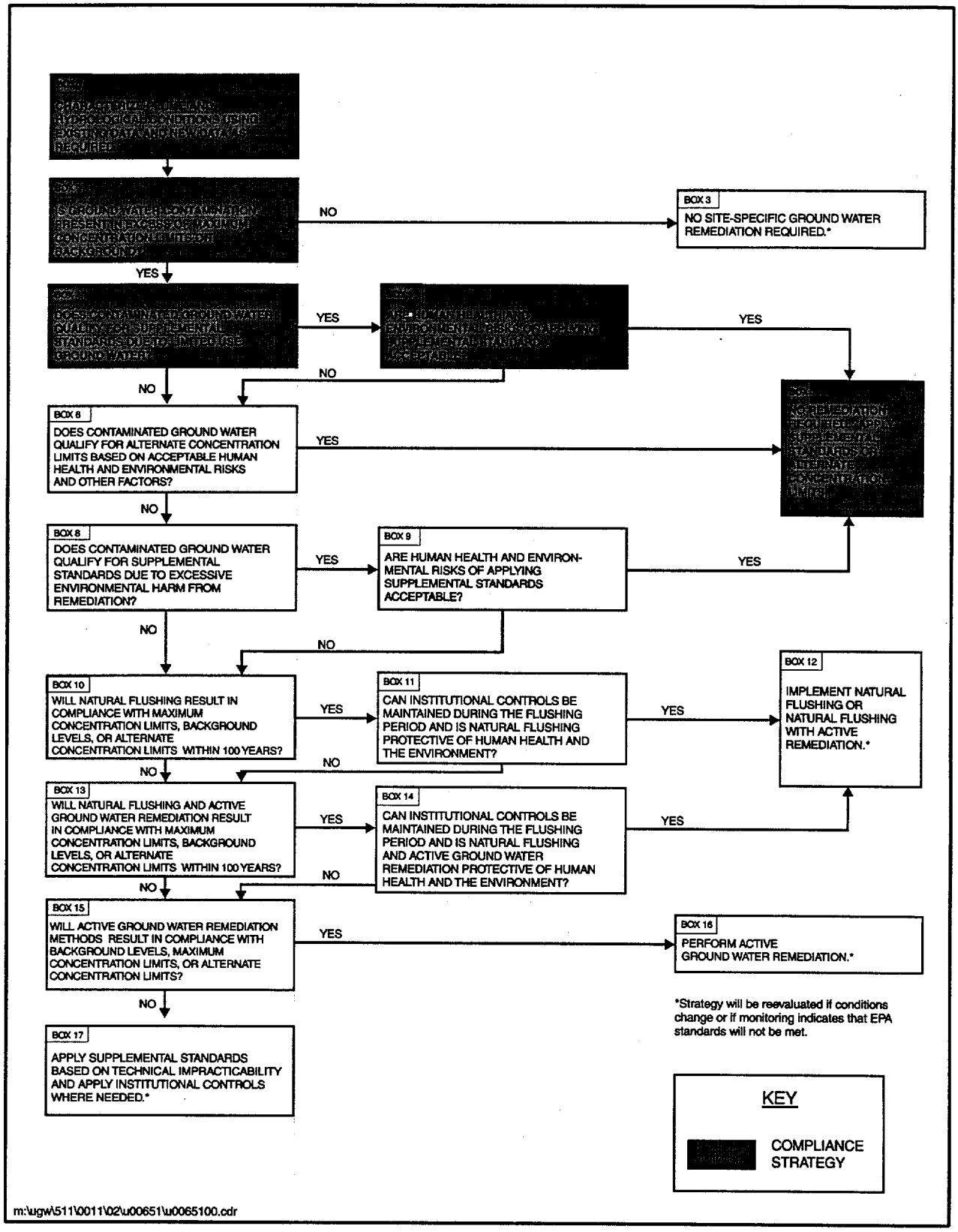

Figure 1. Compliance Selection Framework for the Lakeview, Oregon, Site

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). Potential risks to human health and the environment were addressed in the BLRA (DOE 1996b). Hydrologic information is derived principally from the BLRA, the Surface EA (DOE 1985), and the RAP (DOE 1992).

This proposed action has been determined by applying the compliance strategy selection framework from the PEIS (DOE 1996a), consisting of several evaluative steps presented in the following sections. Figure 1 and Table 1 present a summary of the compliance strategy selection process.

2.1 Assessment of Environmental Data

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

Table 1. Explanation of Compliance Strategy Selection Process

Box (Figure 1)	Action or Question	Result or Decision
1	Characterize plume and hydrologic conditions.	Use of the Surface EA, RAP, BLRA, and March 1999 sample analyses. Go to Box 2.
2	Is ground water contamination present in excess of UMTRA MCLs or background?	Arsenic concentration exceeds the UMTRA MCL. Sulfate and manganese concentrations are above Safe Drinking Water Act suggested limits. Go to Box 4.
4	Does contaminated ground water qualify for supplemental standards due to limited use ground water?	Ground water qualifies for limited use based on widespread, ambient contamination of arsenic from a geothermal source. Go to Box 5.
5	Are human health and environmental risks of applying supplemental standards acceptable?	No one is drinking water contaminated from uranium milling activities. The environment is not being adversely affected by contaminated water. Go to Box 7.
7	No remediation required. Apply supplemental standards or alternate concentration limits.	Supplemental standards are applied. As a best management practice, institutional controls will be adopted and limited monitoring will continue.

MCL = UMTRA Project maximum concentration Limit in 40 CFR 192

The former millsite is located on private land east of County Road 2–18 and north of Missouri Avenue in Section 4, Township 39S, Range 20E (Figure 2). The 258-acre site includes areas formerly occupied by seven raffinate or evaporation ponds and a tailings pile. Pacific Pine Products, a lumber company, now uses the main mill buildings. Barbwire fences enclose the former evaporation pond and tailings pile areas in open fields. The entire site is zoned for commercial–light industrial use.

The regional geology is dominated by fault block structures, as evidenced by the normal fault along the west side of the Warner Mountains and the Goose Lake graben. Volcanic rocks occur in the upthrown fault blocks east and north of Lakeview. Sediments under the site consist of saturated clayey to silty gravels underlain by more than 2,000 ft of basin fill. These units are not laterally continuous, according to interpretations of lithologic logs of boreholes drilled in the area.

Upper and lower zones of ground water have been investigated beneath the Lakeview site. The upper zone is within 30 ft of the ground surface and consists of saturated silty clays and sands that grade downward to clayey and sandy gravels. Discontinuous clay lenses separate the upper zone from the lower zone, which contains more sand and gravel, some clay, and is 60 to 75 ft below ground surface. Ground water communication occurs between the zones. In this area, the ground water moves from northeast to southwest at rates ranging from 50 to 160 ft per year (DOE 1996b). Ground water from a geothermal artesian source northeast of the site flows through the subsurface beneath the site.

2.2 Ground Water Contaminants

The second step compares the concentrations of chemicals of potential concern (COPCs) in ground water with UMTRA Project maximum concentration limits (MCLs) or background levels. Ground water beneath the Lakeview site was contaminated by former uranium-ore processing operations that were ongoing from 1958 through 1961. Site-specific field investigations determined that only the alluvial ground water was affected by the milling operations (DOE 1996b). COPCs in the alluvial aquifer are arsenic, boron, iron, manganese, molybdenum, nickel, sodium, chloride, sulfate, uranium, and polonium-210 (DOE 1996b). Evaluation of 1999 ground water and surface water analyses indicates that the current COPC list should consist only of arsenic, chloride, manganese, and sulfate. Boron, iron, and sodium concentrations are present in background water samples at concentrations comparable to those from millsite samples and should not be considered millsite related. Molybdenum, nickel, and polonium-210 are not present in concentrations high enough to cause concern and are only minor components of the total site risk. Figures 3 through 6 are spot plots that show the distribution of arsenic, chloride, manganese, and sulfate in samples from wells and surface water locations sampled in 1999. Table 2 shows the mean concentrations of the current COPCs at the site compared with background values and regulatory standards. Data in this table were compiled from 1999 analyses of samples collected from wells and surface water locations and from data used to prepare the 1996 BLRA. Background samples were collected from upgradient wells 523 and 524 and from surface water locations 608 and 609. The rationale for combining these locations to determine background mean values is that surface water samples are taken directly from artesian geothermal water and could reasonably represent subsurface water. Mean values for ground water are derived from samples in downgradient shallow wells 503, 505, and 507.

Table 2. Mean Concentrations of Chemicals of Potential Concern at the Lakeview Site

Chemical of Potential Concern	Background (mg/L)	Downgradient (mg/L)	UMTRA MCL[a] (mg/L)	EPA SMCL[b] (mg/L)	Oregon Max. Conc. Limit (mg/L)
Arsenic	0.053[c]	0.042	0.05	0.05	0.01
Chloride	84.7	548	—	250	—
Sulfate	180[c]	1,479	—	Undecided[d]	—
Manganese	0.031[c]	5.65	—	0.05	—

[a]MCL = UMTRA maximum concentration limit
[b]SMCL = Secondary maximum contaminant level (U.S. EPA, Safe Drinking Water Act)
[c]values were derived by combining surface geothermal and subsurface background water
[d]undecided = EPA has this value under discussion; concentrations range from 500 to more than 1,500 mg/L

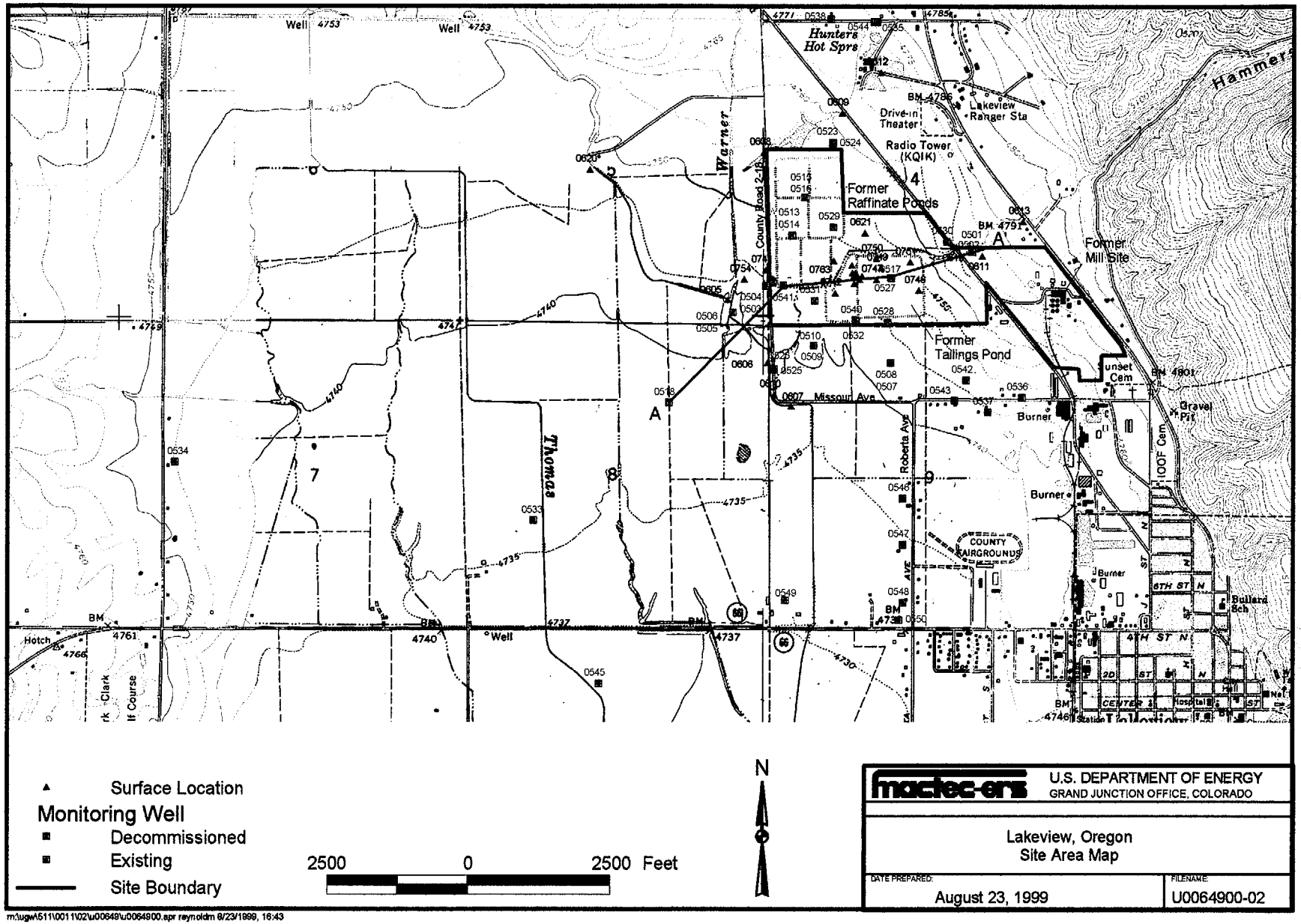

Figure 2. Location of the Lakeview, Oregon, Site

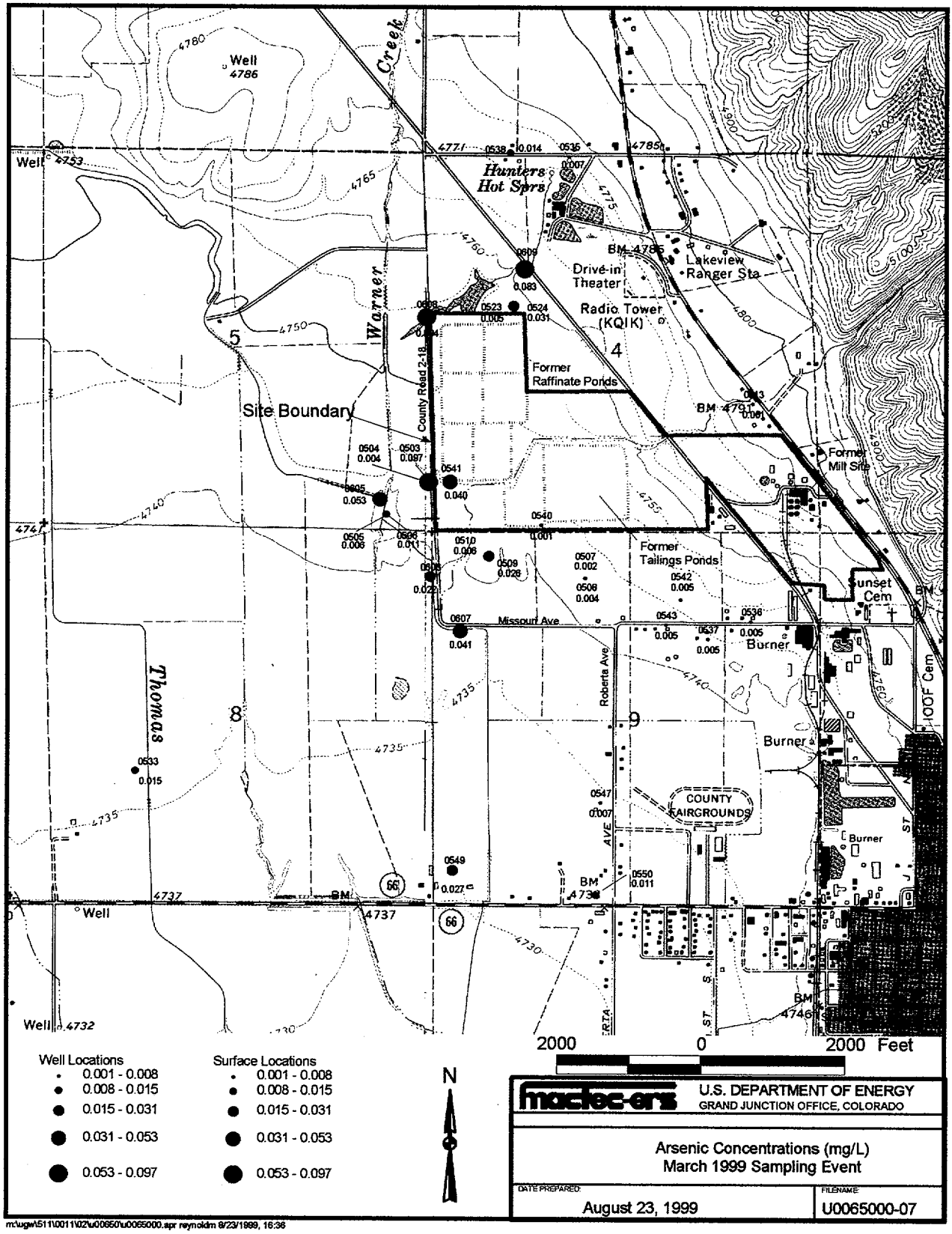

Figure 3. Arsenic Concentrations in Ground Water and Surface Water Samples

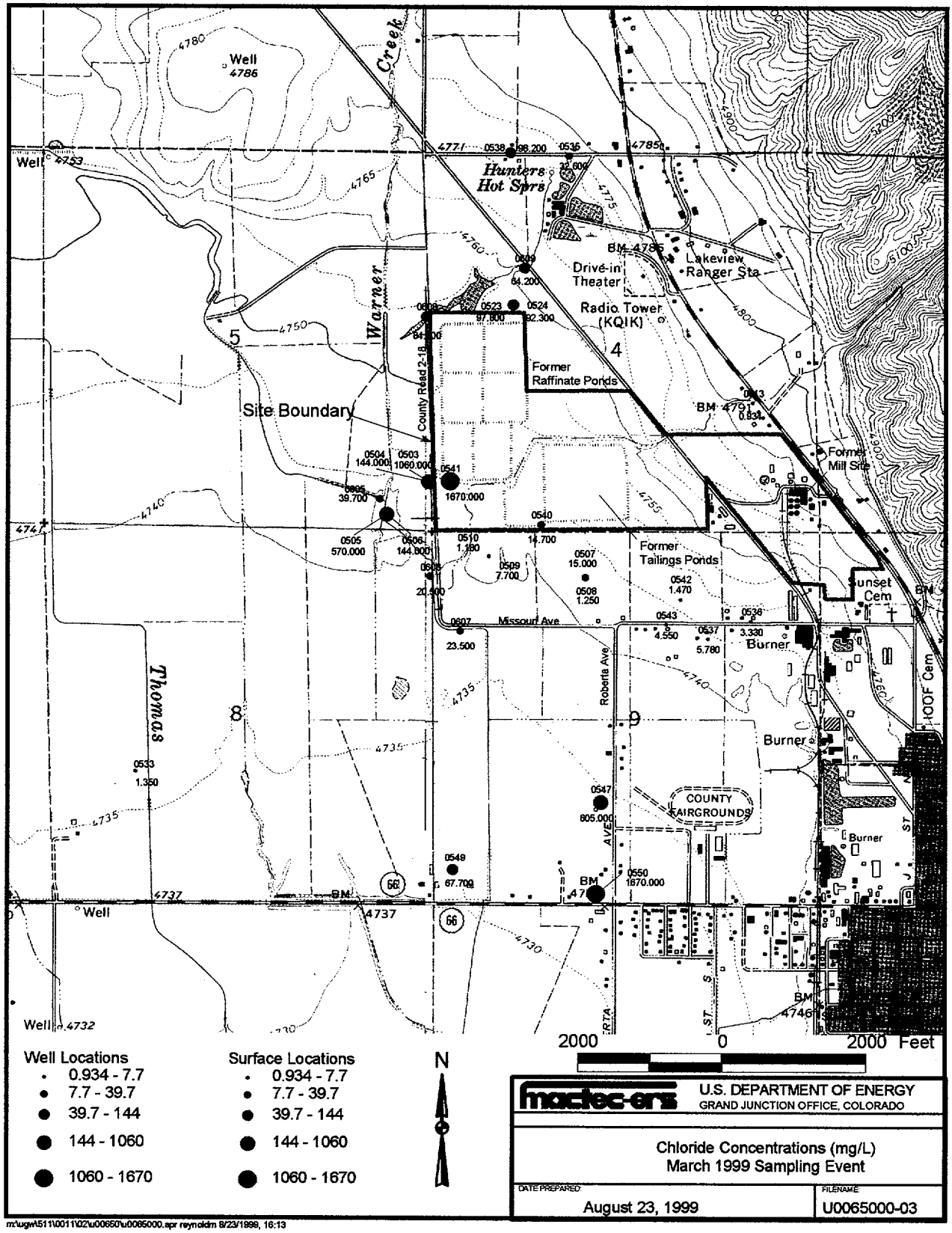

Figure 4. Chloride Concentrations in Ground Water and Surface Water Samples

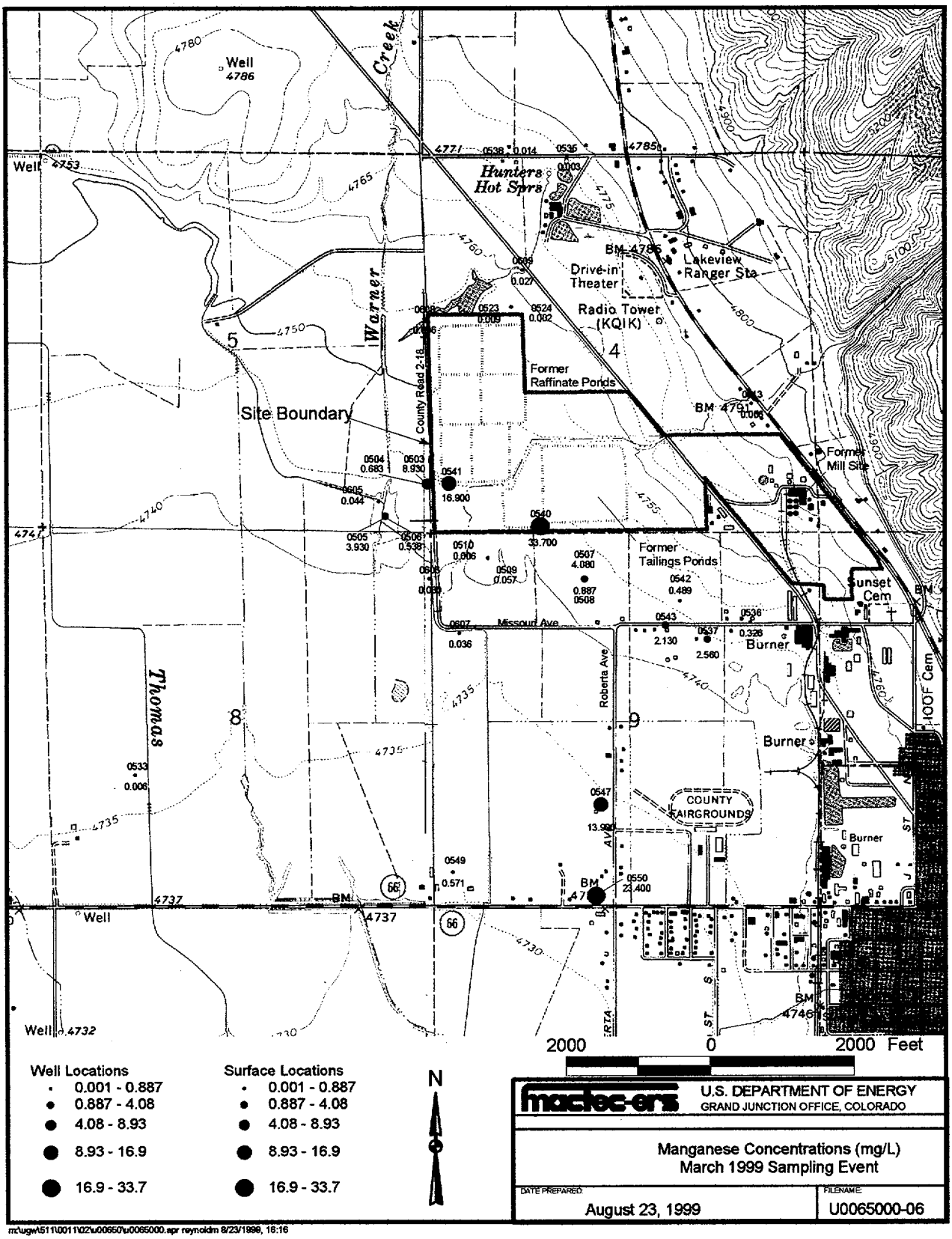

Figure 5. Manganese Concentrations in Ground Water and Surface Water Samples

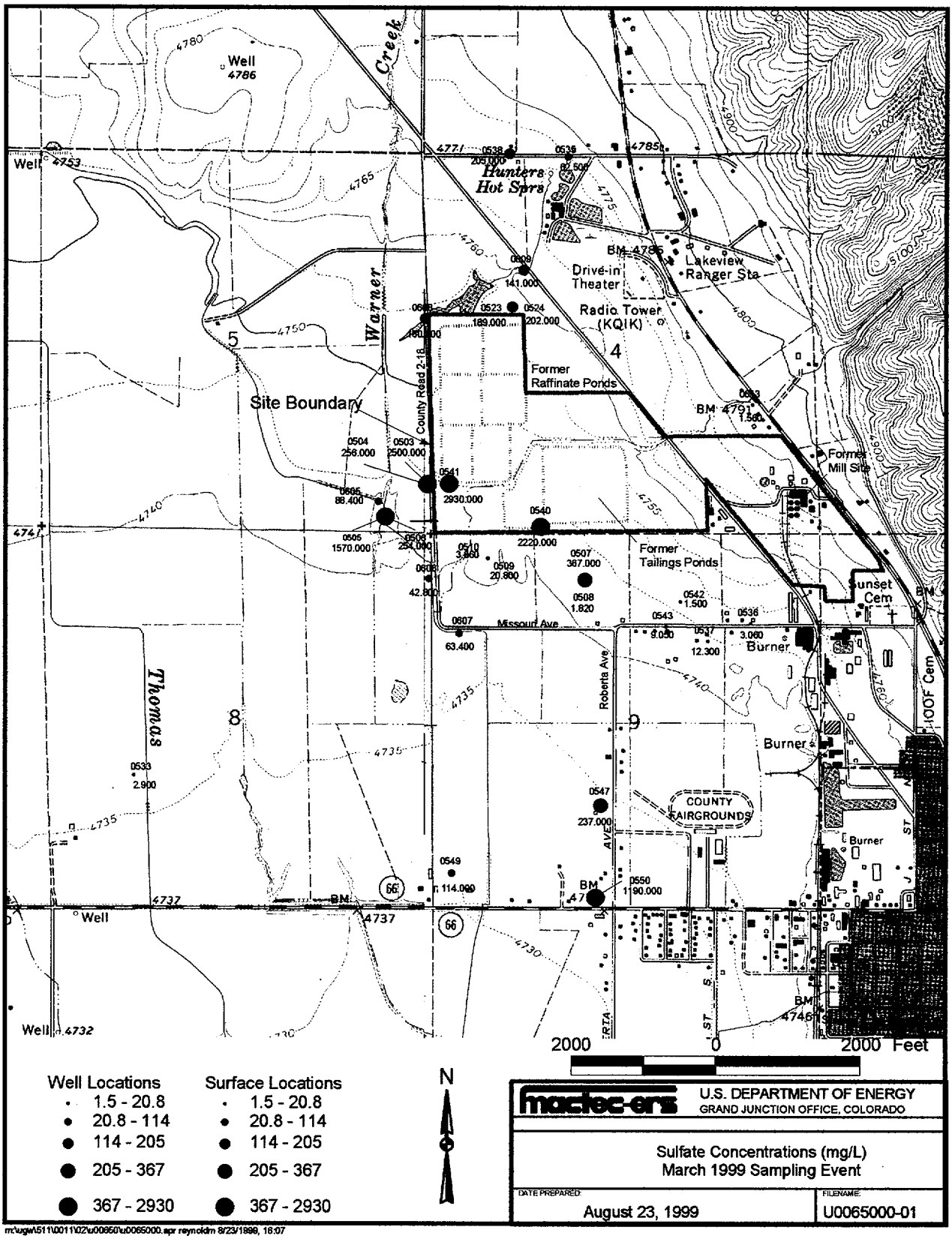

Figure 6. Sulfate Concentrations in Ground Water and Surface Water Samples

Deeper downgradient wells, which are in well pairs with the shallow wells, show much lower concentrations of arsenic and sulfate and higher concentrations of manganese than samples from shallow wells. This increase in manganese concentration is believed to result from natural conditions.

From 1999 data, the background arsenic concentration exceeds the UMTRA MCL of 0.05 milligrams per liter (mg/L) as well as the EPA secondary maximum contaminant level and the State of Oregon standard; downgradient mean arsenic concentration exceeds the State standard.

Chloride has no MCL, but downgradient concentrations exceed the secondary maximum contaminant level of 250 mg/L and exceed the nutrient screening level of 17.85 mg/L, based on U.S. Food and Drug Administration studies (EPA 1994). Background concentrations of chloride also exceed the nutrient screening level.

Manganese also has no MCL, but downgradient concentrations exceed the EPA secondary standard of 0.05 mg/L and the human health risk-based concentration of 0.84 mg/L, according to EPA Region III guidance (EPA 1998). The mean background concentration of manganese is below these standards.

Although sulfate does not have an UMTRA or State standard, EPA is reviewing values considered hazardous to human health. Currently, minimum concentrations considered potentially dangerous to human health range from 500 to 1,500 mg/L. Background sulfate values are below this range, but downgradient mean concentrations are potentially above these levels (Table 2).

Sulfate was added to the ground water from use of sulfuric acid during uranium milling operations; arsenic was added to the ground water from uranium ores that contained arsenic minerals. Chloride and manganese concentrations are more problematic. Although elevated values of these constituents are apparently associated with high sulfate concentrations in samples from the former millsite, it is not clear if they are associated with uranium ores or derived from some other source. High manganese and chloride values are also associated with the elevated sulfate concentrations in samples from an isolated area south of the millsite.

The BLRA shows two areas of ground water with high sulfate concentration migrating off the site; one plume has migrated about 2,300 ft to the southwest, away from the former raffinate or evaporation ponds, and the second plume has moved about 600 ft southeast from the former tailings pond. Because sulfate is the most mobile of the COPCs, these plumes are thought to represent the maximum extent of contamination migrating from the site. Manganese concentrations are high where sulfate concentrations are also elevated. Arsenic concentrations do not follow the same trend because they occur in elevated concentrations from natural sources.

An isolated area of high sulfate concentrations in ground water is located south of the site along Roberta Avenue, about 2,500 ft past the maximum extent of the sulfate plume. This area also has elevated concentrations of chloride, sodium, calcium, manganese, and iron. The BLRA indicates that these constituents are not related to uranium milling activities but instead are associated with ground water and surface water leaching of fill located upgradient of the area (and downgradient of the uranium millsite) that was brought in during the past 12 years. The fill is from former log ponds that contained wood chips, boiler ash, and slimes.

2.3 Applicability of Supplemental Standards

The third step in the decision process is to determine if contaminated ground water qualifies for supplemental standards on the basis of limited use ground water. Ground water in the unconfined surface aquifer is of limited use because of widespread, elevated concentrations of naturally occurring arsenic that cannot be treated by methods reasonably employed in public water systems.

2.3.1 Background Concentrations

Geothermal water from artesian sources upgradient of the millsite flows through the subsurface beneath the millsite. This water contains elevated concentrations of arsenic, chloride, silica, sodium, sulfate, and total dissolved solids (TDS) compared with other basin water that originated from surrounding highlands. Natural arsenic concentrations exceed the UMTRA MCL; however, the other constituents also indicate generally poor quality of water from the geothermal source.

2.3.2 Reasonableness of Ground Water Treatment

If the background geothermal ground water were treated for municipal use, high concentrations of arsenic, chloride, silica, sodium, sulfate, and TDS would need to be removed. No rigorous feasibility study was performed on geothermal water. However, a previous study at another UMTRA Project millsite (DOE 1999a, Appendix J) indicated that the only reasonable method of treating these constituents would be some type of desalination. Reverse osmosis would be the least expensive process.

Chloride, sodium, sulfate, and TDS concentrations in alluvial ground water were elevated at another UMTRA Project site where a detailed study was conducted. Data from the study will be used as an analogue. In that study, arsenic was not among the primary constituents, but selenium and uranium were. Treatment methods for removal of arsenic are similar to those for uranium. The average annual cost to treat the water for a household was estimated to be $400. The treatment cost far exceeds the average real cost of about $200 to $220 per year for residential users. Water for Lakeview residents is produced from rain collectors located in mountains east of the town and, when necessary, from deep wells located near the town (but not downgradient of the millsite). The annual cost per household for domestic water in Lakeview is $150 (personal communication 1999); thus, the cost to treat the shallow water is considered unreasonable.

2.4 Human Health and Environmental Risks

The fourth step considers whether human health and the environmental risks of applying supplemental standards are acceptable.

Assessment of site conditions indicates that supplemental standards would be protective of human health under current conditions. Future risks to human health would be unacceptable if the water were used as a primary source of drinking water. This use is not expected because other sources of drinking water are available and institutional controls would be in place to prohibit access to contaminated ground water.

A limited ecological evaluation was performed for this site in the BLRA. That evaluation concluded that there is a low potential to threaten the food chain (through bioaccumulation and biomagnification) of terrestrial and aquatic wildlife. However, the BLRA identified two potential areas of concern: (1) phytotoxicity of plants that have roots in direct contact with the aquifer and (2) use of ground water as a long-term source of drinking water for livestock. Recent visual reconnaissance of the former millsite indicated that no phytotoxicity is occurring as a result of COPCs in the ground water. Therefore, this does not appear to be a significant issue.

Potential effects on livestock have been studied at other DOE uranium mill tailings sites. Lampham and others (1989) and Henningsen (1997) evaluated this issue at two millsites by comparing COPC concentrations in ground water to tissue concentrations in affected livestock. The 1989 study, conducted near the Ambrosia Lake site in New Mexico, concluded that some concentrations of radionuclides are elevated, but not to the levels predicted from bioaccumulation models. Radionuclides are not an issue at the Lakeview site.

Henningsen conducted the 1997 study downgradient of the former millsite at Monticello, Utah. That study is more relevant to the Lakeview situation because it included the evaluation of arsenic and manganese. The concentrations of arsenic and manganese in ground water from Monticello were lower than those at Lakeview; however, for the study, contributions from soil, sediment, and vegetation resulted in an analogous contaminant loading. The study concluded that the edible portions of livestock were not affected by site contamination. The only effect observed was in bone tissue, which accumulated contaminants with chemical properties similar to those of calcium. One shortcoming of comparing this study to Lakeview is that sulfate was not a COPC. Sulfate concentrations in ground water at the Lakeview site may cause diarrhea in livestock, but long-term negative effects are not likely.

These studies and the qualitative screening evaluation done for the Lakeview BLRA indicate that ground water contaminants are unlikely to significantly affect livestock exposed to the ground water at or downgradient of the site. Overall, the application of supplemental standards would be protective of human health and the environment.

2.5 Compliance Strategy Selection

The fifth and final step in the framework is the selection of an appropriate compliance strategy to meet EPA ground water cleanup standards. DOE considers the appropriate compliance strategy for the Lakeview site to be application of supplemental standards based on widespread, ambient contamination. However, as a best management practice, DOE would implement an institutional control to prevent residents from using contaminated ground water and would conduct a limited ground water monitoring program. This approach would be protective of human health and the environment.

The proposed institutional control would be to limit access to contaminated ground water by upgrading a domestic water line scheduled for construction in the year 2000. The water line will extend from the town of Lakeview to a planned prison located north of town and north of the millsite. The corridor for the water line to the prison will bracket the southern and western sides of the millsite and will include both downgradient perimeters. DOE will pay the difference in cost for a water line to meet the water needs of the prison and the estimated future uses the county commissioners envision for this area. In exchange, Lake County will require that future land users along this corridor obtain taps to the domestic water line. Currently, no one is drinking

contaminated water from private domestic wells downgradient of the site. Should this change, DOE will pay for point of use requirements until a permanent remedy is implemented.

2.6 Ground Water Monitoring

As a best management practice, a limited surface water and ground water monitoring program will continue at the former Lakeview millsite. Samples will be collected from 15 locations every other year for 10 years and will be analyzed for arsenic, chloride, manganese, and sulfate (Table 3 and Figure 7).

Table 3. Summary of Monitoring Requirements

Location	Monitoring Purpose	Analytes	Frequency[a]
LKV-01-501	Well, upgradient/background , non-geothermal	Arsenic, Chloride, Manganese, Sulfate	Biennial for 10 years
LKV-01-524	Well, upgradient/background, geothermal well		
LKV-01-608	Surface, upgradient/background, geothermal		
LKV-01-609	Surface, upgradient/background, geothermal		
LKV-01-622	Surface, upgradient/background, geothermal		
LKV-01-503	Well, downgradient raffinate ponds, deep		
LKV-01-504	Well, downgradient raffinate ponds, shallow		
LKV-01-508	Well, downgradient tailings pile, deep		
LKV-01-509	Well, downgradient tailings pile, shallow		
LKV-01-605	Surface, downgradient		
LKV-01-607	Surface, downgradient		
LKV-01-542	Well, private, along Missouri Ave.		
LKV-01-543	Well, private, along Missouri Ave.		
LKV-01-547	Well, private, along Roberta Ave.		
LKV-01-550	Well, private, along Roberta Ave.		

[a] Biennial monitoring will be discontinued when contaminant concentrations decrease to levels at or below compliance standards for 3 consecutive years.

Monitoring will continue for 10 years and will be reevaluated after that period to ensure that chloride, manganese, and sulfate concentrations are below the secondary maximum contaminant levels of the Safe Drinking Water Act. If concentrations are below the standards, monitoring will be discontinued; otherwise, another strategy will be adopted. Arsenic concentrations are not expected to decrease below the compliance standard because of the naturally occurring geothermal source. This monitoring strategy is consistent with the approach established for monitoring Resource Conservation and Recovery Act corrective actions.

Analysis of water samples from private domestic wells located along Roberta Avenue has not indicated contamination from millsite activities, but DOE will continue monitoring for the sake of public safety. Manganese and sulfate concentrations are above recommended safe values and should decrease over time because the source is likely from slimes, wood chips, and other materials that were hauled in as fill upgradient of the area (DOE 1996b).

Decommissioning of all monitor wells that are no longer needed for compliance monitoring at the Lakeview site will be undertaken in accordance with applicable State of Oregon regulations. This decommissioning will be accomplished by a DOE Grand Junction Office project.

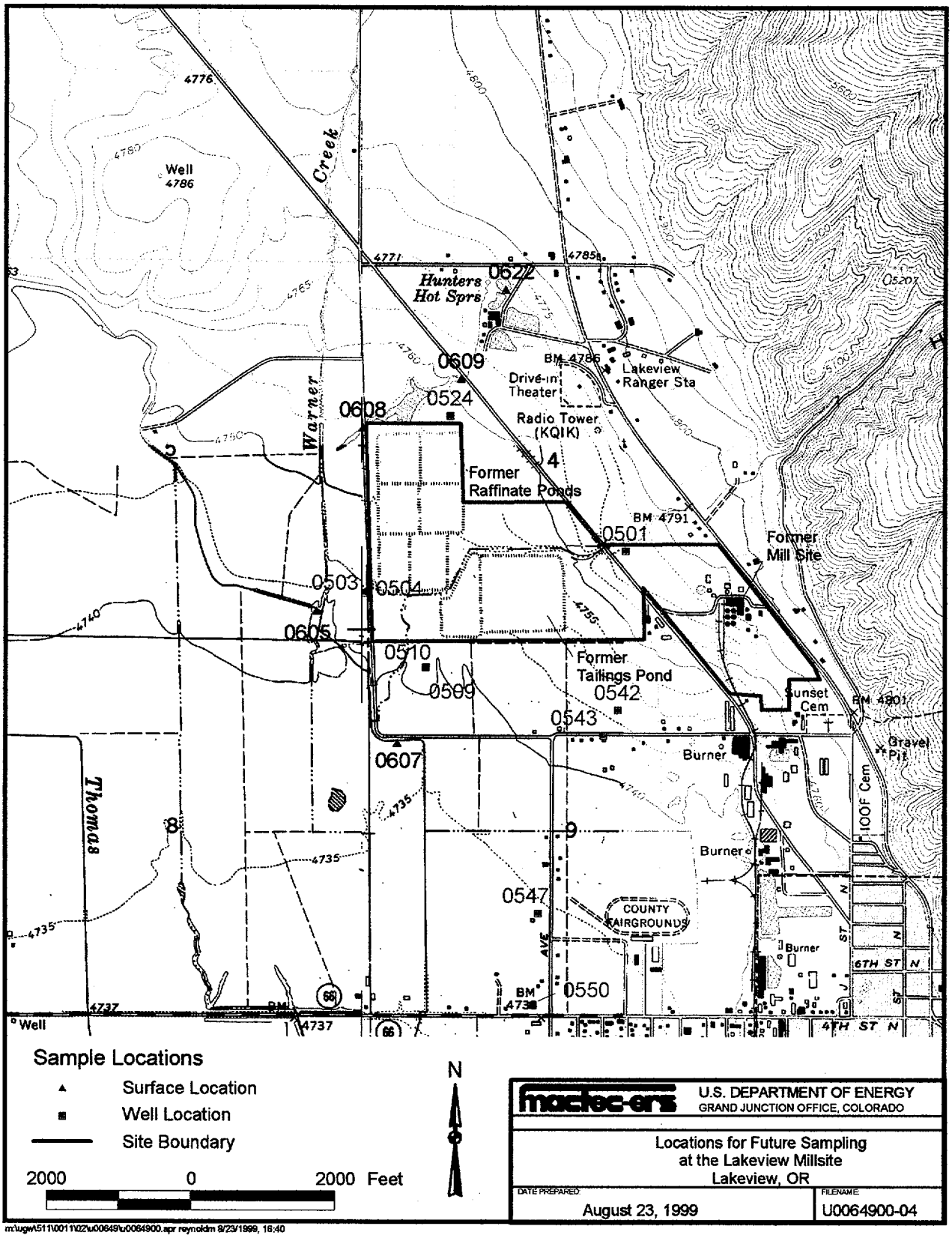

Figure 7. Proposed Monitoring Locations for the Lakeview Site

3.0 Pubic Participation

To comply with National Environmental Policy Act (NEPA) regulations and the PEIS, DOE provided relevant environmental information to public officials and citizens by conducting a public meeting with the Lake County Commissioners on July 21, 1999, and by conducting a second public meeting later that day. The meetings were publicized in a news release dated July 8, 1999, and were advertised in the *Lake County Examiner*, a local newspaper, and on KQIK, the local radio station. Letters of invitation were sent to property owners who own land within the boundaries of the former millsite. DOE gave formal presentations and provided a fact sheet at the meetings. The meeting with the county commissioners resulted in the proposed upgrade of the water line from the town of Lakeview to the prison that will be built north of town. County commissioners were pleased with this pledge. One citizen attended the public meeting held at 7:00 p.m. July 21 at the Lake County Senior Community Center. He was one of the landowners and had no problems with the proposed compliance strategy. DOE distributed minutes of the meetings to county commissioners, a reporter for the *Lake County Examiner*, and landowners (Appendix).

4.0 Environmental Considerations

NEPA requires DOE to prepare a programmatic environmental impact statement (the PEIS, DOE 1996a), which was issued in October 1996. The PEIS assesses the potential programmatic effects of conducting the UMTRA Ground Water Project, provides a method for determining 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 are protective of 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 discussed in Section 2.0 of this document. Environmental impacts from the proposed action on these issues and resources were assessed in several documents (DOE 1981, 1985, 1992, 1996a, and 1996b). The following environmental issues and resources are potentially affected by the proposed action:

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

The proposed compliance strategy will not involve any surface-disturbing activities at the Lakeview site. Surface disturbance will occur along a corridor west and south of the site when the water line is constructed. The State of Oregon will construct the trench, and DOE will pay only for an upgrade to the water line. The only other field activities required following

implementation of the GCAP would be continued monitoring of the sample locations shown in Figure 7 and decommissioning of monitor wells no longer needed for compliance monitoring.

The proposed action will produce no adverse effects to air quality, surface water quality, cultural resources, sensitive plant or wildlife species (including threatened or endangered species), or designated or sensitive natural resource areas (e.g., wetlands, wilderness, parks, and scenic rivers).

On the basis of data evaluated for this report, only four constituents present in the surficial aquifer—arsenic, chloride, manganese, and sulfate—pose a potential risk to human health. The BLRA determined that ingestion of alluvial ground water as a regular source of drinking water would result in the only unacceptable risk to human health. Because this pathway is currently incomplete, no current human health risk exists. Under the proposed action, an institutional control would prohibit ground water use for any purpose for the foreseeable future, and no human health risks would exist as long as access to contaminated ground water is prohibited. Arsenic concentrations are currently above the UMTRA standard and are expected to remain at this elevated value indefinitely. Chloride, manganese, and sulfate concentrations are expected to decrease and eventually be within maximum contaminant levels of the Safe Drinking Water Act. Continued monitoring will track concentrations of these constituents.

Ground water beneath the site is not considered to present ecological risks because of low concentrations of constituents and lack of exposure pathways. Ground water is not being used to water livestock at the site, and surface water is available for this purpose. Because ground water is generally of poor quality in the valley, no future use of ground water for watering livestock is expected. Studies at other DOE uranium-ore processing sites with similar contaminants indicate that the contaminants do not present a risk to livestock or to people who consume tissues from the livestock. Plants growing on the former millsite show no signs of stress.

Existing documents and public participation efforts comply with DOE's NEPA regulations, orders, and guidance. Local government is pleased with the proposed institutional control at the site, and public interest in the site is low. Therefore, an environmental assessment is not recommended. The conditions for evaluating a risk scenario and selecting a compliance strategy at the Lakeview site closely parallel the conditions at the Salt Lake City UMTRA Project site, for which a GCAP was prepared (DOE 1999b) and an environmental assessment was not required.

5.0 References

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———, 1999a. *Final Site Observational Work Plan for the UMTRA Project Site at Grand Junction, Colorado,* GJO-99-86-TAR, Rev. 1, prepared by the U.S. Department of Energy, Grand Junction Office, Grand Junction, Colorado, May.

———, 1999b. *Ground Water Compliance Action Plan for the Salt Lake City, Utah, UMTRA Project Site,* prepared by the U.S. Department of Energy, Grand Junction Office, Grand Junction, Colorado, February.

U.S. Environmental Protection Agency (EPA), 1994. *Evaluating and Identifying Contaminants of Concern for Human Health,* Superfund Technical Guidance No. RA-03, U.S. Environmental Protection Agency Region 8, 999 18th Street, Suite 500, Denver, 80202.

———, 1998. Risk-Based Concentration Table, available through the Internet at **http://www.epa.gov/reg3hwmd/risk/riskmenu.htm**, prepared by the U.S. Environmental Protection Agency, Region 3, 841 Chestnut Building, Philadelphia, Pennsylvania, 19107.

End of current text

UMTRA Ground Water Project

Document Compilation for

Lakeview, Oregon

August 1999

Contents

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- 2.7 Environmental Assessment of Remedial Action at the Lakeview Uranium Mill Tailings Site, Lakeview, Oregon, Volume I: Text, and Appendix D: Hydrology, April 1985

1.0 Introduction

This appendix is a compilation of documents and correspondence completed under the Uranium Mill Tailings Remedial Action (UMTRA) Project for the Lakeview, Oregon, uranium mill tailings site. This document contains portions of UMTRA documents relevant to the UMTRA Ground Water Project at the Lakeview site.

1.1 Purpose

This appendix is a quick-reference document. Section 2 presents excerpts of documents relevant to the UMTRA Ground Water Project. The documents are in chronological order, beginning with the most recent.

1.2 Content

Each subsection includes a summary of the document, a cover sheet, table of contents for the complete document, and the portions of the document relevant to ground water.

Lakeview, Oregon,
Minutes of Public Meetings
July 1999

Two meetings were held on July 21, 1999: one with the Lake County Commissioners and one with the town of Lakeview. A quorum of county commissioners, three DOE representatives, and one State of Oregon representative from the Oregon Department of Energy were present for the first meeting. A DOE representative discussed supplemental standards, limited yield ground water, and widespread ambient contamination based on naturally occurring arsenic from the geothermal springs upgradient of the site. As a best management practice, it was recommended that institutional controls be expanded to prevent domestic use of contaminated ground water from the former millsite. To accomplish this, DOE would fund an upgrade to a water line planned for installation along a downgradient side of the former millsite. In exchange, Lake County would require future land users in this area to obtain a tap to the new water line.

The second meeting was held at a public auditorium in Lakeview the same evening. One person from the community attended the meeting. He asked how long DOE would monitor ground water from the former millsite and was assured that DOE would monitor for at least 10 years or as long as necessary to ensure public health and safety.

Minutes
Lakeview, Oregon, County Commissioners Meeting, July 21, 1999

Attending: Commissioners - Jane O'Keefe (Chair), Kit Collins, and Ray Simms; Lori St.Clair, Lake County Commissioners Secretary; David Steware-Smith, Oregon State Department of Energy; Don Metzler, U.S. Department of Energy; Sam Marutzky and Richard Dayvault, MACTEC contractor for DOE-GJO.
Correspondence to Ms. O'Keefe

Location: Lake County Courthouse, Lakeview, Oregon
Time: 4:30 to 6:00 p.m.

Handouts of viewgraphs and a Fact Sheet were provided out to the group. Additional handouts, Fact Sheets, and other sources of information will be made available for distribution via the Public Library.

Don Metzler discussed the general history of the Uranium Mill Tailings Remedial Action Program (UMTRA) and particularly, the history of surface remedial action involving moving the tailings pile from the old mill site to the Collins Ranch repository. Mr. Metzler also discussed the three chemicals of concern, arsenic, manganese, and sulfate, that are thought to have been added to the ground water as a result of uranium milling activities. Mr. Metzler noted that no radioactive contaminants are left in the ground water that exceed any regulatory standards. Dick Dayvault provided a brief status of the ground water and surface water geochemistry according to the March, 1999 sampling. An example of the sulfate plume extending from the mill site to the southwest was shown. This is considered to be the maximum extent of any chemicals migrating off the site. An area of elevated sulfate and manganese values were found in wells farther south of the plume along Roberta Ave. The Baseline Risk Assessment contented that these high values are not associated with millsite activities. Mr. Metzler told the commissioners that DOE is legally responsible for assuring that humans and the environment are safe from the consequences of activities that occurred at the millsite. The proposed compliance strategy of "no action" is proposed because naturally occurring ground water already has chemicals that exceed federal and state regulatory standards. Arsenic from naturally occurring geothermal water upgradient of the mill site occurs in concentrations as high as ground water currently found in ground water from the former mill site. This naturally occurring ground water flows under the site.

Q. Ray Simms: Would DOE continue to monitor the site and areas downgradient of the site?
A. Don Metzler: Yes. Mr. Metzler discussed the continued monitoring at the Collins ranch that is planned for hundreds of years; therefore, their will be a DOE presence in the valley for many generations. It was decided that sampling at the millsite should continue every other year for the next 10 years for a limited number of wells and surface locations. Results will be reevaluated during the interval and at the end of 10 years.

Q. Ray Simms: Would DOE provide a deeper well to someone if their shallow well were to show contamination from the millsite?
A. Don Metzler: Yes. We can put these things in writing if you would like.

Q. Dick Dayvault to Ray Simms: Could you tell us about the prison system that is planned for the valley in the next year of so?
A. Ray Simms: The prison will be constructed with Oregon state funds north of the millsite beginning in calendar year 2000. Plans are to run a water/sewer line from Lakeview to the prison. Alternately, water may come from a new water district recently established north of Lakeview. The state will only pay for the water and sewer required by the prison. Mr. Metzler suggested that DOE might be able to pay for over sizing the water line along the corridor downgradient of the former millsite. This could include a 1- to 2-mile segment west from Lakeview along Missouri Ave. and north up County 2-18 to a point north of the site. Even if the prison system brought water from the new water district north of town, the sewer line would be dug and DOE could probably pay for a water line to the affected area. Mr. Metzler conceded that DOE would want to limit its financial obligation to $250K for such a project. Mr. Simms thought that this would be more than enough to cover the costs. The commissioners noted that the area south of the former millsite and north of Missouri Ave. will become an Urban Reserve that could be subdivided into large lots for commercial or residential use and that the proposed upgrade in the water line would be a welcomed addition to the city/county infrastructure.

Q. Don Metzler: Is there anything else that we should know about or address?
A. Ray Simms: Land owners would like something from DOE, the state, or someone stating that their land is cleaned up. Currently there is nothing other than a large report (Completion Report) to this effect. David Stewart-Smith indicated that he has been working on a property notification for the vicinity properties and could broaden the scope of this document to include the former millsite area. In the interim, perhaps DOE could provide a copy of the NRC license.

List of Action Items:

1) Any correspondence/phone logs should be sent to Jane O'Keefe, County Commissioner Chair (All)
2) Dan Chamners, Town Manager, should be contacted and the proposed waterline upgrade should be discussed (Dayvault)
3) Letters of the compliance strategy and analytical results should be sent to landowners southwest of the site. They are Flying A Ranch, Audrey Henry, and Marty Foster along Missouri and Roberta Avenues (Dayvault)
4) Minutes of this and the public meeting should be sent to Lynn Wilson (a landowner) and Sarah Benton (newspaper reporter) (Dayvault)
5) Costs and avenues for a water line upgrade from the prison system will be investigated (Ray Simms)
6) A copy of the NRC license for the millsite/repository should be provided (Metzler, Dayvault)

7) A short document stating that the land has been cleaned up should be provided (David Stewart-Smith)

Minutes
Lakeview Town Meeting, July 21, 1999

Attending: Ray Simms, David Stewart-Smith, Don Metzler, Sam Marutzky, Dick Dayvault, and Randell Utley (a landowner and also representing Flying A Ranch)

Location: Lake County Senior Community Center, Lakeview, Oregon

Time: 7:00 p.m. to 8:30 p.m.

Since only one Lakeview citizen attended the meeting (other than Ray Simms), the presentation was informal. Mr. Utley was provided the Fact Sheet and Viewgraph packet for review. Following a short overview by Don Metzler, Mr. Utley was asked if he had any questions. Mr. Utley had a number of pertinent questions.

Q. Randell Utley: Will monitoring continue?
A. Don Metzler: Yes, we will plan to sample a limited number of wells every other year for the next 10 years.

Q. Randell Utley: It says in the fact sheet that DOE will need water use restrictions on lands. This will be difficult. Landowners will resist. How do you intend to do this?
A. Don Metzler: We plan to pay for the over sizing of a water line that will connect the proposed prison system to Lakeview. This will provide water to future users.

This prompted a discussion of how DOE could get dollars to the City/County for the proposed waterline project. Should the money go through the state first? Is there a Cooperative Agreement with the state? David Steward-Smith says the former CA has lapsed. Will the state be required to provide 10% of the funding for the waterline upgrade? Action: Don Metzler will inquire about the cost sharing and CA with the state of Oregon.

Q. Randell Utley: Have property values decreased because ground water use should be limited?
A. Don Metzler: This should not hurt property values, especially if municipal water is available to the affected area. Sam Marutzky added that the property values should be higher as a result of moving mill tailings from the former millsite to the Collins ranch repository.

Q. Randell Utley: During surface remediation 12 years ago, his pond located just north of the site, was expanded into the site to provide water for dust suppression, etc. during earth moving activities. This was never fixed and current land owners use this water for watering livestock. Could DOE fix this?
A. Don Metzler: We might be able to do this, but we need to know any legal ramifications of this action. Would the present owners of the former millsite have any water for grazing if this source were cut off? (R.U. No) Did the current land owners

think that the pond water was a resource that went with the property? (R.U. Probably so) It was decided that Mr. Utley would consult with the current land owner about these issues and write a letter to Don Metzler of DOE if he chose to pursue this issue.

Other points or actions brought out during exchanges:

The current owner of the former John Ryan property is probably Jim Schmidt of Redmond, OR. Mr. Schmidt was a partner(?) with Mr. Ryan on land deals and the association has been terminated.

People who live along Roberta Ave. may want to have any domestic well water tested for manganese and sulfate before they drink the water. These constituents are not associated with the millsite, but are still elevated.

Marty Foster has a new shallow well used to water stock along Missouri Ave. We may want to sample it in our next sampling round. (Dayvault)

Generally, the town is growing to the north.

We should sample the Hunters Springs Geyser next sample round. (Dayvault)

Data Validation
Lakeview, Oregon, UMTRA Project Site
March 1999

This is a standard data package from the March 1999 sampling at the Lakeview site. It contains

A site hydrologist summary
A data package assessment
A data assessment summary
A report of suspected anomalies
UMTRA database printouts
A sampling and analysis work order and trip report.

DATA VALIDATION
LAKEVIEW, OREGON
UMTRA SITE

March 1999
Water Sampling

LAKEVIEW, OREGON
Sampled March 1999

DATA PACKAGE CONTENTS

This data package includes the following information:

Item No.	Description of Contents

1. **Site Hydrologist Summary**

2. **Data Package Assessment,** which includes the following:

   a. Field procedures verification checklist
   b. Confirmation that chain-of-custody was maintained.
   c. Confirmation that holding time requirements were met.
   d. Evaluation of the adequacy of the QC sample results.

3. **Data Assessment Summary,** which describes problems identified in the data validation process and summarizes the validator's findings.

4. **Suspected Anomalies Reports** (SAR) generated by the UMTRA database system. This report compares the new data set with historical data and designates "suspected anomalies" based on the many criteria listed as footnotes on each page. In aggregate, these criteria cause the suspected anomaly program to be very conservative; many of the data shown in the tables are not, in the evaluators judgment, truly anomalies, but merely natural variations in data or routine changes in laboratory detection limits. The designation "OK" affirms the judgment that the particular entry is not an anomaly and, therefore, requires no further inquiry.

5. **UMTRA Database Printouts** of analytical data organized as follows:

   a. Ground Water Quality Data (included on disk)
   b. Surface Water Quality (included on disk)
   c. Equipment Blank Data (included on disk)
   d. Time Versus Concentration Graphs
   e. Static Groundwater Level Measurement Data

6. **Sampling and Analysis Work Order and Trip Report.**

Site Hydrologist Summary

Site: Lakeview

Sampling Period: March 1999

SUMMARY CRITERIA

1. **Did concentrations in water from any domestic wells sampled exceed a ground water standard, primary drinking a water standard, or health advisory?**

   Sample results from domestic wells were below applicable standards.

2. **Were standards exceeded at any point-of-compliance wells?**

   There are no point-of-compliance wells established at the Lakeview processing site.

3. **As a result of this sampling round, is there any indication of unexpected contaminated ground water movement?**

   There is no indication of unexpected contaminant plume movement on the basis of results from this sampling round. The only UMTRA ground water standard exceeded during this sampling event was the arsenic standard (0.050 mg/L) in the sample from well 503 (0.0967); however, this concentration is consistent with historical results (see time versus concentration graphs included in this package).

4. **Is there statistical evidence that UMTRA Project related contaminants were detected in a surface body of water in greater concentrations than upstream ambient water quality?**

   Results from this sampling event were compared to benchmark values derived from locations 608 and 609, which are located on lower and upper Hunter Creek upstream of the site. With one exception, all samples collected from surface water downstream of the site had contaminant concentrations below the respective benchmark values. The uranium result from location 607 (lower east branch of Thomas Creek) exceeded the benchmark value. However, because the uranium value for location 607 (0.0033 mg/L) and the benchmark value (0.0013 mg/L) are low and near the detection limit (0.0010 mg/L), the difference between the two values is within the range of sampling and analytical uncertainty and is not indicative of impacts to downstream water quality in Thomas Creek.

5/18/99

Richard Dayvault Date
Site Hydrologist

DATA ASSESSMENT

UGW Water Sampling Field Activities Verification Checklist

Project Lakeview

Date(s) of Ground Water Sampling 3-15-99 to 3-21-99

Date(s) of Verification 5-17-99

Name of Verifier Sam Campbell

	Response (Yes, No, N/A)	Comments
1. Is the SAP the primary document directing field procedures?	Yes	
List other documents, SOPs, Instructions.		Sampling work order 2-16-99
2. Were the sampling locations specified in the planning documents sampled?	Yes	Except 4 monitor wells (501, 502, and 525 - could not locate (518 access) and 4 domestic wells (545, 546, 548 - no owner contact (544 owner out of town)
3. Was field equipment calibrated as specified in the above named documents?	Yes	
Were the number and types (alkalinity, temperature, conductivity pH, turbidity, DO, Eh) of field measurements taken as specified?	Yes	
Were the standard solutions used for the calibration and operational checks of the field instruments brought to within 10°C of the temperature of the water to be sampled?	Yes	Except at wells 523 and 524 (geo thermal wells)
Was the calibration information recorded on the field data sheets?	Yes	
4. Was a duplicate alkalinity measurement conducted on a frequency of one duplicate per 20 samples?	Yes	
5. Was depth to water measured before purging?	Yes	Except at domestic wells - not required
Was this information used to calculate the purge volume?	Yes	Except at domestic wells - no purge required
6. If conventional purging was used, were the wells purged until parameters stabilized and 3 casing volumes were removed, until the well was purged dry, or until 10 casing volumes were removed?	Yes	
7. If low-flow purging was used, was the purge rate less than 0.125 gal/min, and was the drawdown less than 0.3 feet?	NA	

8. Were duplicates taken at a frequency of one per 20 samples?	Yes	
9. Were equipment blanks taken at a frequency of one per 20 samples that were collected with nondedicated equipment?	Yes	
10. Were trip blanks prepared and included with each shipment of VOC samples?	NA	
11. Were QC samples assigned a fictitious site identification number?	Yes	
Was the true identity of the samples recorded in the field notes?	Yes	
12. Were samples collected in the containers specified?	Yes	
Were certified pre-cleaned containers used for the sampling?	Yes	
13. Were samples filtered and preserved as specified?	Yes	
14. Were the number and types of samples collected as specified?	Yes	
15. Were chain of custody records completed and was sample custody maintained?	Yes	
16. Were sample ticket book numbers recorded on field data forms and on the chain of custody?	Yes	
17. Are field data sheets signed and dated by the field team leader?	Yes	
18. Was all other pertinent information documented on the field data sheets?	Yes	
19. Was the presence or absence of ice in the cooler documented at every sample location?	Yes	
20. Were water levels measured at the locations specified in the planning documents?	Yes	Except 518 - no physical access due to snow/mud and a stream crossing

DATA PACKAGE ASSESSMENT

REQUISITION NUMBERS: 16489 SITE: Lakeview LABORATORY: GJO ANALYSIS DATES: 3-22-99 to 4-20-99

REVIEWER: Sam Campbell (NAME print) Sam Campbell (SIGNATURE) 5-13-99 (DATE)

	ICP-MS	ICP-AES	GFAA	FAA	$NaBH_4$	AS	LSc	PC	IC	Gravimetric	Colorimetric	Other	
CHAIN OF CUSTODY	ok	ok	NA	NA	ok	NA	NA	NA	ok	ok	NA	NA	NA
HOLDING TIME	ok	ok	↓	↓	ok	↓	↓	↓	ok	ok	↓	↓	↓
CALIB. VERIFICATION (For AS, internal tracer)	ok	ok	↓	↓	ok	↓	↓	↓	ok	NA	↓	↓	↓
PREP. BLANKS (Only if digestion)	ok	①	↓	↓	ok	↓	↓	↓	NA	NA	↓	↓	↓
INT/CONT CAL. BLANKS	ok	②	↓	↓	ok	NA	NA	NA	③	NA	↓	↓	↓
ICP SERIAL DILUTION	ok	ok	NA	NA	NA	NA	NA	NA	NA	NA	NA	↓	↓
ICS (ICP only)	ok	ok	NA	NA	NA	NA	NA	NA	NA	NA	NA	↓	↓
LAB. CONTROL SAMPLE	ok	ok	↓	↓	ok	↓	↓	↓	ok	ok	↓	↓	↓
DUPLICATES	ok	ok	↓	↓	ok	↓	↓	↓	ok	ok	↓	↓	↓
POSTDIGEST. SPKS. (Only if MS fails)	NA	NA	↓	↓	NA	NA	NA	NA	NA	NA	NA	↓	↓
MATRIX SPKS.	ok	ok	↓	↓	ok	↓	↓	↓	ok	NA	↓	↓	↓
OVERALL ASSESS.	ok	ok	↓	↓	ok	↓	↓	↓	ok	ok	↓	↓	↓

REVIEWER COMMENTS: ① Ca, Mg, Na, and SiO_2 detected in the prep blank - no samples affected. ② SiO_2 detected in a CCB - no samples affected. ③ SO_4 detected in a CCB - no samples affected

ITEMS REQUIRING ATTENTION: ①. U flag Fe results 258024-258027 because of prep blank contamination. ② U flag the following Fe results because of CCB contamination. 258099, 258101-258103, 258107, 258108, 258110, 258025-258027. ③ U flag Cl result 258109 because of CCB contamination.

LAKEVIEW, OR
MARCH 1999 SAMPLING
DATA ASSESSMENT SUMMARY

The DOE-GJO Analytical Laboratory analyzed samples and reported results for this sampling event under requisition number 16484 for the UMTRA ground water project.

METALS AND MAJOR CATIONS ANALYSIS

The determination of calcium, iron, magnesium, manganese, potassium, sodium, and silica was performed by inductively coupled plasma-atomic emission spectrometry (ICP-AES). Cadmium and uranium were analyzed by inductively coupled plasma-mass spectrometry (ICP-MS). Arsenic was determined by hydride generation atomic absorption spectroscopy ($NaBH_4$).

Iron results 258024 (535), 258025 (535 duplicate), 258026 (538), and 258027 (534) were qualified with a "U" flag in the database because of prep blank contamination. The following iron results were qualified with a "U" flag in the database because of continuing calibration blank (CCB) contamination: 258099 (504), 258101 (523), 258102 (524), 258103 (507), 258107 (509), 258108 (510), 258110 (505), 258025 (535 duplicate), 258026 (538), and 258027 (534).

INORGANIC ANALYSIS

Chloride and sulfate were determined by ion chromatography (IC), and TDS was determined gravimetrically.

Chloride result 258109 (540) was qualified with a "U" flag in the database because of CCB contamination.

FIELD ANALYSIS/ACTIVITIES

There were no wells with a pH value greater than 9 during this sampling event; therefore, "G" flags indicating potential grout contamination were not required. In addition, "L" flags (less than three casing volumes purged), and "F"flags (low flow purging) were not required on data from this sampling event.

One equipment blank was collected for the 18 locations where samples were collected using non-dedicated equipment. The equipment blank was analyzed for the same constituents as the Lakeview environmental samples. There were no UMTRA related contaminants detected in the equipment blanks in concentrations above the contract required detection limit (CRDL) or MDA/3-sigma; therefore, equipment blank results are considered acceptable.

Three field duplicates were collected for the 29 locations sampled. Duplicate samples were collected from wells 535 and 541 surface location 606. There are no established regulatory criteria for the evaluation of field duplicate samples; therefore, EPA guidance for *laboratory* duplicates (which is conservative for field duplicates) was used to assess the precession of the field duplicates. With the exception of two iron results (23 and 86 relative percent difference), duplicate sample results met the laboratory duplicate criteria (20 relative percent difference); duplicate results are considered acceptable.

SAR

Values listed in the SAR were considered valid if: (1) identified low concentrations were the result of low detection limits; (2) the concentration detected was within 50 percent of historical minimum or maximum values; or (3) if there were 4 or less historical results for comparison. All results listed in the SAR met the above criteria and are considered valid.

SUMMARY

All analytical quality control criteria were met except as qualified on the database printouts. The meaning of data qualifiers is as defined on the database printout or as defined in the USEPA Contract Laboratory Program Statement of Work for Inorganic Analysis, Multi-Media Multi-Concentration, Document Number ILMO2.0, 1991. All data in this package are considered validated and acceptable for use.

A disk copy of the Ground Water Quality Data by Parameter, Surface Water Quality by Parameter, and equipment blank database printouts with the qualifiers incorporated is included in this package.

Sam Campbell — 5-19-99
Sam Campbell — Date
Data Validation Lead

Richard Dayvault — 5/18/99
Richard Dayvault — Date
Site Hydrologist

SAR

Site : LKV01 LAKEVIEW Test Data Date Range : 3/1/1999 to 4/1/1999 Older Data Only Used for Baseline Data 391 Chemical Records 3556 History Records

LOC. ID.	ERR. TYPE FLAG	PARAM CODE / UNITS	ANOMALOUS TEST DATA POINT: LOG DATE	SAMPLE	VALUE	FLAGS	UNCERTAINTY	DETLIM	# OF SAMP. / %NON DETEC	ALL TIME MINIMUMS / ALL TIME MAXIMUMS		LOWER BOUND / UPPER BOUND	3 MOST RECENT SAMPLING EVENTS: LOG DATE	SAMPLE	VALUE	FLAGS	UNCERTAINTY	DETLIM	LOG DATE	SAMPLE	VALUE	FLAGS	UNCERTAINTY	DETLIM	LOG DATE	SAMPLE	VALUE	FLAGS	UNCERTAINTY	DET LIM
0503	6	MN	3/18/1999	0001	8.9300				37	8.450	8.490	6.8933	6/24/1995	0001	9.0800				6/24/1995	N001	8.4500				5/13/1994	N001	8.4900			
	OK	mg/L							0	12.000	16.800	8.4592		0	0.01					0	0.01					0	0.01			
0505	6	CA	3/20/1999	0001	134.0000				37	106.000	112.000	100.1031	6/24/1995	0001	112.0000				5/13/1994	0001	127.0000				5/13/1994	N001	118.0000			
	OK	mg/L							0	161.000	163.000	118.7320		0	1				I	0	2.5					0	0.5			
	6	CHLORI	3/20/1999	0001	570.0000				24	460.000	470.000	474.0485	6/24/1995	0001	533.0000				5/13/1994	N001	547.0000				5/13/1994	0001	460.0000			
	OK	mg/L							0	590.000	610.000	548.9053		0	0.5					0	0.5					0	0.5			
	6	K	3/20/1999	0001	11.3000				37	9.600	9.700	7.6289	6/24/1995	0001	10.2000				5/13/1994	0001	11.2000				5/13/1994	N001	9.7000			
	OK	mg/L							0	14.500	16.200	11.2231		0	0.1				I	0	0.1					0	0.1			
	6	MG	3/20/1999	0001	40.3000				37	30.000	32.000	29.8398	6/24/1995	0001	36.8000				5/13/1994	N001	34.8000				5/13/1994	0001	38.6000			
	OK	mg/L							0	44.000	46.000	37.9640		0	0.1					0	0.1				I	0	0.5			
	6	MN	3/20/1999	0001	3.9300				37	0.980	3.360	2.9011	6/24/1995	0001	3.6000				6/24/1995	N001	3.5400				5/13/1994	0001	3.7000			
	OK	mg/L							0	4.740	4.800	3.5323		0	0.01					0	0.01				I	0	0.05			
	6	TDS	3/20/1999	0001	4130.0000				24	3890.000	3930.000	3813.5664	6/24/1995	0001	4070.0000				5/13/1994	0001	3950.0000				5/13/1994	N001	4090.0000			
	OK	mg/L							0	4170.000	4180.000	4090.7505		0	10					0	10					0	10			
0506	5	MG	3/20/1999	0001	3.1400				34	3.080	3.300	3.2559	6/24/1995	0001	3.8800				5/13/1994	0001	3.3000				8/31/1992	0001	4.3000			
	OK	mg/L							0	4.750	5.000	4.1978		0	0.1					0	0.1					0	0.1			
0507	3	FE	3/19/1999	0001	0.0053				36	0.020	0.030	0.0134	6/24/1995	N001	0.0900				6/24/1995	0001	0.0300				5/13/1994	0001	0.0300			
	OK	mg/L	B						47.222	3.810	7.900	11.8500		0	0.03				U	0	0.03				U	0	0.03			
0508	5	CA	3/19/1999	0001	29.7000				33	10.100	10.400	30.1658	6/24/1995	0001	27.3000				5/13/1994	0001	31.0000				8/31/1992	0001	32.0000			
	OK	mg/L							0	33.000	34.400	36.9242		0	1					0	0.5					0	0.5			
	5	MG	3/19/1999	0001	8.5400				33	5.690	6.000	8.8788	6/24/1995	0001	8.9700				5/13/1994	0001	9.1000				8/31/1992	0001	8.9000			
	OK	mg/L							0	9.800	10.100	10.3505		0	0.1					0	0.1					0	0.1			
0509	6	CA	3/19/1999	0001	2.5500				7	2.000	2.090	0.0000	6/23/1995	0001	2.3700				5/12/1994	0001	2.3000				8/27/1993	0001	2.0000			
	OK	mg/L							0	12.800	19.000	1.5274		0	0.1					0	0.5					0	0.5			
	6	CHLORI	3/19/1999	0001	7.7000				6	5.000	5.700	2.9806	6/23/1995	0001	6.6300				5/12/1994	0001	5.0000				8/27/1993	N001	5.7000			
	OK	mg/L							0	13.000	13.000	6.6244		0	0.5					0	0.5					0	0.5			

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Approved by Sam Campbell Date 5-17-99
Hydrologist "Ok" indicates insignificant variation

Site : LKV01 LAKEVIEW | Test Data Date Range : 3/1/1999 to 4/1/1999 | Older Data Only Used for Baseline Data | 391 Chemical Records | 3556 History Records

LOC. ID.	ERR. TYPE FLAG	PARAM CODE / UNITS	ANOMALOUS TEST DATA POINT: LOG DATE / FLAGS	SAMPLE / UNCERTAINTY	VALUE / DETLIM	# OF SAMP. / %NON DETEC	ALL TIME MINIMUMS / ALL TIME MAXIMUMS		LOWER BOUND / UPPER BOUND	3 MOST RECENT SAMPLING EVENTS: LOG DATE / FLAGS	SAMPLE / UNCERTAINTY	VALUE / DETLIM	LOG DATE / FLAGS	SAMPLE / UNCERTAINTY	VALUE / DETLIM	LOG DATE / FLAGS	SAMPLE / UNCERTAINTY	VALUE / DET LIM
0509	5	MN	3/19/1999	0001	0.0567	8	0.020	0.080	0.0822	6/23/1995	N001	0.0900	6/23/1995	0001	0.0900	5/12/1994	0001	0.0900
	OK	mg/L				0	0.090	0.100	0.1144		0	0.01		0	0.01		0	0.01
	5	NA	3/19/1999	0001	103.0000	7	91.000	98.100	103.2597	6/23/1995	0001	105.0000	5/12/1994	0001	105.0000	8/27/1993	0001	100.0000
	OK	mg/L				0	104.000	105.000	110.8079		0	1		0	1		0	1
0510	6	CA	3/19/1999	0001	5.4500	4	3.110	3.480	4.0608	6/23/1995	0001	3.9700	5/12/1994	0001	3.8000	3/13/1985	0001	3.4800
	OK	mg/L				0	3.800	3.970	4.2507		0	0.1		0	0.5		0	0.01
	5	CHLORI	3/19/1999	0001	1.1800	4	1.100	3.000	4.8486	6/23/1995	0001	4.4700	5/12/1994	0001	7.0000	3/13/1985	0001	1.1000
	OK	mg/L				0	4.470	7.000	8.7368		0	0.5		0	0.5		0	1
	3	FE	3/19/1999	0001	0.0068	5	0.030	0.040	0.0201	6/23/1995	0001	0.0300	6/23/1995	N001	0.0400	5/12/1994	0001	0.0300
	OK	mg/L	B			60	0.570	0.570	0.8550	U	0	0.03		0	0.03	U	0	0.03
	3	MN	3/19/1999	0001	0.0057	5	0.010	0.010	0.0067	6/23/1995	N001	0.0100	6/23/1995	0001	0.0100	5/12/1994	0001	0.0100
	OK	mg/L	B			80	0.010	0.010	0.0150	U	0	0.01	U	0	0.01	U	0	0.01
	5	NA	3/19/1999	0001	49.6000	4	57.100	60.700	51.9242	6/23/1995	0001	57.1000	5/12/1994	0001	72.0000	3/13/1985	0001	69.2000
	OK	mg/L				0	69.200	72.000	71.3664		0	1		0	1		0	0.002
	5	TDS	3/19/1999	0001	197.0000	4	217.000	232.000	201.6390	6/23/1995	0001	217.0000	5/12/1994	0001	232.0000	3/13/1985	0001	260.0000
	OK	mg/L				0	248.000	260.000	217.6605		0	10		0	10		0	10
0523	6	ALKALI	3/18/1999	N001	78.0000	5	65.000	72.000	66.0581	6/23/1995	N001	73.0000	5/12/1994	N001	72.0000	7/12/1985	N001	65.0000
	OK	mg/L				0	79.000	88.000	75.2257		0	10		0	0		0	0
	6	CA	3/18/1999	0001	10.2000	6	7.200	8.200	8.0022	6/23/1995	0001	9.1200	5/12/1994	0001	9.7000	5/12/1994	N001	8.2000
	OK	mg/L				0	9.700	10.400	10.1522		0	0.1		0	0.5		0	0.5
	3	FE	3/18/1999	0001	0.0079	7	0.030	0.030	0.0201	6/23/1995	N001	0.0300	6/23/1995	0001	0.0300	5/12/1994	N001	0.0300
	OK	mg/L	B			71.429	0.030	0.030	0.0450		0	0.03	U	0	0.03	U	0	0.03
	6	MG	3/18/1999	0001	0.1140	6	0.100	0.105	0.0000	6/23/1995	0001	0.1000	5/12/1994	N001	0.1000	5/12/1994	0001	0.1000
	OK	mg/L				16.667	0.642	0.642	0.1070		0	0.1		0	0.1	U	0	0.1
0524	6	ALKALI	3/18/1999	0001	73.0000	5	72.000	75.000	66.9664	6/23/1995	N001	72.0000	5/12/1994	N001	75.0000	7/13/1985	N001	75.0000
	OK	mg/L				0	89.000	89.000	72.6683		0	10		0	0		0	0

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Site : LKV01 LAKEVIEW | Test Data Date Range : 3/1/1999 to 4/1/1999 | Older Data Only Used for Baseline Data | 391 Chemical Records | 3556 History Records

LOC. ID.	ERR. TYPE FLAG	PARAM CODE / UNITS	ANOMALOUS TEST DATA POINT: LOG DATE	SAMPLE	VALUE	FLAGS	UNCERTAINTY	DETLIM	# OF SAMP. / %NON DETEC	ALL TIME MINIMUMS / ALL TIME MAXIMUMS	LOWER BOUND / UPPER BOUND	3 MOST RECENT SAMPLING EVENTS: LOG DATE	SAMPLE	VALUE	FLAGS	UNCERTAINTY	DETLIM	LOG DATE	SAMPLE	VALUE	FLAGS	UNCERTAINTY	DET LIM
0524	5	CA	3/18/1999	0001	9.8700				6	6.000	7.850	9.8734	6/23/1995	0001	9.2600			5/12/1994	0001	9.8000			
	OK	mg/L							0	9.260	9.800	11.2882		0	0.1				0	0.5			0.5
	3	FE	3/18/1999	0001	0.0106				7	0.030	0.040	0.0201	6/23/1995	N001	0.0900			6/23/1995	0001	0.0300	5/12/1994	N001	0.3000
	OK	mg/L	B						57.143	0.090	0.300	0.4500		0	0.03			U	0	0.03		0	0.03
	6	K	3/18/1999	0001	4.0200				6	3.900	4.200	0.0695	6/23/1995	0001	4.2000			5/12/1994	N001	3.9000	5/12/1994	0001	4.5000
	OK	mg/L							0	14.400	14.400	2.7745		0	0.1				0	0.1		0	0.1
	3	MN	3/18/1999	0001	0.0022				7	0.010	0.020	0.0067	6/23/1995	0001	0.0100			6/23/1995	N001	0.0100	5/12/1994	N001	0.0200
	OK	mg/L	B						57.143	0.010	0.020	0.0300	U	0	0.01			U	0	0.01		0	0.01
	6	TDS	3/18/1999	0001	695.0000				6	640.000	650.000	638.6891	6/23/1995	0001	657.0000			5/12/1994	N001	650.0000	5/12/1994	0001	640.0000
	OK	mg/L							0	663.000	663.000	660.7623		0	10				0	10		0	10
0533	2	CD	3/17/1999	N001	0.0011				2	0.001	0.001	0.0000	3/20/1985	0001	0.0010			8/28/1984	0001	0.0010	8/28/1984	0001	0.0010
	OK	mg/L	U		0.0011				100	0.001	0.001	0.0010	U	0	0.001			U	0	0.001	U	0	0.001
	3	MN	3/17/1999	N001	0.0062				3	0.040	0.060	0.0200	8/30/1993	N001	0.0400			3/20/1985	0001	0.1000	8/28/1984	0001	0.0600
	OK	mg/L	B						0	0.060	0.100	0.2000		0	0.01				0	0.01		0	0.01
0534	2	CD	3/17/1999	N001	0.0011				1	0.001	0.001	0.0000	8/24/1984	0001	0.0010			8/24/1984	0001	0.0010	8/24/1984	0001	0.0010
	OK	mg/L	U		0.0011				100	0.001	0.001	0.0010	U	0	0.001			U	0	0.001	U	0	0.001
	3	MN	3/17/1999	N001	0.0014				2	0.010	0.010	0.0050	8/30/1993	N001	0.0100			8/24/1984	0001	0.0100	8/24/1984	0001	0.0100
	OK	mg/L	B						100	0.010	0.010	0.0200	U	0	0.01			U	0	0.01	U	0	0.01
	2	U	3/17/1999	N001	0.0011				1	0.001	0.001	0.0000	8/30/1993	N001	0.0010			8/30/1993	N001	0.0010	8/30/1993	N001	0.0010
	OK	mg/L	U		0.0011				100	0.001	0.001	0.0010	U	0	0.001			U	0	0.001	U	0	0.001
0535	4	FE	3/17/1999	N001	0.0988				3	0.030	0.030	0.0150	8/30/1993	N001	0.0300			7/14/1985	0001	0.0300	8/20/1984	0001	0.0300
	OK	mg/L							100	0.030	0.030	0.0600	U	0	0.03			U	0	0.03	U	0	0.03
	3	MN	3/17/1999	N001	0.0032				3	0.010	0.010	0.0050	8/30/1993	N001	0.0100			7/14/1985	0001	0.0100	8/20/1984	0001	0.0100
	OK	mg/L	B						100	0.010	0.010	0.0200	U	0	0.01			U	0	0.01	U	0	0.01
	4	U	3/17/1999	N001	0.0024				1	0.001	0.001	0.0005	8/30/1993	N001	0.0010			8/30/1993	N001	0.0010	8/30/1993	N001	0.0010
	OK	mg/L							0	0.001	0.001	0.0020		0	0.001				0	0.001		0	0.001

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Site : LKV01 LAKEVIEW | Test Data Date Range : 3/1/1999 to 4/1/1999 | Older Data Only Used for Baseline Data | 391 Chemical Records | 3556 History Records

LOC. ID.	ERR. TYPE FLAG	PARAM CODE / UNITS	ANOMALOUS TEST DATA POINT: LOG DATE	SAMPLE	VALUE	FLAGS	UNCERTAINTY	DETLIM	# OF SAMP. / %NON DETEC	ALL TIME MINIMUMS / ALL TIME MAXIMUMS		LOWER BOUND / UPPER BOUND	3 MOST RECENT SAMPLING EVENTS: LOG DATE	SAMPLE	VALUE	FLAGS	UNCERTAINTY	DETLIM	LOG DATE	SAMPLE	VALUE	FLAGS	UNCERTAINTY	DETLIM	LOG DATE	SAMPLE	VALUE	FLAGS	UNCERTAINTY	DET LIM
0536	6	ALKALI	3/17/1999	N001	142.0000				4	138.000	141.000	127.7650	8/30/1993	N001	138.0000				7/13/1985	N001	141.0000				8/20/1984	N001	146.0000			
	OK	mg/L							0	160.000	160.000	135.4460		0	0					0	0					0	0			
	2	CD	3/17/1999	N001	0.0011				2	0.001	0.001	0.0000	7/13/1985	0001	0.0010				8/20/1984	0001	0.0010				8/20/1984	0001	0.0010			
	OK	mg/L	U		0.0011				100	0.001	0.001	0.0010	U	0	0.001				U	0	0.001				U	0	0.001			
	6	CHLORI	3/17/1999	N001	3.3300				4	1.000	2.200	1.5729	8/30/1993	N001	2.2000				7/13/1985	0001	1.0000				8/20/1984	0001	3.7000			
	OK	mg/L							0	2.200	3.700	3.1621		0	0.5					0	1					0	0.1			
	6	FE	3/17/1999	N001	2.0300				4	0.170	0.180	0.0000	8/30/1993	N001	0.7000				7/13/1985	0001	0.1800				8/20/1984	0001	0.1700			
	OK	mg/L							0	2.900	2.900	1.1914		0	0.03					0	0.03					0	0.03			
	5	K	3/17/1999	N001	1.0200				4	1.100	1.200	1.1650	8/30/1993	N001	1.2000				7/13/1985	0001	1.1000				8/20/1984	0001	1.1000			
	OK	mg/L							0	1.300	1.300	1.2769		0	0.1					0	0.01					0	0.01			
	5	MG	3/17/1999	N001	9.2900				4	9.000	9.100	9.5382	8/30/1993	N001	9.5000				7/13/1985	0001	9.1000				8/20/1984	0001	9.5200			
	OK	mg/L							0	9.500	9.520	9.8040		0	0.1					0	0.001					0	0.001			
	5	TDS	3/17/1999	N001	190.0000				4	182.000	200.000	193.7653	8/30/1993	N001	200.0000				7/13/1985	0001	210.0000				8/20/1984	0001	204.0000			
	OK	mg/L							0	204.000	210.000	207.4992		0	10					0	10					0	10			
	2	U	3/17/1999	N001	0.0011				2	0.001	0.001	0.0000	8/30/1993	N001	0.0010				7/28/1982	0001	0.0010				7/28/1982	0001	0.0010			
	OK	mg/L	U		0.0011				100	0.001	0.001	0.0010	U	0	0.001				U	0	0.001				U	0	0.001			
0537	6	CA	3/17/1999	N001	46.8000				4	38.100	38.700	37.4146	5/15/1994	0001	41.5000				5/15/1994	N001	38.1000				8/30/1993	N001	41.2000			
	OK	mg/L							0	41.200	41.500	43.8019		0	0.5					0	0.5					0	0.5			
	2	CD	3/17/1999	N001	0.0011				1	0.001	0.001	0.0000	8/21/1984	0001	0.0010				8/21/1984	0001	0.0010				8/21/1984	0001	0.0010			
	OK	mg/L	U		0.0011				100	0.001	0.001	0.0010	U	0	0.001				U	0	0.001				U	0	0.001			
	6	CHLORI	3/17/1999	N001	5.7800				4	3.000	3.500	0.0000	5/15/1994	N001	3.0000				5/15/1994	0001	3.0000				8/30/1993	N001	3.5000			
	OK	mg/L							0	21.000	21.000	-5.3298		0	0.5					0	0.5					0	0.5			
	6	FE	3/17/1999	N001	1.2400				4	0.280	0.500	0.6040	5/15/1994	0001	0.5000				5/15/1994	N001	0.5600				8/30/1993	N001	0.5300			
	OK	mg/L							0	0.530	0.560	0.7110		0	0.03					0	0.03					0	0.03			
	6	MG	3/17/1999	N001	15.7000				4	13.400	13.800	13.1111	5/15/1994	0001	14.4000				5/15/1994	N001	13.4000				8/30/1993	N001	14.2000			
	OK	mg/L							0	14.200	14.400	14.8968		0	0.1					0	0.1					0	0.1			

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Site : LKV01 LAKEVIEW Test Data Date Range : 3/1/1999 to 4/1/1999 Older Data Only Used for Baseline Data 391 Chemical Records 3556 History Records

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0537	6	MN	3/17/1999	N001	2.5600				4	2.190	2.210	2.1602	5/15/1994	N001	2.1900				5/15/1994	0001	2.4000				8/30/1993	N001	2.3600			
	OK	mg/L							0	2.360	2.400	2.5395		0	0.01					0	0.01					0	0.01			
	6	NA	3/17/1999	N001	32.4000				4	27.200	27.700	27.5137	5/15/1994	0001	29.6000				5/15/1994	N001	27.7000				8/30/1993	N001	30.0000			
	OK	mg/L							0	29.600	30.000	31.7422		0	1					0	1					0	1			
	6	SO4	3/17/1999	N001	12.3000				4	8.000	9.000	4.5817	5/15/1994	N001	8.0000				5/15/1994	0001	8.0000				8/30/1993	N001	9.0000			
	OK	mg/L							0	14.000	14.000	5.6495		0	1					0	1					0	1			
	6	TDS	3/17/1999	N001	287.0000				4	268.000	270.000	256.7496	5/15/1994	0001	268.0000				5/15/1994	N001	268.0000				8/30/1993	N001	270.0000			
	OK	mg/L							0	290.000	290.000	257.5098		0	10					0	10					0	10			
0538	2	CD	3/17/1999	N001	0.0011				1	0.001	0.001	0.0000	8/20/1984	0001	0.0010				8/20/1984	0001	0.0010				8/20/1984	0001	0.0010			
	OK	mg/L	U		0.0011				100	0.001	0.001	0.0010	U	0	0.001				U	0	0.001				U	0	0.001			
	2	U	3/17/1999	N001	0.0011				2	0.001	0.001	0.0000	8/30/1993	N001	0.0010				7/28/1982	0001	0.0010				7/28/1982	0001	0.0010			
	OK	mg/L	U		0.0011				100	0.001	0.001	0.0010	U	0	0.001				U	0	0.001				U	0	0.001			
0540	3	AS	3/20/1999	0001	0.0010				11	0.002	0.005	0.0013	6/25/1995	0001	0.0050				6/25/1995	N001	0.0050				5/13/1994	0001	0.0050			
	OK	mg/L	U		0.001				90.909	0.010	0.010	0.0150	U	0	0.005				U	0	0.005				U	0	0.005			
	5	SIO2	3/20/1999	0001	64.7000				7	56.000	59.300	66.1598	5/13/1994	0001	66.1000				8/27/1993	N001	76.8000				9/1/1992	0001	64.6000			
	OK	mg/L							0	73.000	76.800	100.3128		0	0.1				H	0	0.5					0	0.1			
	5	TDS	3/20/1999	0001	3400.0000				9	3610.000	3810.000	3837.8868	6/25/1995	0001	3840.0000				5/13/1994	0001	4000.0000				5/13/1994	N001	3860.0000			
	OK	mg/L							0	3920.000	4000.000	4220.2361		0	10					0	10					0	10			
0541	6	ALKALI	3/19/1999	N001	181.0000				8	158.000	161.000	124.0993	6/25/1995	N001	164.0000				5/13/1994	N001	158.0000				8/27/1993	N001	161.0000			
	OK	mg/L							0	185.000	189.000	171.2786		0	10					0	0					0	0			
	6	MN	3/19/1999	0001	16.9000				10	7.990	8.440	0.6685	6/25/1995	N001	8.4700				6/25/1995	0001	8.5200				5/13/1994	N001	14.5000			
	OK	mg/L							0	14.500	15.700	16.4297		0	0.01					0	0.01					0	0.01			
	6	U	3/19/1999	0001	0.0010				10	0.001	0.001	0.0000	6/25/1995	N001	0.0010				5/13/1994	N001	0.0010				5/13/1994	0001	0.0010			
	OK	mg/L	U		0.001				50	0.002	0.004	0.0006	U	0	0.001				U	0	0.001				U	0	0.001			
0542	2	U	3/18/1999	N001	0.0011				3	0.001	0.001	0.0000	5/15/1994	0001	0.0010				5/15/1994	N001	0.0010				8/31/1993	N001	0.0010			
	OK	mg/L	U		0.0011				100	0.001	0.001	0.0010	U	0	0.001				U	0	0.001				U	0	0.001			

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Approved by Sam Campbell Date 5-17-99

Hydrologist "Ok" indicates insignificant variation

Site : LKV01 LAKEVIEW Test Data Date Range : 3/1/1999 to 4/1/1999 Older Data Only Used for Baseline Data 391 Chemical Records 3556 History Records

LOC. ID.	ERR. TYPE FLAG	PARAM CODE / UNITS	ANOMALOUS TEST DATA POINT: LOG DATE	SAMPLE	VALUE	# OF SAMP. / %NON DETEC	ALL TIME MINIMUMS / ALL TIME MAXIMUMS		LOWER BOUND / UPPER BOUND	3 MOST RECENT SAMPLING EVENTS: LOG DATE	SAMPLE	VALUE	LOG DATE	SAMPLE	VALUE	LOG DATE	SAMPLE	VALUE
			FLAGS	UNCERTAINTY	DETLIM					FLAGS	UNCERTAINTY	DETLIM	FLAGS	UNCERTAINTY	DETLIM	FLAGS	UNCERTAINTY	DET LIM
0543	2	U	3/17/1999	N001	0.0011	1	0.001	0.001	0.0000	8/31/1993	N001	0.0010	8/31/1993	N001	0.0010	8/31/1993	N001	0.0010
	OK	mg/L	U		0.0011	0	0.001	0.001	0.0010		0	0.001		0	0.001		0	0.001
0547	2	U	3/17/1999	N001	0.0011	3	0.001	0.001	0.0000	5/15/1994	0001	0.0010	5/15/1994	N001	0.0010	10/28/1993	N001	0.0010
	OK	mg/L	U		0.0011	100	0.001	0.001	0.0010	U	0	0.001	U	0	0.001	U	0	0.001
0549	4	FE	3/17/1999	N001	4.5100	3	0.720	0.790	0.3600	5/15/1994	0001	0.7900	5/15/1994	N001	0.8000	10/28/1993	N001	0.7200
	OK	mg/L				0	0.790	0.800	1.6000		0	0.03		0	0.03		0	0.03
	2	U	3/17/1999	N001	0.0011	3	0.001	0.001	0.0000	5/15/1994	0001	0.0010	5/15/1994	N001	0.0010	10/28/1993	N001	0.0010
	OK	mg/L	U		0.0011	66.667	0.001	0.001	0.0010	U	0	0.001	U	0	0.001		0	0.001
0550	4	CA	3/17/1999	N001	585.0000	2	191.000	228.000	95.5000	5/16/1994	0001	228.0000	5/15/1994	N001	191.0000	5/15/1994	N001	191.0000
	OK	mg/L				0	191.000	228.000	456.0000		0	0.5		0	0.5		0	0.5
	4	CHLORI	3/17/1999	N001	1670.0000	2	651.000	829.000	325.5000	5/16/1994	0001	651.0000	5/15/1994	N001	829.0000	5/15/1994	N001	829.0000
	OK	mg/L				0	829.000	829.000	1658.0000		0	0.5		0	0.5		0	0.5
	4	FE	3/17/1999	N001	5.3500	2	1.730	1.730	0.8650	5/16/1994	0001	1.7300	5/15/1994	N001	1.7300	5/15/1994	N001	1.7300
	OK	mg/L				0.	1.730	1.730	3.4600		0	0.03		0	0.03		0	0.03
	4	MG	3/17/1999	N001	185.0000	2	61.400	74.800	30.7000	5/16/1994	0001	74.8000	5/15/1994	N001	61.4000	5/15/1994	N001	61.4000
	OK	mg/L				0	61.400	74.800	149.6000		0	0.1		0	0.1		0	0.1
	4	MN	3/17/1999	N001	23.4000	2	9.000	10.800	4.5000	5/16/1994	0001	10.8000	5/15/1994	N001	9.0000	5/15/1994	N001	9.0000
	OK	mg/L				0	9.000	10.800	21.6000		0	0.01		0	0.01		0	0.01
	4	SO4	3/17/1999	N001	1190.0000	2	377.000	483.000	188.5000	5/16/1994	0001	377.0000	5/15/1994	N001	483.0000	5/15/1994	N001	483.0000
	OK	mg/L				0	483.000	483.000	966.0000		0	1		0	1		0	1
	2	U	3/17/1999	N001	0.0011	2	0.001	0.001	0.0000	5/16/1994	0001	0.0010	5/15/1994	N001	0.0010	5/15/1994	N001	0.0010
	OK	mg/L	U		0.0011	100	0.001	0.001	0.0010	U	0	0.001	U	0	0.001	U	0	0.001
0605	4	ALKALI	3/16/1999	0001	127.0000	1	52.000	52.000	26.0000	8/22/1984	N001	52.0000	8/22/1984	N001	52.0000	8/22/1984	N001	52.0000
	OK	mg/L				0	52.000	52.000	104.0000		0	0		0	0		0	0
	4	ALKALI	3/16/1999	N001	129.0000	1	52.000	52.000	26.0000	8/22/1984	N001	52.0000	8/22/1984	N001	52.0000	8/22/1984	N001	52.0000
	OK	mg/L				0	52.000	52.000	104.0000		0	0		0	0		0	0

Error Type Flags :
2 - All time high detection limit
3 - Too low (non-trend approach)
4 - Too high (non-trend approach)
5 - Too low (trend approach)
6 - Too high (trend approach)

Flags :
I - Increased detection limit due to required dilution.
L - Less than three bore volumes removed before sampling.
J - Estimated value.
H - Hold time expired, value suspect.

Approved by Sam Campbell Date 5-17-99
Hydrologist "Ok" s insignificant variation

Site : LKV01 LAKEVIEW | Test Data Date Range : 3/1/1999 to 4/1/1999 | Older Data Only Used for Baseline Data | 391 Chemical Records | 3556 History Records

LOC. ID.	ERR. TYPE FLAG	PARAM CODE / UNITS	ANOMALOUS TEST DATA POINT: LOG DATE	SAMPLE	VALUE	FLAGS	UNCERTAINTY	DETLIM	# OF SAMP. / %NON DETEC	ALL TIME MINIMUMS / ALL TIME MAXIMUMS		LOWER BOUND / UPPER BOUND	3 MOST RECENT SAMPLING EVENTS: LOG DATE	SAMPLE	VALUE	FLAGS	UNCERTAINTY	DETLIM	LOG DATE	SAMPLE	VALUE	FLAGS	UNCERTAINTY	DETLIM	LOG DATE	SAMPLE	VALUE	FLAGS	UNCERTAINTY	DET LIM
0605	4	CHLORI	3/16/1999	0001	39.7000				1	7.000	7.000	3.5000	8/22/1984	0001	7.0000				8/22/1984	0001	7.0000				8/22/1984	0001	7.0000			
	OK	mg/L							0	7.000	7.000	14.0000		0	0.1					0	0.1					0	0.1			
	4	MG	3/16/1999	0001	5.5700				2	1.000	1.270	0.5000	10/26/1993	N001	1.0000				8/22/1984	0001	1.2700				8/22/1984	0001	1.2700			
	OK	mg/L							0	1.270	1.270	2.5400		0	0.1					0	0.001					0	0.001			
	4	NA	3/16/1999	0001	107.0000				1	27.200	27.200	13.6000	8/22/1984	0001	27.2000				8/22/1984	0001	27.2000				8/22/1984	0001	27.2000			
	OK	mg/L							0	27.200	27.200	54.4000		0	0					0	0					0	0			
	4	TDS	3/16/1999	0001	453.0000				1	180.000	180.000	90.0000	8/22/1984	0001	180.0000				8/22/1984	0001	180.0000				8/22/1984	0001	180.0000			
	OK	mg/L							0	180.000	180.000	360.0000		0	10					0	10					0	10			
0607	4	U	3/16/1999	0001	0.0033				1	0.001	0.001	0.0005	7/1/1982	0001	0.0010				7/1/1982	0001	0.0010				7/1/1982	0001	0.0010			
	OK	mg/L							100	0.001	0.001	0.0020	U	0	0.001				U	0	0.001				U	0	0.001			
0608	4	ALKALI	3/16/1999	0001	255.0000				2	77.000	97.000	38.5000	8/26/1984	N001	77.0000				8/26/1984	N001	77.0000				7/1/1982	N001	97.0000			
	OK	mg/L							0	97.000	97.000	194.0000		0	0					0	0					0	0			
	4	ALKALI	3/16/1999	N001	206.0000				2	77.000	97.000	38.5000	8/26/1984	N001	77.0000				8/26/1984	N001	77.0000				7/1/1982	N001	97.0000			
	OK	mg/L							0	97.000	97.000	194.0000		0	0					0	0					0	0			
	4	MG	3/16/1999	0001	9.1700				3	0.358	1.000	0.1790	10/26/1993	N001	1.0000				8/26/1984	0001	0.3580				7/1/1982	0001	1.0000			
	OK	mg/L							33.333	1.000	1.000	2.0000		0	0.1					0	0.001				U	0	1			
0609	5	AS	3/16/1999	0001	0.0831				4	0.160	0.190	0.2612	10/26/1993	N001	0.2400				7/13/1985	0001	0.1600				8/26/1984	0001	0.1900			
	OK	mg/L							0	0.190	0.240	0.2866		0	0.005					0	0.01					0	0.01			
	5	CA	3/16/1999	0001	37.0000				4	13.000	14.000	57.9842	10/26/1993	N001	44.4000				7/13/1985	0001	13.0000				8/26/1984	0001	14.0000			
	OK	mg/L							0	17.000	44.400	64.3768		0	1					0	0.01					0	0.01			
	5	FE	3/16/1999	0001	0.2290				4	0.040	0.060	0.9109	10/26/1993	N001	0.6300				7/13/1985	0001	0.0700				8/26/1984	0001	0.0400			
	OK	mg/L							0	0.070	0.630	0.9953		0	0.03					0	0.03					0	0.03			
	6	MG	3/16/1999	0001	9.4600				4	0.220	0.291	4.0319	10/26/1993	N001	3.0000				7/13/1985	0001	0.2200				8/26/1984	0001	0.2910			
	OK	mg/L							0	1.000	3.000	4.7922		0	0.1					0	0.001					0	0.001			
	5	SO4	3/16/1999	0001	141.0000				4	220.000	268.000	316.8713	10/26/1993	N001	305.0000				7/13/1985	0001	220.0000				8/26/1984	0001	270.0000			
	OK	mg/L							0	270.000	305.000	352.4292	I	0	3.8					0	0.1					0	0.1			

Error Type Flags :
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Flags :
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L - Less than three bore volumes removed before sampling.
J - Estimated value.
H - Hold time expired, value suspect.

Approved by Jon Campbell Date 5-17-99

Hydrologist "Ok" indicates insignificant variation

Site : LKV01 LAKEVIEW | Test Data Date Range : 3/1/1999 to 4/1/1999 | Older Data Only Used for Baseline Data | 391 Chemical Records | 3556 History Records

LOC. ID.	ERR. TYPE FLAG	PARAM CODE / UNITS	ANOMALOUS TEST DATA POINT: LOG DATE	SAMPLE	VALUE	# OF SAMP. / %NON DETEC	ALL TIME MINIMUMS / ALL TIME MAXIMUMS		LOWER BOUND / UPPER BOUND	3 MOST RECENT SAMPLING EVENTS: LOG DATE	SAMPLE	VALUE
			FLAGS	UNCERTAINTY	DETLIM					FLAGS	UNCERTAINTY	DETLIM
0613	3	AS	3/16/1999	0001	0.0010	1	0.005	0.005	0.0013	10/27/1993	N001	0.0050
	OK	mg/L	U		0.001	0	0.005	0.005	0.0200	W	0	0.005
	3	MG	3/16/1999	0001	3.1800	1	16.900	16.900	8.4500	10/27/1993	N001	16.9000
	OK	mg/L				0	16.900	16.900	33.8000		0	0.1
	3	MN	3/16/1999	0001	0.0056	1	0.030	0.030	0.0150	10/27/1993	N001	0.0300
	OK	mg/L	B			0	0.030	0.030	0.0600		0	0.01
	3	SO4	3/16/1999	0001	1.5600	1	4.500	4.500	2.2500	10/27/1993	N001	4.5000
	OK	mg/L				0	4.500	4.500	9.0000		0	1

3 MOST RECENT SAMPLING EVENTS: LOG DATE	SAMPLE	VALUE	LOG DATE	SAMPLE	VALUE
FLAGS	UNCERTAINTY	DETLIM	FLAGS	UNCERTAINTY	DETLIM
10/27/1993	N001	0.0050	10/27/1993	N001	0.0050
W	0	0.005	W	0	0.005
10/27/1993	N001	16.9000	10/27/1993	N001	16.9000
	0	0.1		0	0.1
10/27/1993	N001	0.0300	10/27/1993	N001	0.0300
	0	0.01		0	0.01
10/27/1993	N001	4.5000	10/27/1993	N001	4.5000
	0	1		0	1

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Approved by Sean Capell Date 5-17-99

Hydrologist "Ok" i insignificant variation

WATER QUALITY DATA

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/18/1999 7:38 a

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB DATA QA	DETECTION LIMIT	UN-CERTAINTY
Alkalinity as CaCO3	mg/L	0503	03/18/1999	0001	SP	D	388	#	-	-
	mg/L	0503	03/18/1999	N001	SP	D	392	#	-	-
	mg/L	0504	03/18/1999	0001	SP	D	110	#	-	-
	mg/L	0504	03/18/1999	N001	SP	D	108	#	-	-
	mg/L	0505	03/20/1999	0001	SP	D	587	#	-	-
	mg/L	0505	03/20/1999	N001	SP	D	582	#	-	-
	mg/L	0506	03/20/1999	0001	SP	D	119	#	-	-
	mg/L	0506	03/20/1999	N001	SP	D	117	#	-	-
	mg/L	0507	03/19/1999	0001	SP	C	172	#	-	-
	mg/L	0507	03/19/1999	N001	SP	C	178	#	-	-
	mg/L	0508	03/19/1999	0001	SP	C	146	#	-	-
	mg/L	0508	03/19/1999	N001	SP	C	149	#	-	-
	mg/L	0509	03/19/1999	0001	SP	D	184	#	-	-
	mg/L	0509	03/19/1999	N001	SP	D	187	#	-	-
	mg/L	0510	03/19/1999	0001	SP	D	125	#	-	-
	mg/L	0510	03/19/1999	N001	SP	D	116	#	-	-
	mg/L	0523	03/18/1999	0001	SP	N	68	#	-	-
	mg/L	0523	03/18/1999	N001	SP	N	78	#	-	-
	mg/L	0524	03/18/1999	0001	SP	N	73	#	-	-
	mg/L	0524	03/18/1999	N001	SP	N	72	#	-	-
	mg/L	0533	03/17/1999	N001	NR	N	95	#	-	-
	mg/L	0534	03/17/1999	N001	NR	N	136	#	-	-
	mg/L	0535	03/17/1999	N001	NR	N	194	#	-	-
	mg/L	0536	03/17/1999	N001	NR	N	142	#	-	-
	mg/L	0537	03/17/1999	N001	NR	N	215	#	-	-
	mg/L	0538	03/17/1999	N001	NR	N	79	#	-	-
	mg/L	0540	03/20/1999	0001	AL	D	53	#	-	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/18/1999 7:38 a

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	DATA	QA	DETECTION LIMIT	UN-CERTAINTY
Alkalinity as CaCO3	mg/L	0540	03/20/1999	N001	AL	D	50			#	-	-
	mg/L	0541	03/19/1999	0001	AL	D	170			#	-	-
	mg/L	0541	03/19/1999	N001	AL	D	181			#	-	-
	mg/L	0542	03/18/1999	N001	NR	N	145			#	-	-
	mg/L	0543	03/17/1999	N001	NR	N	201			#	-	-
	mg/L	0547	03/17/1999	N001	NR	N	193			#	-	-
	mg/L	0549	03/17/1999	N001	NR	N	87			#	-	-
	mg/L	0550	03/17/1999	N001	NR	N	182			#	-	-
Arsenic	mg/L	0503	03/18/1999	0001	SP	D	0.0967			#	-	-
	mg/L	0504	03/18/1999	0001	SP	D	0.0037	B		#	-	-
	mg/L	0505	03/20/1999	0001	SP	D	0.0063			#	-	-
	mg/L	0506	03/20/1999	0001	SP	D	0.0113			#	-	-
	mg/L	0507	03/19/1999	0001	SP	C	0.0024	B		#	-	-
	mg/L	0508	03/19/1999	0001	SP	C	0.0045	B		#	-	-
	mg/L	0509	03/19/1999	0001	SP	D	0.0263			#	-	-
	mg/L	0510	03/19/1999	0001	SP	D	0.0058			#	-	-
	mg/L	0523	03/18/1999	0001	SP	N	0.0053			#	-	-
	mg/L	0524	03/18/1999	0001	SP	N	0.0310			#	-	-
	mg/L	0533	03/17/1999	N001	NR	N	0.0150			#	-	-
	mg/L	0534	03/17/1999	N001	NR	N	0.0055	B		#	-	-
	mg/L	0535	03/17/1999	N001	NR	N	0.0071			#	-	-
	mg/L	0535	03/17/1999	N002	NR	N	0.0071			#	-	-
	mg/L	0536	03/17/1999	N001	NR	N	0.0053	B		#	-	-
	mg/L	0537	03/17/1999	N001	NR	N	0.0046	B		#	-	-
	mg/L	0538	03/17/1999	N001	NR	N	0.0141			#	-	-
	mg/L	0540	03/20/1999	0001	AL	D	0.0010	U		#	0.001	-
	mg/L	0541	03/19/1999	0001	AL	D	0.0404			#	-	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/18/1999 7:38 a

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	DATA	QA	DETECTION LIMIT	UN-CERTAINTY
Arsenic	mg/L	0541	03/19/1999	0002	AL	D	0.0395			#	-	-
	mg/L	0542	03/18/1999	N001	NR	N	0.0048	B		#	-	-
	mg/L	0543	03/17/1999	N001	NR	N	0.0055	B		#	-	-
	mg/L	0547	03/17/1999	N001	NR	N	0.0075			#	-	-
	mg/L	0549	03/17/1999	N001	NR	N	0.0267			#	-	-
	mg/L	0550	03/17/1999	N001	NR	N	0.0110			#	-	-
Cadmium	mg/L	0503	03/18/1999	0001	SP	D	0.0010	U		#	0.001	-
	mg/L	0504	03/18/1999	0001	SP	D	0.0010	U		#	0.001	-
	mg/L	0505	03/20/1999	0001	SP	D	0.0010	U		#	0.001	-
	mg/L	0506	03/20/1999	0001	SP	D	0.0010	U		#	0.001	-
	mg/L	0507	03/19/1999	0001	SP	C	0.0010	U		#	0.001	-
	mg/L	0508	03/19/1999	0001	SP	C	0.0010	U		#	0.001	-
	mg/L	0509	03/19/1999	0001	SP	D	0.0010	U		#	0.001	-
	mg/L	0510	03/19/1999	0001	SP	D	0.0010	U		#	0.001	-
	mg/L	0523	03/18/1999	0001	SP	N	0.0010	U		#	0.001	-
	mg/L	0524	03/18/1999	0001	SP	N	0.0010	U		#	0.001	-
	mg/L	0533	03/17/1999	N001	NR	N	0.0011	U		#	0.0011	-
	mg/L	0534	03/17/1999	N001	NR	N	0.0011	U		#	0.0011	-
	mg/L	0535	03/17/1999	N001	NR	N	0.0011	U		#	0.0011	-
	mg/L	0535	03/17/1999	N002	NR	N	0.0011	U		#	0.0011	-
	mg/L	0536	03/17/1999	N001	NR	N	0.0011	U		#	0.0011	-
	mg/L	0537	03/17/1999	N001	NR	N	0.0011	U		#	0.0011	-
	mg/L	0538	03/17/1999	N001	NR	N	0.0011	U		#	0.0011	-
	mg/L	0540	03/20/1999	0001	AL	D	0.0032			#	-	-
	mg/L	0541	03/19/1999	0001	AL	D	0.0010	U		#	0.001	-
	mg/L	0541	03/19/1999	0002	AL	D	0.0010	U		#	0.001	-
	mg/L	0542	03/18/1999	N001	NR	N	0.0011	U		#	0.0011	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/18/1999 7:38 a

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	DATA	QA	DETECTION LIMIT	UN-CERTAINTY
Cadmium	mg/L	0543	03/17/1999	N001	NR	N	0.0011	U		#	0.0011	-
	mg/L	0547	03/17/1999	N001	NR	N	0.0011	U		#	0.0011	-
	mg/L	0549	03/17/1999	N001	NR	N	0.0011	U		#	0.0011	-
	mg/L	0550	03/17/1999	N001	NR	N	0.0011	U		#	0.0011	-
Calcium	mg/L	0503	03/18/1999	0001	SP	D	225.000			#	-	-
	mg/L	0504	03/18/1999	0001	SP	D	9.100			#	-	-
	mg/L	0505	03/20/1999	0001	SP	D	134.000			#	-	-
	mg/L	0506	03/20/1999	0001	SP	D	10.400			#	-	-
	mg/L	0507	03/19/1999	0001	SP	C	119.000			#	-	-
	mg/L	0508	03/19/1999	0001	SP	C	29.700			#	-	-
	mg/L	0509	03/19/1999	0001	SP	D	2.550			#	-	-
	mg/L	0510	03/19/1999	0001	SP	D	5.450			#	-	-
	mg/L	0523	03/18/1999	0001	SP	N	10.200			#	-	-
	mg/L	0524	03/18/1999	0001	SP	N	9.870			#	-	-
	mg/L	0533	03/17/1999	N001	NR	N	11.200			#	-	-
	mg/L	0534	03/17/1999	N001	NR	N	35.600			#	-	-
	mg/L	0535	03/17/1999	N001	NR	N	82.800			#	-	-
	mg/L	0535	03/17/1999	N002	NR	N	85.500			#	-	-
	mg/L	0536	03/17/1999	N001	NR	N	29.900			#	-	-
	mg/L	0537	03/17/1999	N001	NR	N	46.800			#	-	-
	mg/L	0538	03/17/1999	N001	NR	N	5.190			#	-	-
	mg/L	0540	03/20/1999	0001	AL	D	447.000			#	-	-
	mg/L	0541	03/19/1999	0001	AL	D	444.000			#	-	-
	mg/L	0541	03/19/1999	0002	AL	D	445.000			#	-	-
	mg/L	0542	03/18/1999	N001	NR	N	28.900			#	-	-
	mg/L	0543	03/17/1999	N001	NR	N	44.300			#	-	-
	mg/L	0547	03/17/1999	N001	NR	N	248.000			#	-	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/18/1999 7:38 a

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	DATA	QA	DETECTION LIMIT	UN-CERTAINTY
Calcium	mg/L	0549	03/17/1999	N001	NR	N	6.800			#	-	-
	mg/L	0550	03/17/1999	N001	NR	N	585.000			#	-	-
Chloride	mg/L	0503	03/18/1999	0001	SP	D	1060.000			#	-	-
	mg/L	0504	03/18/1999	0001	SP	D	144.000			#	-	-
	mg/L	0505	03/20/1999	0001	SP	D	570.000			#	-	-
	mg/L	0506	03/20/1999	0001	SP	D	144.000			#	-	-
	mg/L	0507	03/19/1999	0001	SP	C	15.000			#	-	-
	mg/L	0508	03/19/1999	0001	SP	C	1.250			#	-	-
	mg/L	0509	03/19/1999	0001	SP	D	7.700			#	-	-
	mg/L	0510	03/19/1999	0001	SP	D	1.180			#	-	-
	mg/L	0523	03/18/1999	0001	SP	N	97.800			#	-	-
	mg/L	0524	03/18/1999	0001	SP	N	92.300			#	-	-
	mg/L	0533	03/17/1999	N001	NR	N	1.350			#	-	-
	mg/L	0534	03/17/1999	N001	NR	N	2.060			#	-	-
	mg/L	0535	03/17/1999	N001	NR	N	32.600			#	-	-
	mg/L	0535	03/17/1999	N002	NR	N	32.200			#	-	-
	mg/L	0536	03/17/1999	N001	NR	N	3.330			#	-	-
	mg/L	0537	03/17/1999	N001	NR	N	5.780			#	-	-
	mg/L	0538	03/17/1999	N001	NR	N	98.200			#	-	-
	mg/L	0540	03/20/1999	0001	AL	D	14.700		U	#	-	-
	mg/L	0541	03/19/1999	0001	AL	D	1670.000			#	-	-
	mg/L	0541	03/19/1999	0002	AL	D	1690.000			#	-	-
	mg/L	0542	03/18/1999	N001	NR	N	1.470			#	-	-
	mg/L	0543	03/17/1999	N001	NR	N	4.550			#	-	-
	mg/L	0547	03/17/1999	N001	NR	N	605.000			#	-	-
	mg/L	0549	03/17/1999	N001	NR	N	67.700			#	-	-
	mg/L	0550	03/17/1999	N001	NR	N	1670.000			#	-	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/18/1999 7:38 a

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	DATA	QA	DETECTION LIMIT	UN-CERTAINTY
Iron	mg/L	0503	03/18/1999	0001	SP	D	1.870			#	-	-
	mg/L	0504	03/18/1999	0001	SP	D	0.0115	B	U	#	-	-
	mg/L	0505	03/20/1999	0001	SP	D	0.0511		U	#	-	-
	mg/L	0506	03/20/1999	0001	SP	D	0.173			#	-	-
	mg/L	0507	03/19/1999	0001	SP	C	0.0053	B	U	#	-	-
	mg/L	0508	03/19/1999	0001	SP	C	0.0050	U		#	0.005	-
	mg/L	0509	03/19/1999	0001	SP	D	0.0259	B	U	#	-	-
	mg/L	0510	03/19/1999	0001	SP	D	0.0068	B	U	#	-	-
	mg/L	0523	03/18/1999	0001	SP	N	0.0079	B	U	#	-	-
	mg/L	0524	03/18/1999	0001	SP	N	0.0106	B	U	#	-	-
	mg/L	0533	03/17/1999	N001	NR	N	0.155			#	-	-
	mg/L	0534	03/17/1999	N001	NR	N	0.0283	B	U	#	-	-
	mg/L	0535	03/17/1999	N001	NR	N	0.0988		U	#	-	-
	mg/L	0535	03/17/1999	N002	NR	N	0.0394		U	#	-	-
	mg/L	0536	03/17/1999	N001	NR	N	2.030			#	-	-
	mg/L	0537	03/17/1999	N001	NR	N	1.240			#	-	-
	mg/L	0538	03/17/1999	N001	NR	N	0.0513		U	#	-	-
	mg/L	0540	03/20/1999	0001	AL	D	10.400			#	-	-
	mg/L	0541	03/19/1999	0001	AL	D	7.800			#	-	-
	mg/L	0541	03/19/1999	0002	AL	D	7.830			#	-	-
	mg/L	0542	03/18/1999	N001	NR	N	0.164			#	-	-
	mg/L	0543	03/17/1999	N001	NR	N	1.120			#	-	-
	mg/L	0547	03/17/1999	N001	NR	N	3.460			#	-	-
	mg/L	0549	03/17/1999	N001	NR	N	4.510			#	-	-
	mg/L	0550	03/17/1999	N001	NR	N	5.350			#	-	-
Magnesium	mg/L	0503	03/18/1999	0001	SP	D	42.700			#	-	-
	mg/L	0504	03/18/1999	0001	SP	D	3.270			#	-	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE LKV01, LAKEVIEW
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PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	DATA	QA	DETECTION LIMIT	UN-CERTAINTY
Magnesium	mg/L	0505	03/20/1999	0001	SP	D	40.300			#	-	-
	mg/L	0506	03/20/1999	0001	SP	D	3.140			#	-	-
	mg/L	0507	03/19/1999	0001	SP	C	42.600			#	-	-
	mg/L	0508	03/19/1999	0001	SP	C	8.540			#	-	-
	mg/L	0509	03/19/1999	0001	SP	D	0.659			#	-	-
	mg/L	0510	03/19/1999	0001	SP	D	0.756			#	-	-
	mg/L	0523	03/18/1999	0001	SP	N	0.114			#	-	-
	mg/L	0524	03/18/1999	0001	SP	N	0.0392	B		#	-	-
	mg/L	0533	03/17/1999	N001	NR	N	3.610			#	-	-
	mg/L	0534	03/17/1999	N001	NR	N	7.190			#	-	-
	mg/L	0535	03/17/1999	N001	NR	N	15.100			#	-	-
	mg/L	0535	03/17/1999	N002	NR	N	15.500			#	-	-
	mg/L	0536	03/17/1999	N001	NR	N	9.290			#	-	-
	mg/L	0537	03/17/1999	N001	NR	N	15.700			#	-	-
	mg/L	0538	03/17/1999	N001	NR	N	0.188			#	-	-
	mg/L	0540	03/20/1999	0001	AL	D	192.000			#	-	-
	mg/L	0541	03/19/1999	0001	AL	D	94.400			#	-	-
	mg/L	0541	03/19/1999	0002	AL	D	94.700			#	-	-
	mg/L	0542	03/18/1999	N001	NR	N	8.870			#	-	-
	mg/L	0543	03/17/1999	N001	NR	N	13.400			#	-	-
	mg/L	0547	03/17/1999	N001	NR	N	98.400			#	-	-
	mg/L	0549	03/17/1999	N001	NR	N	2.760			#	-	-
	mg/L	0550	03/17/1999	N001	NR	N	185.000			#	-	-
Manganese	mg/L	0503	03/18/1999	0001	SP	D	8.930			#	-	-
	mg/L	0504	03/18/1999	0001	SP	D	0.683			#	-	-
	mg/L	0505	03/20/1999	0001	SP	D	3.930			#	-	-
	mg/L	0506	03/20/1999	0001	SP	D	0.538			#	-	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE LKV01, LAKEVIEW
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PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	DATA	QA	DETECTION LIMIT	UN-CERTAINTY
Manganese	mg/L	0507	03/19/1999	0001	SP	C	4.080			#	-	-
	mg/L	0508	03/19/1999	0001	SP	C	0.887			#	-	-
	mg/L	0509	03/19/1999	0001	SP	D	0.0567			#	-	-
	mg/L	0510	03/19/1999	0001	SP	D	0.0057	B		#	-	-
	mg/L	0523	03/18/1999	0001	SP	N	0.0088	B		#	-	-
	mg/L	0524	03/18/1999	0001	SP	N	0.0022	B		#	-	-
	mg/L	0533	03/17/1999	N001	NR	N	0.0062	B		#	-	-
	mg/L	0534	03/17/1999	N001	NR	N	0.0014	B		#	-	-
	mg/L	0535	03/17/1999	N001	NR	N	0.0032	B		#	-	-
	mg/L	0535	03/17/1999	N002	NR	N	0.0015	B		#	-	-
	mg/L	0536	03/17/1999	N001	NR	N	0.326			#	-	-
	mg/L	0537	03/17/1999	N001	NR	N	2.560			#	-	-
	mg/L	0538	03/17/1999	N001	NR	N	0.0137			#	-	-
	mg/L	0540	03/20/1999	0001	AL	D	33.700			#	-	-
	mg/L	0541	03/19/1999	0001	AL	D	16.900			#	-	-
	mg/L	0541	03/19/1999	0002	AL	D	17.000			#	-	-
	mg/L	0542	03/18/1999	N001	NR	N	0.489			#	-	-
	mg/L	0543	03/17/1999	N001	NR	N	2.130			#	-	-
	mg/L	0547	03/17/1999	N001	NR	N	13.900			#	-	-
	mg/L	0549	03/17/1999	N001	NR	N	0.571			#	-	-
	mg/L	0550	03/17/1999	N001	NR	N	23.400			#	-	-
pH	s.u.	0503	03/18/1999	N001	SP	D	6.85			#	-	-
	s.u.	0504	03/18/1999	N001	SP	D	7.42			#	-	-
	s.u.	0505	03/20/1999	N001	SP	D	7.08			#	-	-
	s.u.	0506	03/20/1999	N001	SP	D	7.95			#	-	-
	s.u.	0507	03/19/1999	N001	SP	C	6.89			#	-	-
	s.u.	0508	03/19/1999	N001	SP	C	7.56			#	-	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE LKV01, LAKEVIEW
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PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	DATA	QA	DETECTION LIMIT	UN-CERTAINTY
pH	s.u.	0509	03/19/1999	N001	SP	D	7.75			#	-	-
	s.u.	0510	03/19/1999	N001	SP	D	8.44			#	-	-
	s.u.	0523	03/18/1999	N001	SP	N	8.30			#	-	-
	s.u.	0524	03/18/1999	N001	SP	N	8.14			#	-	-
	s.u.	0533	03/17/1999	N001	NR	N	7.72			#	-	-
	s.u.	0534	03/17/1999	N001	NR	N	7.28			#	-	-
	s.u.	0535	03/17/1999	N001	NR	N	7.08			#	-	-
	s.u.	0536	03/17/1999	N001	NR	N	7.27			#	-	-
	s.u.	0537	03/17/1999	N001	NR	N	7.15			#	-	-
	s.u.	0538	03/17/1999	N001	NR	N	8.28			#	-	-
	s.u.	0540	03/20/1999	N001	AL	D	5.70			#	-	-
	s.u.	0541	03/19/1999	N001	AL	D	6.67			#	-	-
	s.u.	0542	03/18/1999	N001	NR	N	7.20			#	-	-
	s.u.	0543	03/17/1999	N001	NR	N	7.46			#	-	-
	s.u.	0547	03/17/1999	N001	NR	N	7.08			#	-	-
	s.u.	0549	03/17/1999	N001	NR	N	7.31			#	-	-
	s.u.	0550	03/17/1999	N001	NR	N	7.14			#	-	-
Potassium	mg/L	0503	03/18/1999	0001	SP	D	20.300			#	-	-
	mg/L	0504	03/18/1999	0001	SP	D	4.420			#	-	-
	mg/L	0505	03/20/1999	0001	SP	D	11.300			#	-	-
	mg/L	0506	03/20/1999	0001	SP	D	4.950			#	-	-
	mg/L	0507	03/19/1999	0001	SP	C	2.450			#	-	-
	mg/L	0508	03/19/1999	0001	SP	C	1.220			#	-	-
	mg/L	0509	03/19/1999	0001	SP	D	1.180			#	-	-
	mg/L	0510	03/19/1999	0001	SP	D	3.330			#	-	-
	mg/L	0523	03/18/1999	0001	SP	N	5.420			#	-	-
	mg/L	0524	03/18/1999	0001	SP	N	4.020			#	-	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/18/1999 7:38 a

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	DATA	QA	DETECTION LIMIT	UN-CERTAINTY
Potassium	mg/L	0533	03/17/1999	N001	NR	N	4.880			#	-	-
	mg/L	0534	03/17/1999	N001	NR	N	6.600			#	-	-
	mg/L	0535	03/17/1999	N001	NR	N	2.680			#	-	-
	mg/L	0535	03/17/1999	N002	NR	N	2.810			#	-	-
	mg/L	0536	03/17/1999	N001	NR	N	1.020			#	-	-
	mg/L	0537	03/17/1999	N001	NR	N	0.842			#	-	-
	mg/L	0538	03/17/1999	N001	NR	N	6.520			#	-	-
	mg/L	0540	03/20/1999	0001	AL	D	1.710			#	-	-
	mg/L	0541	03/19/1999	0001	AL	D	27.200			#	-	-
	mg/L	0541	03/19/1999	0002	AL	D	27.100			#	-	-
	mg/L	0542	03/18/1999	N001	NR	N	1.140			#	-	-
	mg/L	0543	03/17/1999	N001	NR	N	0.798			#	-	-
	mg/L	0547	03/17/1999	N001	NR	N	6.130			#	-	-
	mg/L	0549	03/17/1999	N001	NR	N	3.670			#	-	-
	mg/L	0550	03/17/1999	N001	NR	N	16.300			#	-	-
Redox Potential	mV	0503	03/18/1999	N001	SP	D	-35			#	-	-
	mV	0504	03/18/1999	N001	SP	D	-14			#	-	-
	mV	0505	03/20/1999	N001	SP	D	59			#	-	-
	mV	0506	03/20/1999	N001	SP	D	-210			#	-	-
	mV	0507	03/19/1999	N001	SP	C	67			#	-	-
	mV	0508	03/19/1999	N001	SP	C	-41			#	-	-
	mV	0509	03/19/1999	N001	SP	D	-25			#	-	-
	mV	0510	03/19/1999	N001	SP	D	-228			#	-	-
	mV	0523	03/18/1999	N001	SP	N	-312			#	-	-
	mV	0524	03/18/1999	N001	SP	N	-299			#	-	-
	mV	0533	03/17/1999	N001	NR	N	119			#	-	-
	mV	0534	03/17/1999	N001	NR	N	157			#	-	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE LKV01, LAKEVIEW
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PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB DATA QA	DETECTION LIMIT	UN-CERTAINTY
Redox Potential	mV	0535	03/17/1999	N001	NR	N	170	#	-	-
	mV	0536	03/17/1999	N001	NR	N	-69	#	-	-
	mV	0537	03/17/1999	N001	NR	N	-38	#	-	-
	mV	0538	03/17/1999	N001	NR	N	121	#	-	-
	mV	0540	03/20/1999	N001	AL	D	56	#	-	-
	mV	0541	03/19/1999	N001	AL	D	-97	#	-	-
	mV	0542	03/18/1999	N001	NR	N	103	#	-	-
	mV	0543	03/17/1999	N001	NR	N	-76	#	-	-
	mV	0547	03/17/1999	N001	NR	N	-71	#	-	-
	mV	0549	03/17/1999	N001	NR	N	-28	#	-	-
	mV	0550	03/17/1999	N001	NR	N	-93	#	-	-
Silica	mg/L	0503	03/18/1999	0001	SP	D	57.200	#	-	-
	mg/L	0504	03/18/1999	0001	SP	D	55.500	#	-	-
	mg/L	0505	03/20/1999	0001	SP	D	46.700	#	-	-
	mg/L	0506	03/20/1999	0001	SP	D	55.800	#	-	-
	mg/L	0507	03/19/1999	0001	SP	C	46.700	#	-	-
	mg/L	0508	03/19/1999	0001	SP	C	49.700	#	-	-
	mg/L	0509	03/19/1999	0001	SP	D	54.000	#	-	-
	mg/L	0510	03/19/1999	0001	SP	D	57.800	#	-	-
	mg/L	0523	03/18/1999	0001	SP	N	93.600	#	-	-
	mg/L	0524	03/18/1999	0001	SP	N	93.900	#	-	-
	mg/L	0533	03/17/1999	N001	NR	N	55.500	#	-	-
	mg/L	0534	03/17/1999	N001	NR	N	56.900	#	-	-
	mg/L	0535	03/17/1999	N001	NR	N	44.100	#	-	-
	mg/L	0535	03/17/1999	N002	NR	N	44.300	#	-	-
	mg/L	0536	03/17/1999	N001	NR	N	45.300	#	-	-
	mg/L	0537	03/17/1999	N001	NR	N	44.500	#	-	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/18/1999 7:38 a

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB DATA QA	DETECTION LIMIT	UN-CERTAINTY
Silica	mg/L	0538	03/17/1999	N001	NR	N	106.000	#	-	-
	mg/L	0540	03/20/1999	0001	AL	D	64.700	#	-	-
	mg/L	0541	03/19/1999	0001	AL	D	60.500	#	-	-
	mg/L	0541	03/19/1999	0002	AL	D	60.300	#	-	-
	mg/L	0542	03/18/1999	N001	NR	N	53.900	#	-	-
	mg/L	0543	03/17/1999	N001	NR	N	44.900	#	-	-
	mg/L	0547	03/17/1999	N001	NR	N	56.600	#	-	-
	mg/L	0549	03/17/1999	N001	NR	N	62.000	#	-	-
	mg/L	0550	03/17/1999	N001	NR	N	56.400	#	-	-
Sodium	mg/L	0503	03/18/1999	0001	SP	D	1690.000	#	-	-
	mg/L	0504	03/18/1999	0001	SP	D	252.000	#	-	-
	mg/L	0505	03/20/1999	0001	SP	D	1120.000	#	-	-
	mg/L	0506	03/20/1999	0001	SP	D	248.000	#	-	-
	mg/L	0507	03/19/1999	0001	SP	C	52.100	#	-	-
	mg/L	0508	03/19/1999	0001	SP	C	19.200	#	-	-
	mg/L	0509	03/19/1999	0001	SP	D	103.000	#	-	-
	mg/L	0510	03/19/1999	0001	SP	D	49.600	#	-	-
	mg/L	0523	03/18/1999	0001	SP	N	186.000	#	-	-
	mg/L	0524	03/18/1999	0001	SP	N	177.000	#	-	-
	mg/L	0533	03/17/1999	N001	NR	N	24.900	#	-	-
	mg/L	0534	03/17/1999	N001	NR	N	14.400	#	-	-
	mg/L	0535	03/17/1999	N001	NR	N	26.100	#	-	-
	mg/L	0535	03/17/1999	N002	NR	N	26.800	#	-	-
	mg/L	0536	03/17/1999	N001	NR	N	18.000	#	-	-
	mg/L	0537	03/17/1999	N001	NR	N	32.400	#	-	-
	mg/L	0538	03/17/1999	N001	NR	N	184.000	#	-	-
	mg/L	0540	03/20/1999	0001	AL	D	152.000	#	-	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/18/1999 7:38 a

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB DATA QA	DETECTION LIMIT	UN-CERTAINTY
Sodium	mg/L	0541	03/19/1999	0001	AL	D	1790.000	#	-	-
	mg/L	0541	03/19/1999	0002	AL	D	1750.000	#	-	-
	mg/L	0542	03/18/1999	N001	NR	N	19.700	#	-	-
	mg/L	0543	03/17/1999	N001	NR	N	31.800	#	-	-
	mg/L	0547	03/17/1999	N001	NR	N	119.000	#	-	-
	mg/L	0549	03/17/1999	N001	NR	N	129.000	#	-	-
	mg/L	0550	03/17/1999	N001	NR	N	615.000	#	-	-
Specific Conductance	umhos/cm	0503	03/18/1999	N001	SP	D	8240	#	-	-
	umhos/cm	0504	03/18/1999	N001	SP	D	1331	#	-	-
	umhos/cm	0505	03/20/1999	N001	SP	D	5660	#	-	-
	umhos/cm	0506	03/20/1999	N001	SP	D	1336	#	-	-
	umhos/cm	0507	03/19/1999	N001	SP	C	920	#	-	-
	umhos/cm	0508	03/19/1999	N001	SP	C	296	#	-	-
	umhos/cm	0509	03/19/1999	N001	SP	D	473	#	-	-
	umhos/cm	0510	03/19/1999	N001	SP	D	258	#	-	-
	umhos/cm	0523	03/18/1999	N001	SP	N	1012	#	-	-
	umhos/cm	0524	03/18/1999	N001	SP	N	986	#	-	-
	umhos/cm	0533	03/17/1999	N001	NR	N	219	#	-	-
	umhos/cm	0534	03/17/1999	N001	NR	N	314	#	-	-
	umhos/cm	0535	03/17/1999	N001	NR	N	710	#	-	-
	umhos/cm	0536	03/17/1999	N001	NR	N	316	#	-	-
	umhos/cm	0537	03/17/1999	N001	NR	N	496	#	-	-
	umhos/cm	0538	03/17/1999	N001	NR	N	996	#	-	-
	umhos/cm	0540	03/20/1999	N001	AL	D	3340	#	-	-
	umhos/cm	0541	03/19/1999	N001	AL	D	9790	#	-	-
	umhos/cm	0542	03/18/1999	N001	NR	N	282	#	-	-
	umhos/cm	0543	03/17/1999	N001	NR	N	448	#	-	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/18/1999 7:38 a

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB DATA QA	DETECTION LIMIT	UN-CERTAINTY
Specific Conductance	umhos/cm	0547	03/17/1999	N001	NR	N	2640	#	-	-
	umhos/cm	0549	03/17/1999	N001	NR	N	845	#	-	-
	umhos/cm	0550	03/17/1999	N001	NR	N	6710	#	-	-
Sulfate	mg/L	0503	03/18/1999	0001	SP	D	2500.000	#	-	-
	mg/L	0504	03/18/1999	0001	SP	D	256.000	#	-	-
	mg/L	0505	03/20/1999	0001	SP	D	1570.000	#	-	-
	mg/L	0506	03/20/1999	0001	SP	D	254.000	#	-	-
	mg/L	0507	03/19/1999	0001	SP	C	367.000	#	-	-
	mg/L	0508	03/19/1999	0001	SP	C	1.820	#	-	-
	mg/L	0509	03/19/1999	0001	SP	D	20.800	#	-	-
	mg/L	0510	03/19/1999	0001	SP	D	3.660	#	-	-
	mg/L	0523	03/18/1999	0001	SP	N	202.000	#	-	-
	mg/L	0524	03/18/1999	0001	SP	N	189.000	#	-	-
	mg/L	0533	03/17/1999	N001	NR	N	2.900	#	-	-
	mg/L	0534	03/17/1999	N001	NR	N	8.660	#	-	-
	mg/L	0535	03/17/1999	N001	NR	N	62.500	#	-	-
	mg/L	0535	03/17/1999	N002	NR	N	62.200	#	-	-
	mg/L	0536	03/17/1999	N001	NR	N	3.060	#	-	-
	mg/L	0537	03/17/1999	N001	NR	N	12.300	#	-	-
	mg/L	0538	03/17/1999	N001	NR	N	205.000	#	-	-
	mg/L	0540	03/20/1999	0001	AL	D	2220.000	#	-	-
	mg/L	0541	03/19/1999	0001	AL	D	2930.000	#	-	-
	mg/L	0541	03/19/1999	0002	AL	D	2960.000	#	-	-
	mg/L	0542	03/18/1999	N001	NR	N	1.500	#	-	-
	mg/L	0543	03/17/1999	N001	NR	N	9.050	#	-	-
	mg/L	0547	03/17/1999	N001	NR	N	237.000	#	-	-
	mg/L	0549	03/17/1999	N001	NR	N	114.000	#	-	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/18/1999 7:38 a

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB DATA QA	DETECTION LIMIT	UN-CERTAINTY
Sulfate	mg/L	0550	03/17/1999	N001	NR	N	1190.000	#	-	-
Temperature	C	0503	03/18/1999	N001	SP	D	9.8	#	-	-
	C	0504	03/18/1999	N001	SP	D	11.0	#	-	-
	C	0505	03/20/1999	N001	SP	D	9.7	#	-	-
	C	0506	03/20/1999	N001	SP	D	10.7	#	-	-
	C	0507	03/19/1999	N001	SP	C	10.1	#	-	-
	C	0508	03/19/1999	N001	SP	C	11.0	#	-	-
	C	0509	03/19/1999	N001	SP	D	9.9	#	-	-
	C	0510	03/19/1999	N001	SP	D	10.7	#	-	-
	C	0523	03/18/1999	N001	SP	N	41.2 106F	#	-	-
	C	0524	03/18/1999	N001	SP	N	63.3 146F	#	-	-
	C	0533	03/17/1999	N001	NR	N	8.8	#	-	-
	C	0534	03/17/1999	N001	NR	N	9.9	#	-	-
	C	0535	03/17/1999	N001	NR	N	6.1	#	-	-
	C	0536	03/17/1999	N001	NR	N	7.6	#	-	-
	C	0537	03/17/1999	N001	NR	N	11.3	#	-	-
	C	0538	03/17/1999	N001	NR	N	7.4	#	-	-
	C	0540	03/20/1999	N001	AL	D	10.5	#	-	-
	C	0541	03/19/1999	N001	AL	D	9.7	#	-	-
	C	0542	03/18/1999	N001	NR	N	11.5	#	-	-
	C	0543	03/17/1999	N001	NR	N	10.3	#	-	-
	C	0547	03/17/1999	N001	NR	N	10.6	#	-	-
	C	0549	03/17/1999	N001	NR	N	11.2	#	-	-
	C	0550	03/17/1999	N001	NR	N	8.1	#	-	-
Total Dissolved Solids	mg/L	0503	03/18/1999	0001	SP	D	6140	#	-	-
	mg/L	0504	03/18/1999	0001	SP	D	833	#	-	-
	mg/L	0505	03/20/1999	0001	SP	D	4130	#	-	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/18/1999 7:38 a

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	DATA	QA	DETECTION LIMIT	UN-CERTAINTY
Total Dissolved Solids	mg/L	0506	03/20/1999	0001	SP	D	847			#	-	-
	mg/L	0507	03/19/1999	0001	SP	C	823			#	-	-
	mg/L	0508	03/19/1999	0001	SP	C	202			#	-	-
	mg/L	0509	03/19/1999	0001	SP	D	342			#	-	-
	mg/L	0510	03/19/1999	0001	SP	D	197			#	-	-
	mg/L	0523	03/18/1999	0001	SP	N	690			#	-	-
	mg/L	0524	03/18/1999	0001	SP	N	695			#	-	-
	mg/L	0533	03/17/1999	N001	NR	N	137			#	-	-
	mg/L	0534	03/17/1999	N001	NR	N	202			#	-	-
	mg/L	0535	03/17/1999	N001	NR	N	432			#	-	-
	mg/L	0535	03/17/1999	N002	NR	N	428			#	-	-
	mg/L	0536	03/17/1999	N001	NR	N	190			#	-	-
	mg/L	0537	03/17/1999	N001	NR	N	287			#	-	-
	mg/L	0538	03/17/1999	N001	NR	N	665			#	-	-
	mg/L	0540	03/20/1999	0001	AL	D	3400			#	-	-
	mg/L	0541	03/19/1999	0001	AL	D	7520			#	-	-
	mg/L	0541	03/19/1999	0002	AL	D	7510			#	-	-
	mg/L	0542	03/18/1999	N001	NR	N	197			#	-	-
	mg/L	0543	03/17/1999	N001	NR	N	265			#	-	-
	mg/L	0547	03/17/1999	N001	NR	N	1700			#	-	-
	mg/L	0549	03/17/1999	N001	NR	N	514			#	-	-
	mg/L	0550	03/17/1999	N001	NR	N	4000			#	-	-
Turbidity	NTU	0503	03/18/1999	N001	SP	D	9.50			#	-	-
	NTU	0504	03/18/1999	N001	SP	D	0.11			#	-	-
	NTU	0505	03/20/1999	N001	SP	D	0.75			#	-	-
	NTU	0506	03/20/1999	N001	SP	D	0.22			#	-	-
	NTU	0507	03/19/1999	N001	SP	C	1.12			#	-	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/18/1999 7:38 a

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	DATA	QA	DETECTION LIMIT	UN-CERTAINTY
Turbidity	NTU	0508	03/19/1999	N001	SP	C	0.28			#	-	-
	NTU	0509	03/19/1999	N001	SP	D	0.39			#	-	-
	NTU	0510	03/19/1999	N001	SP	D	0.37			#	-	-
	NTU	0523	03/18/1999	N001	SP	N	0.67			#	-	-
	NTU	0524	03/18/1999	N001	SP	N	0.72			#	-	-
	NTU	0533	03/17/1999	N001	NR	N	1.14			#	-	-
	NTU	0534	03/17/1999	N001	NR	N	0.12			#	-	-
	NTU	0535	03/17/1999	N001	NR	N	2.48			#	-	-
	NTU	0536	03/17/1999	N001	NR	N	5.93			#	-	-
	NTU	0537	03/17/1999	N001	NR	N	2.96			#	-	-
	NTU	0538	03/17/1999	N001	NR	N	0.94			#	-	-
	NTU	0540	03/20/1999	N001	AL	D	9.72			#	-	-
	NTU	0541	03/19/1999	N001	AL	D	5.48			#	-	-
	NTU	0542	03/18/1999	N001	NR	N	1.09			#	-	-
	NTU	0543	03/17/1999	N001	NR	N	5.41			#	-	-
	NTU	0547	03/17/1999	N001	NR	N	4.87			#	-	-
	NTU	0549	03/17/1999	N001	NR	N	25.7			#	-	-
	NTU	0550	03/17/1999	N001	NR	N	3.58			#	-	-
Uranium	mg/L	0503	03/18/1999	0001	SP	D	0.0010	U		#	0.001	-
	mg/L	0504	03/18/1999	0001	SP	D	0.0010	U		#	0.001	-
	mg/L	0505	03/20/1999	0001	SP	D	0.0010	U		#	0.001	-
	mg/L	0506	03/20/1999	0001	SP	D	0.0010	U		#	0.001	-
	mg/L	0507	03/19/1999	0001	SP	C	0.0020			#	-	-
	mg/L	0508	03/19/1999	0001	SP	C	0.0010	U		#	0.001	-
	mg/L	0509	03/19/1999	0001	SP	D	0.0010	U		#	0.001	-
	mg/L	0510	03/19/1999	0001	SP	D	0.0010	U		#	0.001	-
	mg/L	0523	03/18/1999	0001	SP	N	0.0010	U		#	0.001	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/18/1999 7:38 a

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	DATA	QA	DETECTION LIMIT	UN-CERTAINTY
Uranium	mg/L	0524	03/18/1999	0001	SP	N	0.0010	U		#	0.001	-
	mg/L	0533	03/17/1999	N001	NR	N	0.0011	U		#	0.0011	-
	mg/L	0534	03/17/1999	N001	NR	N	0.0011	U		#	0.0011	-
	mg/L	0535	03/17/1999	N001	NR	N	0.0024			#	-	-
	mg/L	0535	03/17/1999	N002	NR	N	0.0024			#	-	-
	mg/L	0536	03/17/1999	N001	NR	N	0.0011	U		#	0.0011	-
	mg/L	0537	03/17/1999	N001	NR	N	0.0014			#	-	-
	mg/L	0538	03/17/1999	N001	NR	N	0.0011	U		#	0.0011	-
	mg/L	0540	03/20/1999	0001	AL	D	0.0190			#	-	-
	mg/L	0541	03/19/1999	0001	AL	D	0.0010	U		#	0.001	-
	mg/L	0541	03/19/1999	0002	AL	D	0.0010	U		#	0.001	-
	mg/L	0542	03/18/1999	N001	NR	N	0.0011	U		#	0.0011	-
	mg/L	0543	03/17/1999	N001	NR	N	0.0011	U		#	0.0011	-
	mg/L	0547	03/17/1999	N001	NR	N	0.0011	U		#	0.0011	-
	mg/L	0549	03/17/1999	N001	NR	N	0.0011	U		#	0.0011	-
	mg/L	0550	03/17/1999	N001	NR	N	0.0011	U		#	0.0011	-

GROUND WATER QUALITY DATA BY PARAMETER (USEE200) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/18/1999 7:38 a

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	ZONE COMPL	FLOW REL.	RESULT	QUALIFIERS: LAB	DATA	QA	DETECTION LIMIT	UN-CERTAINTY

RECORDS: SELECTED FROM USEE200 WHERE site_code='LKV01' AND quality_assurance = TRUE AND (NOT (data_validation_qualifiers LIKE '*R*' OR data_validation_qualifiers LIKE '*X*') OR IsNull(data_validation_qualifiers)) AND DATE_SAMPLED between #3/1/1999# and #3/31/1999#

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.	F	Low flow sampling method used.	G	Possible grout contamination, pH > 9.
L	Less than 3 bore volumes purged prior to sampling.	R	Unusable result.	X	Location is undefined.
U	Parameter analyzed for but was not detected.				

QA QUALIFIER: # = validated according to Quality Assurance guidelines.

SURFACE WATER QUALITY DATA BY PARAMETER (USEE800) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/18/1999 7:38 am

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	RESULT	QUALIFIERS: LAB DATA QA	DETECTION LIMIT	UN-CERTAINTY
Alkalinity as CaCO3	mg/L	0605	03/16/1999	0001	127	#	-	-
	mg/L	0605	03/16/1999	N001	129	#	-	-
	mg/L	0606	03/16/1999	0001	100	#	-	-
	mg/L	0606	03/16/1999	N001	98	#	-	-
	mg/L	0607	03/16/1999	0001	101	#	-	-
	mg/L	0607	03/16/1999	N001	104	#	-	-
	mg/L	0608	03/16/1999	0001	255	#	-	-
	mg/L	0608	03/16/1999	N001	206	#	-	-
	mg/L	0609	03/16/1999	0001	203	#	-	-
	mg/L	0609	03/16/1999	N001	211	#	-	-
	mg/L	0613	03/16/1999	0001	63	#	-	-
	mg/L	0613	03/16/1999	N001	61	#	-	-
Arsenic	mg/L	0605	03/16/1999	0001	0.0527	#	-	-
	mg/L	0606	03/16/1999	0001	0.0220	#	-	-
	mg/L	0606	03/16/1999	0002	0.0218	#	-	-
	mg/L	0607	03/16/1999	0001	0.0412	#	-	-
	mg/L	0608	03/16/1999	0001	0.0941	#	-	-
	mg/L	0609	03/16/1999	0001	0.0831	#	-	-
	mg/L	0613	03/16/1999	0001	0.0010 U	#	0.001	-
Cadmium	mg/L	0605	03/16/1999	0001	0.0010 U	#	0.001	-
	mg/L	0606	03/16/1999	0001	0.0010 U	#	0.001	-
	mg/L	0606	03/16/1999	0002	0.0010 U	#	0.001	-
	mg/L	0607	03/16/1999	0001	0.0010 U	#	0.001	-
	mg/L	0608	03/16/1999	0001	0.0010 U	#	0.001	-
	mg/L	0609	03/16/1999	0001	0.0010 U	#	0.001	-
	mg/L	0613	03/16/1999	0001	0.0010 U	#	0.001	-
Calcium	mg/L	0605	03/16/1999	0001	21.200	#	-	-
	mg/L	0606	03/16/1999	0001	16.800	#	-	-
	mg/L	0606	03/16/1999	0002	16.700	#	-	-
	mg/L	0607	03/16/1999	0001	23.700	#	-	-
	mg/L	0608	03/16/1999	0001	37.000	#	-	-
	mg/L	0609	03/16/1999	0001	37.000	#	-	-
	mg/L	0613	03/16/1999	0001	14.000	#	-	-
Chloride	mg/L	0605	03/16/1999	0001	39.700	#	-	-
	mg/L	0606	03/16/1999	0001	20.500	#	-	-
	mg/L	0606	03/16/1999	0002	20.600	#	-	-

SURFACE WATER QUALITY DATA BY PARAMETER (USEE800) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/18/1999 7:38 am

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	RESULT	QUALIFIERS: LAB	DATA	QA	DETECTION LIMIT	UN-CERTAINTY
Chloride	mg/L	0607	03/16/1999	0001	23.500			#	-	-
	mg/L	0608	03/16/1999	0001	84.300			#	-	-
	mg/L	0609	03/16/1999	0001	64.200			#	-	-
	mg/L	0613	03/16/1999	0001	0.934			#	-	-
Iron	mg/L	0605	03/16/1999	0001	0.428			#	-	-
	mg/L	0606	03/16/1999	0001	0.359			#	-	-
	mg/L	0606	03/16/1999	0002	0.454			#	-	-
	mg/L	0607	03/16/1999	0001	0.240			#	-	-
	mg/L	0608	03/16/1999	0001	0.155			#	-	-
	mg/L	0609	03/16/1999	0001	0.229			#	-	-
	mg/L	0613	03/16/1999	0001	0.199			#	-	-
Magnesium	mg/L	0605	03/16/1999	0001	5.570			#	-	-
	mg/L	0606	03/16/1999	0001	5.100			#	-	-
	mg/L	0606	03/16/1999	0002	5.130			#	-	-
	mg/L	0607	03/16/1999	0001	7.160			#	-	-
	mg/L	0608	03/16/1999	0001	9.170			#	-	-
	mg/L	0609	03/16/1999	0001	9.460			#	-	-
	mg/L	0613	03/16/1999	0001	3.180			#	-	-
Manganese	mg/L	0605	03/16/1999	0001	0.0445			#	-	-
	mg/L	0606	03/16/1999	0001	0.0303			#	-	-
	mg/L	0606	03/16/1999	0002	0.0318			#	-	-
	mg/L	0607	03/16/1999	0001	0.0360			#	-	-
	mg/L	0608	03/16/1999	0001	0.0364			#	-	-
	mg/L	0609	03/16/1999	0001	0.0267			#	-	-
	mg/L	0613	03/16/1999	0001	0.0056	B		#	-	-
pH	s.u.	0605	03/16/1999	N001	7.67			#	-	-
	s.u.	0606	03/16/1999	N001	7.88			#	-	-
	s.u.	0607	03/16/1999	N001	7.83			#	-	-
	s.u.	0608	03/16/1999	N001	8.27			#	-	-
	s.u.	0609	03/16/1999	N001	8.24			#	-	-
	s.u.	0613	03/16/1999	N001	7.58			#	-	-
Potassium	mg/L	0605	03/16/1999	0001	7.020			#	-	-
	mg/L	0606	03/16/1999	0001	4.120			#	-	-
	mg/L	0606	03/16/1999	0002	4.080			#	-	-
	mg/L	0607	03/16/1999	0001	3.570			#	-	-
	mg/L	0608	03/16/1999	0001	8.840			#	-	-

SURFACE WATER QUALITY DATA BY PARAMETER (USEE800) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/18/1999 7:38 am

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	RESULT	QUALIFIERS: LAB DATA QA	DETECTION LIMIT	UN-CERTAINTY
Potassium	mg/L	0609	03/16/1999	0001	7.300	#	-	-
	mg/L	0613	03/16/1999	0001	0.867	#	-	-
Redox Potential	mV	0605	03/16/1999	N001	162	#	-	-
	mV	0606	03/16/1999	N001	124	#	-	-
	mV	0607	03/16/1999	N001	171	#	-	-
	mV	0608	03/16/1999	N001	169	#	-	-
	mV	0609	03/16/1999	N001	43	#	-	-
	mV	0613	03/16/1999	N001	189	#	-	-
Silica	mg/L	0605	03/16/1999	0001	46.200	#	-	-
	mg/L	0606	03/16/1999	0001	40.700	#	-	-
	mg/L	0606	03/16/1999	0002	41.600	#	-	-
	mg/L	0607	03/16/1999	0001	26.800	#	-	-
	mg/L	0608	03/16/1999	0001	67.000	#	-	-
	mg/L	0609	03/16/1999	0001	64.100	#	-	-
	mg/L	0613	03/16/1999	0001	30.700	#	-	-
Sodium	mg/L	0605	03/16/1999	0001	107.000	#	-	-
	mg/L	0606	03/16/1999	0001	52.600	#	-	-
	mg/L	0606	03/16/1999	0002	52.600	#	-	-
	mg/L	0607	03/16/1999	0001	55.400	#	-	-
	mg/L	0608	03/16/1999	0001	185.000	#	-	-
	mg/L	0609	03/16/1999	0001	149.000	#	-	-
	mg/L	0613	03/16/1999	0001	9.610	#	-	-
Specific Conductance	umhos/cm	0605	03/16/1999	N001	886	#	-	-
	umhos/cm	0606	03/16/1999	N001	396	#	-	-
	umhos/cm	0607	03/16/1999	N001	478	#	-	-
	umhos/cm	0608	03/16/1999	N001	1163	#	-	-
	umhos/cm	0609	03/16/1999	N001	952	#	-	-
	umhos/cm	0613	03/16/1999	N001	147	#	-	-
Sulfate	mg/L	0605	03/16/1999	0001	88.400	#	-	-
	mg/L	0606	03/16/1999	0001	42.800	#	-	-
	mg/L	0606	03/16/1999	0002	42.800	#	-	-
	mg/L	0607	03/16/1999	0001	63.400	#	-	-
	mg/L	0608	03/16/1999	0001	180.000	#	-	-
	mg/L	0609	03/16/1999	0001	141.000	#	-	-
	mg/L	0613	03/16/1999	0001	1.560	#	-	-
Temperature	C	0605	03/16/1999	N001	7.5	#	-	-

SURFACE WATER QUALITY DATA BY PARAMETER (USEE800) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/18/1999 7:38 am

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	RESULT	QUALIFIERS: LAB	DATA	QA	DETECTION LIMIT	UN-CERTAINTY
Temperature	C	0606	03/16/1999	N001	8.7			#	-	-
	C	0607	03/16/1999	N001	8.4			#	-	-
	C	0608	03/16/1999	N001	16.4			#	-	-
	C	0609	03/16/1999	N001	16.4			#	-	-
	C	0613	03/16/1999	N001	4.8			#	-	-
Total Dissolved Solids	mg/L	0605	03/16/1999	0001	453			#	-	-
	mg/L	0606	03/16/1999	0001	302			#	-	-
	mg/L	0606	03/16/1999	0002	293			#	-	-
	mg/L	0607	03/16/1999	0001	298			#	-	-
	mg/L	0608	03/16/1999	0001	765			#	-	-
	mg/L	0609	03/16/1999	0001	632			#	-	-
	mg/L	0613	03/16/1999	0001	108			#	-	-
Turbidity	NTU	0605	03/16/1999	N001	46.4			#	-	-
	NTU	0606	03/16/1999	N001	61.2			#	-	-
	NTU	0607	03/16/1999	N001	19.1			#	-	-
	NTU	0608	03/16/1999	N001	18.1			#	-	-
	NTU	0609	03/16/1999	N001	26.4			#	-	-
	NTU	0613	03/16/1999	N001	17.3			#	-	-
Uranium	mg/L	0605	03/16/1999	0001	0.0010 U			#	0.001	-
	mg/L	0606	03/16/1999	0001	0.0010 U			#	0.001	-
	mg/L	0606	03/16/1999	0002	0.0010 U			#	0.001	-
	mg/L	0607	03/16/1999	0001	0.0033			#	-	-
	mg/L	0608	03/16/1999	0001	0.0012			#	-	-
	mg/L	0609	03/16/1999	0001	0.0013			#	-	-
	mg/L	0613	03/16/1999	0001	0.0010 U			#	0.001	-

SURFACE WATER QUALITY DATA BY PARAMETER (USEE800) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/18/1999 7:38 am

PARAMETER	UNITS	LOCATION ID	SAMPLE: DATE	ID	RESULT	QUALIFIERS: LAB	DATA	QA	DETECTION LIMIT	UN-CERTAINTY

RECORDS: SELECTED FROM USEE800 WHERE site_code='LKV01' AND quality_assurance = TRUE AND (NOT (data_validation_qualifiers LIKE "*R" OR data_validation_qualifiers LIKE "*X") OR IsNull(data_validation_qualifiers)) AND DATE_SAMPLED between #3/1/1999# and #3/31/1999#

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:

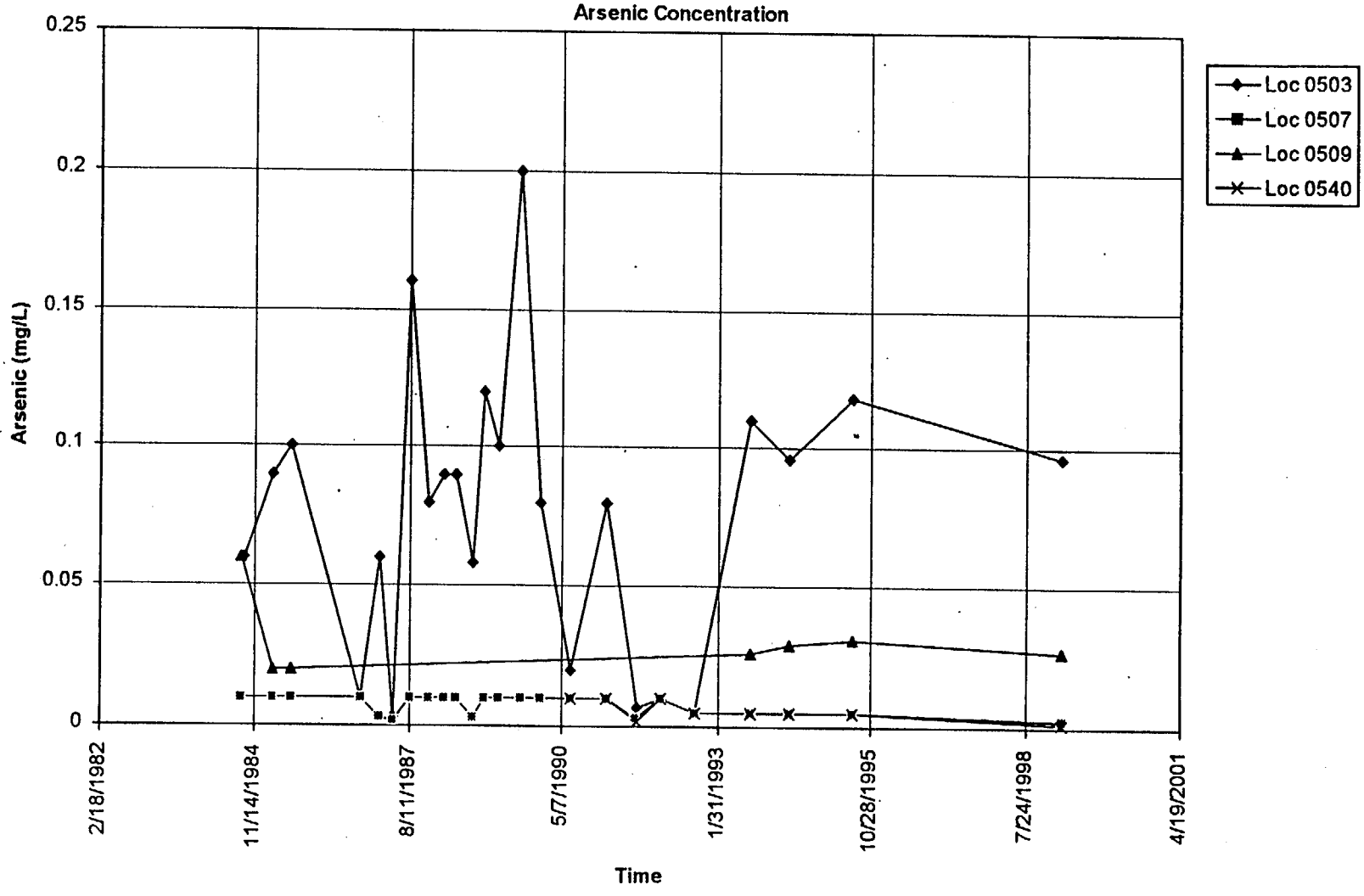
J	Estimated value.
G	Possible grout contamination, pH > 9.
R	Unusable result.
U	Parameter analyzed for but was not detected.
F	Low flow sampling method used.
L	Less than 3 bore volumes purged prior to sampling.
X	Location is undefined.

QA QUALIFIER: # = validated according to Quality Assurance guidelines.

ANALYTE	SITE_CODE	LOCATION_CODE	DATE	SAMPLE_ID	UNIT	RESULT	LAB_QUALIFIERS	DATA_VALIDATION_QUALIFIERS	DETECTION_LIMIT	UNCERTAINTY
Arsenic	LKV01	0999	3/16/1999	0001	mg/L	0.001	U		0.001	
Cadmium	LKV01	0999	3/16/1999	0001	mg/L	0.001	U		0.001	
Calcium	LKV01	0999	3/16/1999	0001	mg/L	0.0548	B			
Chloride	LKV01	0999	3/16/1999	0001	mg/L	0.0304	B			
Iron	LKV01	0999	3/16/1999	0001	mg/L	0.005	U		0.005	
Magnesium	LKV01	0999	3/16/1999	0001	mg/L	0.019	U		0.019	
Manganese	LKV01	0999	3/16/1999	0001	mg/L	0.001	U		0.001	
Potassium	LKV01	0999	3/16/1999	0001	mg/L	0.071	U		0.071	
Silica	LKV01	0999	3/16/1999	0001	mg/L	0.0503	B			
Sodium	LKV01	0999	3/16/1999	0001	mg/L	0.833	U		0.833	
Sulfate	LKV01	0999	3/16/1999	0001	mg/L	0.04	U		0.04	
Total Dissolved Solids	LKV01	0999	3/16/1999	0001	mg/L	50				
Uranium	LKV01	0999	3/16/1999	0001	mg/L	0.001	U		0.001	

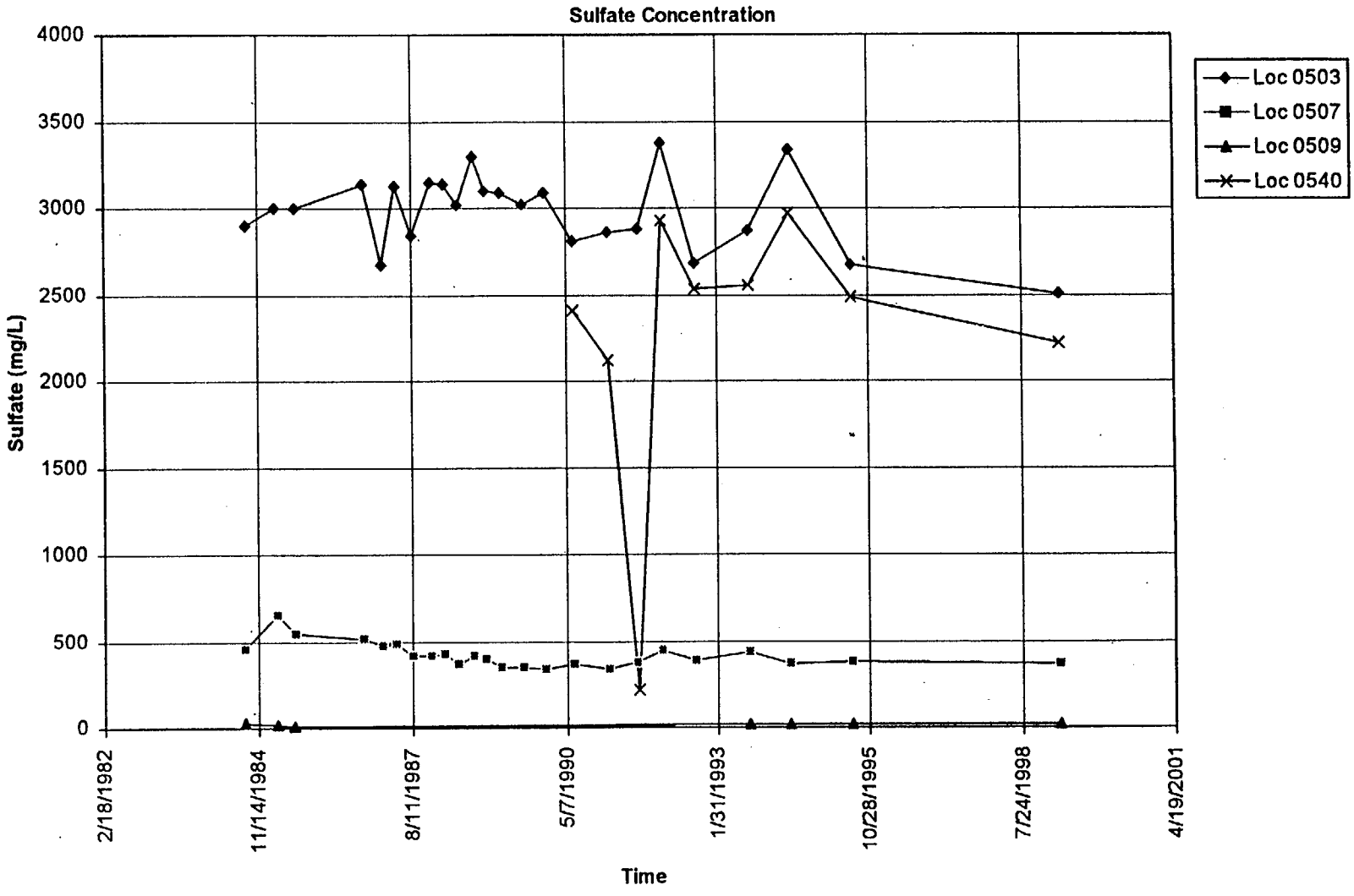
TIME VERSUS CONCENTRATION GRAPHS

LAKEVIEW (LKV01)



5/18/1999 8:04 am

LAKEVIEW (LKV01)



5/18/1999 8:05 am

WATER LEVELS

STATIC GROUND WATER LEVELS (USEE700) FOR SITE LKV01, LAKEVIEW
REPORT DATE: 5/19/1999 8:17 am

LOCATION CODE	FLOW CODE	TOP OF CASING ELEVATION (FT NGVD)	MEASUREMENT		DEPTH FROM TOP OF CASING (FT)	GROUND WATER ELEVATION (FT NGVD)
			DATE	TIME		
0503	D	4747.73	03/18/1999	10:53	4.64	4743.09
0504	D	4747.63	03/18/1999	09:50	6.97	4740.66
0505	D	4744.64	03/20/1999	10:42	5.03	4739.61
0506	D	4744.72	03/20/1999	11:09	5.26	4739.46
0507	C	4742.77	03/19/1999	08:56	2.18	4740.59
0508	C	4743.25	03/19/1999	09:22	4.19	4739.06
0509	D	4742.14	03/19/1999	13:58	2.36	4739.78
0510	D	4742.30	03/19/1999	14:25	3.23	4739.07
0523	N	4759.62	03/18/1999	12:57	4.32	4755.30
0524	N	4759.90	03/18/1999	13:49	5.10	4754.80
0540	D	4747.89	03/20/1999	08:23	3.97	4743.92
0541	D	4747.56	03/19/1999	11:31	5.30	4742.26

RECORDS: SELECTED FROM USEE700 WHERE site_code='LKV01' AND LOG_DATE between #3/1/1999# and #3/31/1999#

FLOW CODES:
C CROSS GRADIENT D DOWN GRADIENT N UNKNOWN

mactec-ers
MACTEC ENVIRONMENTAL RESTORATION SERVICES, LLC

CONTRACT NO.: DE-AC13-96GJ87335
TASK ORDER NO.: MAC99-05
CONTROL NO.: 3100-T99-0496

February 16, 1999

ULKV000017

Project Manager
Department of Energy
Grand Junction Office
2597 B3/4 Road
Grand Junction, CO 81503
ATTN: Donald Metzler

SUBJECT: Contract No. DE-AC13-96GJ87335—March 1999 UMTRA Ground Water Sampling at Lakeview, Oregon

Dear Mr. Metzler:

Attached are the map and tables specifying the sampling locations and analytes for routine monitoring at the Lakeview, Oregon, UMTRA site. Water quality data will be collected from monitoring wells at this site as part of the routine UMTRA ground water sampling which is scheduled to begin March 15, 1999.

The following lists show the Ground Water Project monitor wells (with associated zone of completion), private wells, and surface water locations that will be sampled during this sampling event.

Ground Water Project Monitor Wells (LKV01) (filtered)*

501 Sp/Sm	504 Sp/Sm	507 Sp/Sm	509 Sp/Sm	518 Sp/Sm	524 Sp/Sm	540 Al
502 Sp/Sm	505 Sp/Sm	508 Sp/Sm	510 Sp/Sm	523 Sp/Sm	525 Sp/Sm	541 Al
503 Sp/Sm	506 Sp/Sm					

Private Wells (LKV01) (unfiltered)*

533 Nr	536 Nr	538 Nr	543 Nr	545 Nr	547 Nr	549 Nr
534 Nr	537 Nr	542 Nr	544 Nr	546 Nr	548 Nr	550 Nr
535 Nr						

*NOTE: Al = Alluvium; Nr = No recovery of data for classifying: Sm = Silty sand or silty gravelly sand; Sp = Sand or gravelly sand, poorly graded

Ground Water Project Surface Locations (LKV01) (filtered)

605	606	607	608	609	613

QA/QC samples will be collected as directed in the *Sampling and Analysis Plan for the UMTRA Ground Water Project*. Samples collected for alkalinity will be both filtered and unfiltered.

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2597 B 3/4 ROAD
GRAND JUNCTION, COLORADO 81503
970/248-6000 (FAX) 970/248-6040

GJ1KV14.06

Water level information will be collected from all wells at the Lakeview site and monitor well inspections will be conducted and documented to confirm the status of all existing wells.

If you have any questions, please call me at extension 6059 or Dave Miller at extension 6652.

Sincerely,

Sam Marutzky
Project Manager

SM/lcg/ld
Attachments

cc w/o att: C. Bahrke
R. Bowen
D. E. Miller
K. E. Miller
D. G. Traub
Contract File (C. Spor)
cc w/att: R. Chessmore
Project Record File GWLKV 14.06 thru P. Taylor

Sampling Frequencies for Locations at Lakeview, Oregon

Wells	Quarterly	Semiannually	Annually	Biennially	Not Sampled	Notes
Ground Water Project Monitor Wells						
501			X			
502			X			
503			X			
504			X			
505			X			
506			X			
507			X			
508			X			
509			X			
510			X			
518			X			
523			X			
524			X			
525			X			
540			X			
541			X			
LTSM Project Monitor Wells						
515					X	SAMPLED EVERY 5 YEARS
602					X	"
603					X	"
604					X	"
605					X	"
606					X	"
607					X	"
608					X	"
609					X	"
Private Wells						
533			X			
534			X			
535			X			
536			X			
537			X			
538			X			
542			X			
543			X			
544			X			
545			X			
546			X			
547			X			
548			X			
549			X			
550			X			

Sampling Frequencies for Locations at Lakeview, Oregon

Wells	Quarterly	Semiannually	Annually	Biennially	Not Sampled	Notes
Surface Water/Sediment Locations						
605			X			
606			X			
607			X			
608			X			
609			X			
613			X			
Finger Drain 1					X	
Finger Drain 2					X	
Finger Drain 3					X	
Drainage Channel					X	

Constituent Sampling Breakdown For Individual UMTRA Sites

Site	Lakeview	
Analyte	Ground Water	Surface Water
Approx. No. Samples/yr.	9	4
Field Measurements	LTSM	LTSM
Alkalinity	X	X
Dissolved Oxygen		
Redox Potential	X	X
pH	X	X
Specific Conductance	X	X
Turbidity		
Temperature	X	X
Laboratory Measurements	LTSM	LTSM
Aluminum		
Ammonium		
Antimony		
Arsenic	X	X
Barium		
Beryllium		
Bromide		
Cadmium	X	X
Calcium	X	X
Chloride	X	X
Chromium		
Cobalt		
Copper		
Fluoride		
Gamma Spec		
Gross Alpha		
Gross Beta		
Iron	X	X
Lead		
Lead-210		
Magnesium	X	X
Manganese	X	X
Molybdenum		

Constituent Sampling Breakdown For Individual UMTRA Sites

Site	Lakeview	
Analyte	Ground Water	Surface Water
Laboratory Measurements (Continued)	LTSM	LTSM
Nickel		
Nickel-63		
Nitrate		
PCBs		
Phosphate		
Polonium-210		
Potassium	X	X
Radium-226		
Radium-228		
Selenium		
Silica	X	X
Sodium	X	X
Strontium		
Sulfate	X	X
Sulfide		
Thallium		
Thorium-230		
Tin		
Total Dissolved Solids	X	X
Total Organic Carbon		
Tritium		
Uranium	X	X
Vanadium		
Zinc		
Total Analytes	13	13

Note: All analyte samples are considered filtered unless stated otherwise. All private well samples are to be unfiltered. The total number of analytes does not include the field parameters.

* The left number represents Ground Water Project samples and the right number represents LTSM Project samples.

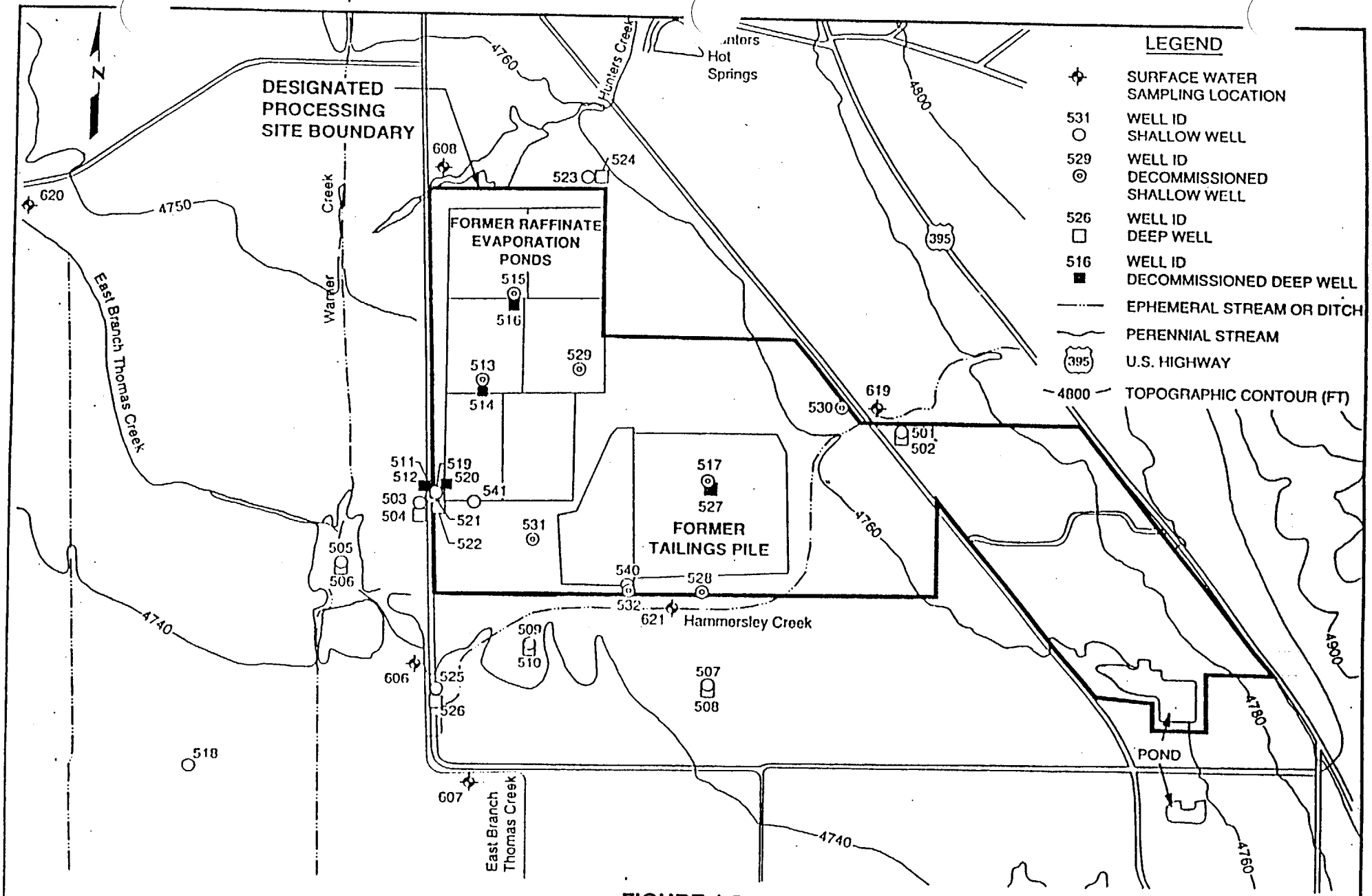
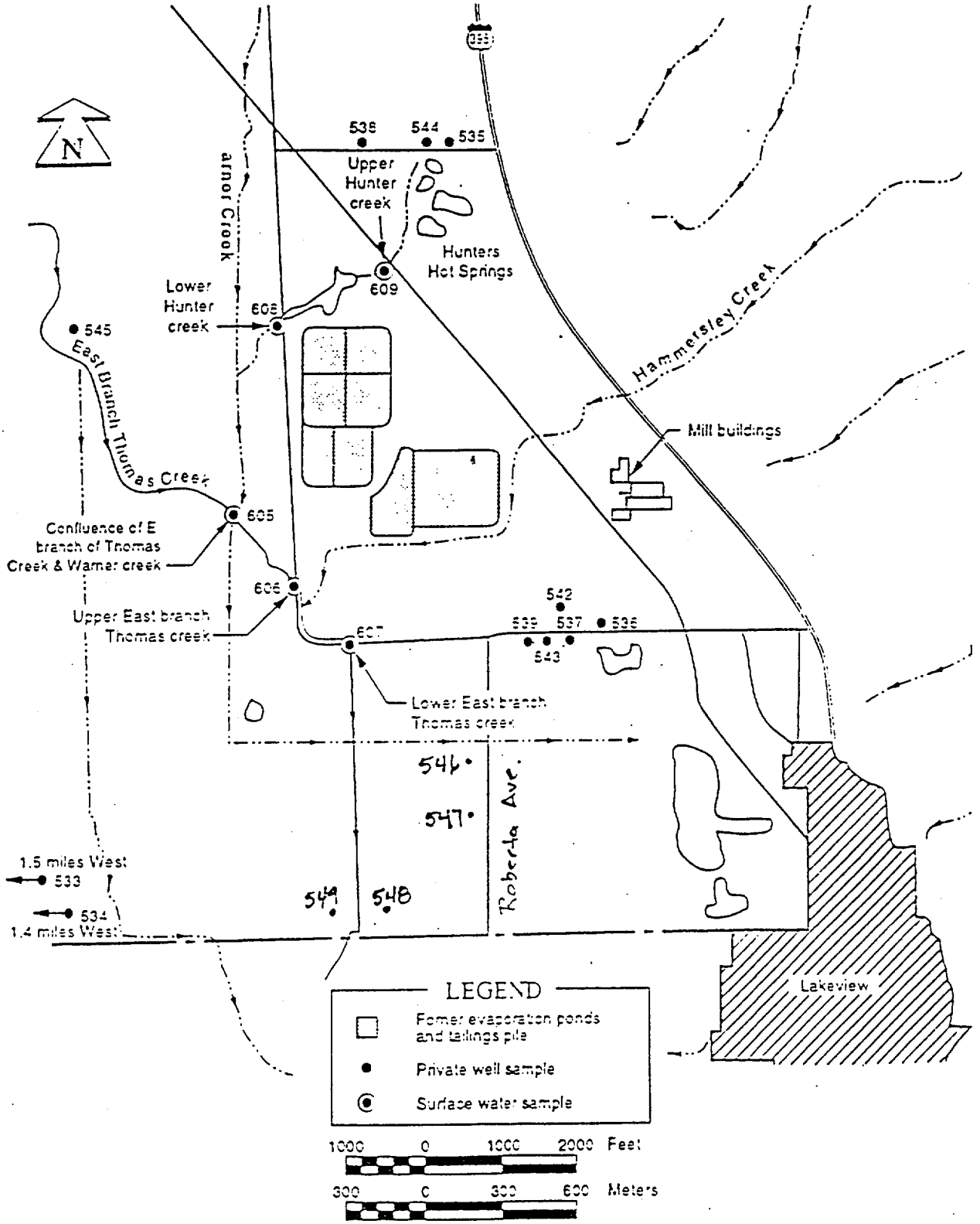


FIGURE 1.3
LOCATIONS OF SELECTED DOE MONITOR WELLS AND SURFACE WATER SAMPLING POINTS IN THE VICINITY OF THE LAKEVIEW PROCESSING SITE, LAKEVIEW, OREGON

MAC: SITE/ APPBASE DOEMONWELLOC

Figure 2

Off-Site Water Quality Sampling Locations in the Vicinity of the Lakeview Processing Site



ULKV000019

mactec-ers
MACTEC ENVIRONMENTAL RESTORATION SERVICES, LLC

CONTRACT NO.: DE-AC13-96GJ87335
TASK ORDER NO.: MAC99-05
CONTROL NO.: 3100-N/A

MEMO TO: Sam Marutzky

FROM: C. E. Poland

DATE: March 25, 1999

SUBJECT: UMTRA Ground Water Trip Report

Site: Lakeview, OR

Dates of Sampling Event: March 15 through March 21, 1999.

Team Members: Sam Campbell and Chuck Poland

Number of Locations Sampled: 23 ground water locations (12 monitoring locations and 11 private wells) and 6 surface locations sampled.

Locations Not Sampled/Reason: Four ground water project monitor wells and four domestic wells were not sampled.

Locations 501 and 502 were not sampled because the wells could not be located. It appeared that the wells had been destroyed or buried by activities on the privately owned site. According to the map of the site, the wells are located on a privately owned logging/trucking operation. The owner indicated that he had not seen any monitor wells on the property since he purchased the property "several years ago."

Location 518 was not sampled because it was not accessible. Because of extremely wet/muddy conditions, access to the well was very difficult because a swollen creek could not be crossed with the sampling equipment. An approximate ¾-mile hike was required to access the well from a different direction.

Location 525 was not sampled because it could not be located. The well adjacent to 525 (well 526) could also not be located.

Location 544 was not sampled because the owner stated that she was afraid to turn it on, as her husband was out of town.

Location 545 was not sampled because the property was sold to someone from out-of-town. The name and phone number of the new owner could not be located.

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Location 546 was not sampled because the owner was out of town. The owner's son attempted but was unable to start the pump. He attempted to contact his father (owner) but was unable to locate him.

Location 548 was not sampled because the new owner lives in a different city (original owner's son). The property is currently unoccupied, and appears to be a non-habitable structure.

Field Variance: The temperature of the calibration standards was not within 10° C of the sample temperature at ground water locations 523 and 524. Both wells are influenced by geothermal ground water.

Data Logger Download: There are no data loggers on the site.

Quality Control Sample Cross Reference: Following are the false identification numbers assigned to the field duplicate quality control samples and the equipment blanks:

False ID	True ID	Sample Type	Associated Matrix	Ticket Number
100	606	Duplicate	Surface Water	NDG-581
101	Equipment Blank	Equipment Blank	Surface Water	NDG-583
102	535 (Domestic Well)	Duplicate	Ground Water	NDG-589
103	541	Duplicate	Ground Water	NDF-954

Requisition Numbers Assigned: Samples were assigned to requisition 16484.

Water Level Measurements: Water level measurements were taken on all wells that were sampled.

Well Inspection Summary: Well inspections were conducted on all wells that were sampled. Wells 504 and 510 did not have locks. New locks were installed on both wells. Locks were in place on wells 507 and 508, but the hasp on both of the wells had been cut off. It was not possible to secure the wells.

Equipment: None

Regulatory: None

Site Issues: None

Additional Action Required/Taken: Contact was made with the concerned citizen [Debra Barns, 727 North 6th Street, Lakeview, OR, (541) 947-5604]. She is apparently new to the community and was concerned about radiation associated with living in the Lakeview area and the proximity to the former tailings pile and millsite. It was explained that the surface remediation phase of the project had removed all of the contaminated soil associated with the millsite, that the ground water monitoring phase of the project was ongoing, and that she could

obtain a copy of the Baseline Risk Assessment from the local library. This document would explain the ground water and the associated contaminants. If the document is not in the library, she was told that she could contact Don Metzler at the GJO.

All owners of domestic wells that were sampled during the trip wanted copies of the analytical results. The owners' names, addresses, phone numbers, and the associated well numbers are as follows:

Name	Well No.	Phone No.	Residential Address	Mailing Address
Harvey Harrington	537	[redacted]		(same)
Marty Foster	543			P.O. Box 665 Lakeview, OR
James Bradley	536			(same)
Evert McDonald	535			(same)
Donald Mautz	538			P.O. Box 528, Lakeview, OR 97630
Lee Hancock	534			(same)
Bill Armstrong	547			(same)
George Hesse	550			(same)
Jeanette Binion	549			318 North U Street, Lakeview, OR 97630 (mother's residence)
Jerry Owen	533			(same)
Duane Kastor	542			P.O. Box 162, Lakeview, OR 97630
Andy Parker (Not Sampled)	544			P.O. Box 709, Lakeview, OR 97630
Al Strain (Strain's Truck Shop) (Not Sampled)	546			(not available)
John Cremin	**			(same)

** John Cremin runs cattle in the area surrounding DOE monitoring wells 523 and 524 and would like copies of the analytical results for the wells.

Surface water location 613 was not found on the map in the Field Notebook or other maps obtained from the GJO. The location was determined from coordinates obtained from the SEE UMTRA database, and plotted at Hammersley Creek and Highway 395.

Domestic well location 533 is plotted incorrectly on the site maps. The maps show wells 533 and 534 approximately 2 miles southwest of the site, within approximately ¼-mile of each other. A sample was collected from location 534 (owner Lee Hancock). Mr. Hancock was fully aware

of the sampling program and his well had been sampled in the past by the UMTRA Ground Water sampling teams. Well 534 appears to be plotted correctly on the site maps. Location 533 (owner Jerry Owen) was found on Thomas Creek Road, approximately 1 mile southwest of the site, and approximately 1¼ miles east of where it is indicated on the map. This indicates that location 533 is plotted incorrectly on the site maps. Mrs. Owen indicated that there was a Hancock residence just down the road from them, but discussions with that owner indicate that they had never been sampled by the UMTRA Ground Water sampling teams.

CP/lcg

Distribution:

cc: R. Bowen
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Uranium Mill Tailings Remedial Action
Ground Water Project
Record of Decision
April 28, 1997

The final Record of Decision (ROD) was published in the *Federal Register* (Vol. 62, No. 81). DOE prepared this ROD pursuant to the Council on Environmental Quality regulations for implementing DOE's NEPA regulations. The ROD is based on the *Final Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project* (PEIS) (DOE/EIS-0198), issued October 1996.

The proposed action (preferred alternative) in the PEIS establishes a consistent risk-based framework for implementing the UMTRA Ground Water Project and for determining appropriate strategies to comply with EPA ground water standards. Under the preferred alternative, DOE may use active, passive, and no-remediation strategies to comply with the standards. Before making site-specific decisions to implement the preferred alternative, DOE will prepare appropriate NEPA documentation.

If ground water at an UMTRA Project site is contaminated as a result of uranium-ore processing, and contaminant concentrations exceed background levels or EPA ground water standards, the next step is to determine whether compliance with the standards could be achieved by applying supplemental standards under 40 CFR 192.21(g). If the ground water meets EPA's definition of limited use ground water, and if supplemental standards are shown to be protective of human health and the environment, no remediation is required.

Uranium Mill Tailings Remedial Action (UMTRA) Ground Water Project Record of Decision, April 28, 1997

This is the complete and final Record of Decision (ROD) taken from the Federal Register (Vol. 62, 81). The DOE issued this ROD regarding its programmatic decision for the UMTRA Ground Water Project. DOE prepared this ROD pursuant to the Council on Environmental Quality Regulations for implementing the procedural provisions of NEPA and DOE's NEPA regulations. This ROD is based on the Final PEIS for the UMTRA Ground Water Project (PEIS) (DOE/EIS-0198), issued December 1996).

DOE has decided to implement the Proposed Action for conducting the Ground Water Project (UGW). The Proposed Action, which was identified as DOE's preferred alternative in the final PEIS, is intended to establish a consistent risk-based framework for implementing the UGW and determining appropriate ground water compliance strategies for complying with EPA ground water standards at the UMTRA project Former processing sites (i.e., Ambrosia UMTRA site). Under the preferred alternative, DOE may use active, passive, and no-remediation strategies to comply with the ground water standards as conditions warrant at specific sites. Before making site-specific decisions to implement the preferred alternative for the UGW, DOE will prepare appropriate further NEPA documentation.

Using the step by step frame work, if ground water has been contaminated by uranium processing activities at a specific site and exceed background levels or MCLs, the next step will be to determine whether compliance with EPA ground water standards could be achieved by applying supplemental standards under 40 CFR 192.21 (g), based on a determination that the ground water met EPA's definition of "limited-use ground water ." If limited-use ground water is shown to exist and if supplemental standards are protective of human health and the environment, no site-specific remediation will be required.

export to Canada should be clearly marked with Docket EA-144.

'ditional copies are to be filed directly · Kevin J. Lipson, Jolanta Sterbenz, ı & Hartson L.L.P. Columbia ...re, 555 Thirteenth Street, N.W., ...shington, D.C. 20004-1109, (202)637-5600 *and* Gary A. Jeffries, CNG Energy Services Corporation, One Park Ridge Center, P.O. Box 15746, Pittsburgh, Pennsylvania 15244-0746, (412)787-4268.

A final decision will be made on these applications after the environmental impacts have been evaluated pursuant to the National Environmental Policy Act of 1969 (NEPA), and a determination is made by the DOE that the proposed actions will not adversely impact on the reliability of the U.S. electric power supply system.

Copies of these applications will be made available, upon request, for public inspection and copying at the address provided above.

Issued in Washington, DC on April 21, 1997.

Anthony J. Como,

Director, Electric Power Regulation, Coal & Power Im/Ex, Office of Coal & Power Systems, Office of Fossil Energy.

[FR Doc. 97-10858 Filed 4-25-97; 8:45 am]

BILLING CODE 6450-01-P

...RTMENT OF ENERGY

...ranium Mill Tailings Remedial Action (UMTRA) Ground Water Project

AGENCY: Department of Energy.

ACTION: Record of decision.

SUMMARY: The Department of Energy (DOE) is issuing this Record of Decision regarding its programmatic decision for the Uranium Mill Tailings Remedial Action (UMTRA) Ground Water Project. This decision enables DOE to take action under its UMTRA Ground Water Project, and is based on the environmental analyses in the Final Programmatic Environmental Impact Statement (PEIS) for the Uranium Mill Tailings Remedial Action Ground Water Project (DOE/EIS-0198), which DOE issued in December 1996. The Nuclear Regulatory Commission, the Navajo Nation, the Hopi Tribe, the State of Colorado and the State of Texas cooperated in the preparation of the PEIS.

Under Title I of the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA), DOE is responsible for ...forming remedial action to bring 22 ...ated former uranium mill ...sing sites into compliance with ...pplicable Environmental Protection Agency (EPA) standards for milling-related contamination (40 CFR part 192). Under DOE's UMTRA Surface Project, DOE has completed surface remediation at 20 sites and work is underway at the remaining two sites. These sites are located in nine States and are on or near four Indian Tribal lands. The shallow ground water at most of these sites has been contaminated with uranium, nitrates, and other milling-related contaminants. The purpose of the UMTRA Ground Water Project is to protect human health and the environment by meeting EPA's ground water standards, which were issued January 11, 1995.

DOE has decided to implement the Proposed Action for conducting the Ground Water Project. The Proposed Action, which was identified as DOE's preferred alternative in the final PEIS, is intended to establish a consistent risk-based framework for implementing the UMTRA Ground Water Project and determining appropriate ground water compliance strategies for complying with EPA ground water standards at the UMTRA project former processing sites. Under this preferred alternative, DOE may use active, passive, and no-remediation strategies to comply with the ground water standards as conditions warrant at specific sites.

Before making site-specific decisions to implement the preferred alternative for the Ground Water Project, DOE will prepare appropriate further National Environmental Policy Act (NEPA) documentation. DOE encourages affected States, tribes, local government agencies and members of the public to continue to participate in the site-specific decision making processes for the Ground Water Project.

FOR FURTHER INFORMATION CONTACT: Further information on the final PEIS can be obtained by contacting Mr. Donald R. Metzler, Grand Junction Office, Department of Energy, 2567 B 3/4 Road, Grand Junction, Colorado 81503, telephone 970-248-7612. Information about the Department of Energy National Environmental Policy Act process can be obtained by contacting Carol M. Borgstrom, Director, Office of NEPA Policy and Assistance, EH-42, U.S. Department of Energy, 1000 Independence Avenue SW, Washington, D.C. 20585, telephone 202-586-4600, or leave a message at 800-472-2756.

SUPPLEMENTARY INFORMATION: DOE has prepared this Record of Decision pursuant to the Council on Environmental Quality Regulations for implementing the procedural provisions of NEPA (40 CFR parts 1500-1508) and DOE's NEPA regulations (10 CFR part 1021). This Record of Decision is based on the Final Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project (PEIS) (DOE/EIS-0198, issued December 1996). The Nuclear Regulatory Commission (NRC), the Navajo Nation, the Hopi Tribe, the State of Colorado and the State of Texas participated as cooperating agencies in the preparation of this PEIS.

A Notice of Intent was published in the **Federal Register** on November 18, 1992 (57 FR 54374), announcing that the Department would prepare a PEIS to examine programmatic alternatives for conducting the UMTRA Ground Water Project at former uranium processing sites. Dates, locations, and times for public scoping meetings were announced locally and published in the **Federal Register** on February 8, 1993 (58 FR 7551). Nineteen public scoping meetings in 16 communities were held between November 18, 1992, and April 15, 1993, to solicit public comment regarding the scope and content of the PEIS. The UMTRA Ground Water Project PEIS Implementation Plan (DOE/AL/62350-72D, March 31, 1994) summarized the comments received during scoping and described how the comments would be addressed in the PEIS.

A Notice of Availability of the draft PEIS was published in the **Federal Register** on May 17, 1995 (60 FR 26417). Nine public hearings were conducted in communities near tailings sites between June 7 and 28, 1995, to solicit public comment on the draft PEIS. Volume II of the final PEIS identifies and responds to the 576 comments received during the public comment period.

Alternatives Considered

Proposed Action (Preferred Alternative)

Under the proposed action, which was identified in the draft PEIS as DOE's preferred alternative, DOE would use ground water compliance strategies tailored for each site to achieve conditions that are protective of human health and the environment and that meet EPA ground water standards. The proposed action would consider ground water compliance decisions in a step-by-step approach, beginning with consideration of a "no-remediation" strategy and proceeding, if necessary, to consideration of passive strategies, such as natural flushing with compliance monitoring and institutional controls, and finally to consideration of more complex, active ground water methods, if needed. For example, under the proposed action, if a site risk assessment and Site Observational Work Plan

indicate that the strategy of "no-remediation" would be protective of ...man health and the environment, a ...e complex and potentially ...ironmentally disruptive strategy ...olving active cleanup methods ...ould not be necessary.

The proposed action is intended to establish a consistent risk-based framework for implementing the UMTRA Ground Water Project and determining appropriate ground water compliance strategies for complying with EPA ground water standards at the UMTRA Project former processing sites. In determining site-specific ground water compliance strategies DOE will consider: site-specific ground water conditions; human and environmental risks; the views of tribes, States and local communities; and cost. The proposed action as well as all the other alternatives discussed below except for "no action," are sufficiently flexible to allow DOE to conduct interim actions, such as providing alternate water supply systems, should they be necessary in order to reduce risk and/or support institutional controls. The proposed action would also allow the consideration of new ground water cleanup methods as they become available.

Action Alternative

...ne Council on Environmental ...lity regulations for implementing ...PA require assessment of the no action alternative (40 CFR 1502.14(d)), even if the agency is under a legislative mandate to act, to enable decision makers to compare the magnitude of environmental effects of the action alternatives (51 FR 15618 April 25, 1986). Under the no action alternative, no further activities would be carried out to comply with EPA standards at the inactive UMTRA Project former processing sites.

Active Remediation to Background Levels Alternative

Under this alternative, ground water at the former processing sites would be restored to background levels or to levels as close to background as possible using active ground water remediation methods without regard to existing risk or cost of implementation. The philosophy behind this alternative is an assumption that ground water at most of the former uranium processing sites was of better quality before uranium processing activities occurred and that the ground water should be restored to ...preprocessing quality. If this ...rnative were implemented, most of ... UMTRA Project sites would require ...e use of active ground water remediation methods such as gradient manipulation, ground water extraction and treatment, or *in situ* ground water treatment, regardless of the quality of the unaffected background ground water. The specific active remediation method at each site would be determined using the observational approach and evaluation of site-specific data in the pertinent Site Observational Work Plans.

Passive Remediation Alternative

Under this alternative, only passive remediation strategies would be used to meet the EPA ground water standards.[1] The passive remediation strategies are: (1) Performing no remediation at sites that qualify for supplemental standards or alternate concentration limits as defined below or sites where contaminant concentrations are below maximum concentration limits or background levels, or (2) relying on natural flushing. Natural flushing means allowing the natural ground water movement and geochemical processes to decrease contaminant concentrations. This alternative differs from the no action alternative in that it includes site characterization, monitoring, and risk assessment activities.

Under the first strategy of this alternative, the DOE would apply supplemental standards or alternate concentration limits if maximum concentration limits and/or background concentrations were exceeded. If supplemental standards or alternate concentration limits are to be applied at any site, concurrence by the NRC would be required.

Under the second strategy of this alternative, natural flushing would be used to achieve background levels or maximum concentration limits if supplemental standards and alternate concentration limits are not applied. Concurrence by the NRC would be required. According to the EPA standards, natural flushing can be used if it is shown to be protective of human health and the environment, if it will meet the EPA standards within 100 years, and if it complies with other provisions that EPA established for its use. However, natural flushing may not always meet the EPA standards in 100 years, and may not be protective of human health and the environment at all sites. Therefore, if the passive remediation alternative were selected, DOE may not comply with the EPA standards at some sites.

The specific passive ground water compliance strategy selected for each site would be determined using the observational approach and evaluation of data gathered and included in the pertinent Site Observational Work Plan. Active ground water remediation methods would not be used under this alternative, even if the EPA standards cannot be met by passive methods.

Existing Conditions

The designated UMTRA Project processing sites were active for varying lengths of time from the 1940s into the 1970s. These sites, the surrounding areas, and the underlying ground water constitute the affected environment for this PEIS. Minority or low income groups near UMTRA sites that have the potential for disproportionately high and adverse effects include those near the Tuba City and Monument Valley, Arizona; Shiprock, New Mexico; Mexican Hat, Utah; and Riverton, Wyoming, sites. Land contaminated by uranium mill tailings and other contaminants associated with UMTRA Title I former processing sites ranged from a low of 21 acres (ac) (8 hectares (ha)) at the Spook, Wyoming, site to a maximum of 612 ac (248 ha) at the Ambrosia Lake, New Mexico, site. The amount of contaminated materials ranged from 85,000 cubic yards (yd^3) (65,000 cubic meters (m^3)) at the North Continent Slick Rock, Colorado, site to 5,764,000 yd^3 (4,407,000 m^3) at the Falls City, Texas, site. The total amount of contaminated material at the sites is 39,000,000 yd^3 (30,000,000 m^3). As a result of uranium processing, contaminants have entered the shallow ground water at most of the UMTRA Project sites. Some of the more common contaminants at UMTRA sites that exceed maximum concentration limits under EPA's standards include but are not limited to molybdenum, nitrate, selenium, and uranium.

DOE currently estimates that approximately 10 billion gallons (gal) (39 million m^3) of ground water are contaminated. One site (Lowman, Idaho) shows no sign of contamination related to processing activities. The site with the largest amount of contamination, Gunnison, Colorado, has an estimated 1.9 billion gal (7.0 million m^3) of contaminated ground water.

[1] EPA's ground water protection standards provide three alternative approaches to determining site-specific cleanup requirements. Concentrations of certain contaminants that are within "maximum concentration limits" or at background levels are acceptable without further consideration. Alternatively, DOE may apply "alternate concentration limits" that will not pose a substantial present or potential hazard to human health or the environment under site-specific circumstances. Finally, when certain criteria are met (e.g., ground water restoration is technically impracticable), DOE may develop and apply "supplemental standards" in lieu of the otherwise applicable standards.

Surface remediation of the designated sites has been in progress since the mid-[illegible]80s; surface remediation is complete [illegible] sites and under way at the [illegible]ning two sites. Two additional [illegible], in Belfield and Bowman, North [illegible]kota, were included in the PEIS analysis but at the request of the State are not scheduled for surface remediation. These two sites therefore will not be included in the DOE Ground Water Program. Affected States are required by UMTRCA to share 10 percent of remedial action costs.

Impacts Analysis

The PEIS provides a qualitative analysis of potential impacts of the alternative ground water compliance strategies and compares the relative potential impacts of the alternatives. More detailed site-specific quantitative impact assessments will be provided in the NEPA documents that tier off the PEIS. Tiering is process in which broad environmental issues are analyzed in an initial NEPA document (the PEIS in this case) to facilitate subsequent NEPA reviews of narrower scope (site-specific reviews in this case).

To give more weight to impacts that may have more significant consequences (for example, human health), long-term and short-term [illegible]cts are compared separately in the [illegible] Long-term impacts are those that [illegible]d occur from leaving contaminated [illegible]ound water in place or from implementing institutional controls for an extended period of time. Short-term impacts would usually occur only during remediation activities. In general, short-term impacts would be less significant than long-term impacts, because most (for example, habitat destruction, noise, and dust emissions) would be relatively minor and temporary and could be mitigated. While these impacts are of concern, there is greater concern regarding potential long-term health and environmental effects.

Potential long-term impacts could arise under the following circumstances:

- If the contaminated ground water did not comply with EPA standards and its use were not sufficiently controlled. This could occur under the no action alternative and the passive remediation alternative.
- If the ground water compliance strategy were not protective of human health and the environment at all sites. This could occur under the no action alternative and passive remediation [illegible]native.
- [illegible] institutional controls were [illegible]mented and were needed for [illegible]nger than they should reasonably be relied upon (i.e., in excess of 100 years under the EPA standard). This could occur under all the alternatives except the no action alternative, but is unlikely to occur under the proposed action and active remediation alternatives.

If the no action alternative were selected, significant adverse impacts to human health and the environment could result. Under this alternative, the public could be exposed to hazardous contaminants by drinking contaminated ground water. Further, minority and/or low-income communities would be disproportionately impacted under the no action alternative because such communities comprise the majority of the population near several UMTRA Project sites. Adverse impacts to the environment could potentially occur if contamination enters the food chain (such as through livestock or produce) or affects sensitive habitats (such as wetlands) or threatened or endangered species. These potentially significant adverse impacts are not expected to occur under the proposed action or the active remediation to background levels alternative because these alternatives are intended to comply with EPA standards at all UMTRA Project sites in a reasonable timeframe. In addition, when required, surface and ground water monitoring would take place before, during, and after implementation of the proposed action and the active remediation to background levels alternative to ensure the public is not exposed to existing or potential surface and ground water contamination.

Implementation of the passive remediation alternative also could result in potential exposure of humans and the environment to hazardous contaminants because institutional controls may not always effectively restrict access to contaminated ground water. Under the passive remediation alternative, no active remediation of contaminated ground water would occur even if such a hazard were identified. In contrast, under both the proposed action and active remediation to background levels alternatives, DOE would use hydrogeologic data and risk assessments to identify the need for implementing active remediation strategies to mitigate risks.

While no active remediation would occur under this alternative, the passive remediation alternative could result in institutional controls for more than 100 years and could result in potentially significant long-term land use and social and economic impacts associated with access restrictions at contaminated sites. In contrast, the proposed action and the active remediation to background levels alternatives would implement strategies intended to achieve ground water compliance within 100 years.

In summary, the proposed action and active remediation to background levels alternatives are most effective in protecting human health and the environment from the contaminated ground water at the UMTRA Project sites. Short-term adverse environmental impacts associated with construction and operation of ground water remediation systems (e.g., habitat destruction, noise and dust emissions) would occur under both of these alternatives; such impacts would likely be greater under the active remediation alternative because remediation systems would be employed at every site. For all the reasons stated above, DOE regards both of these alternatives as environmentally preferable to the no action and passive remediation alternatives. The proposed action likely would be more cost effective than the active remediation alternative because it relies on less costly passive ground water compliance strategies at sites where these strategies can be shown to be protective of human health and the environment. The active remediation alternative would be the most costly option. Both it and the preferred alternative would result in compliance with the EPA ground water standards, but the active remediation alternative, with its reliance on active ground water remediation, would provide no substantial additional benefits to human health and the environment. Further, active remediation technologies may not always achieve background concentrations of contaminants within 100 years at former uranium processing sites.

Decision

The Department has decided to implement the proposed action, which was identified as the Department's preferred alternative in the draft PEIS. This approach provides a health and environmental risk-based framework for implementing the UMTRA Ground Water Project and for determining appropriate ground water compliance strategies at the UMTRA Project former processing sites.

The Department will use a logic framework established by the proposed action to identify the appropriate specific ground water compliance strategy or strategies for a site to ensure compliance with EPA standards and the protection of public health and the environment.

The first step in the decision process will be to determine whether the uranium processing activities at a specific site have resulted in ground

water contamination exceeding background levels or maximum ·centration limits. If ground water imination has not exceeded these dards and is not expected to do so e future, remediation will not be ired.

Pursuant to the EPA standards, if ground water has been contaminated by uranium processing activities and the contamination exceeds background levels or maximum concentration limits, the next step will be to determine whether compliance with EPA ground water standards could be achieved by applying supplemental standards under 40 CFR 192.21(g), based on a determination that the ground water met EPA's definition of "limited use ground water." "Limited use ground water" means ground water that is not a current or potential source of drinking water because of: high concentration of dissolved solids; ambient contamination unrelated to milling operations that cannot reasonably be cleaned up; or poor aquifer yield (40 CFR 192.11(e)). If limited use ground water is shown to exist and if supplemental standards are protective of human health and the environment, no site-specific remediation will be required. If supplemental standards based on limited use ground water is not icable, the next step will be to mine whether alternate entration limits apply.

. alternate concentration limits are protective of human health and the environment, alternate concentration limits will be applied. If not, it will be necessary to determine whether the contaminated ground water plume(s) will qualify for supplemental standards which, under 40 CFR 192.21(b) of the EPA ground water standards, may be appropriate if remediation will cause more environmental harm than benefit. At some sites where supplemental standards or alternate concentration limits may be applied, ground water monitoring and institutional controls may be necessary to ensure that the application of alternate concentration limits or supplemental standards will continue to be protective of human health and the environment. In addition, when limited-use ground water is present, supplemental standards must ensure that current and reasonably projected uses of the affected ground water are preserved.

If supplemental standards will not be protective, the next step will be to determine whether natural flushing ·nuation) will bring the iminated ground water into pliance (i.e., within maximum ·ncentration limits, background levels, or alternate concentration limits) within 100 years. Natural flushing could be used if DOE determines and NRC concurs that institutional controls could be implemented, maintained, and enforced during the natural flushing period; that this strategy is protective of human health and the environment; and that all other EPA provisions are met.

If natural flushing will not be protective, it will be necessary to determine whether natural flushing combined with active remediation methods will meet the EPA ground water standards and will be protective of human health and the environment. If so, a two-part strategy will be implemented. Active remediation methods will first be used for a short time to remove the most contaminated ground water in a discrete area, and then natural flushing will occur. When appropriate, DOE would use active methods that have low operational and maintenance requirements, such as gradient manipulation or geochemical barriers, in conjunction with natural flushing.

Site characterization data may show that natural flushing combined with active remediation will not result in ground water quality that is protective of human health and the environment. If that is the case, the next step in the framework will be to determine whether active ground water remediation techniques will meet the EPA ground water standards, and if so, to implement these techniques. Several methods of active ground water remediation could be used, including gradient manipulation, ground water extraction, and *in situ* ground water treatment. The active remediation methods could be used individually or in combination with other cleanup methods. If active remediation results in compliance with the EPA standards, remedial action will be complete. If these methods do not result in compliance, supplemental standards based on technical impracticability of remediation will be applied, along with institutional controls where necessary.

Site-specific NEPA documentation will be prepared to evaluate the impact(s) from alternative strategies for implementing the programmatic decision described above. In accordance with DOE policy, DOE will solicit input from the public, local organizations, and educational institutions on issues that should be identified, considered, and analyzed, and will conduct public meetings for that purpose in the affected communities. Furthermore, DOE will adopt all practicable means to avoid or minimize environmental harm during site-specific activities.

Issued in Washington, DC, on April 21, 1997.

Alvin L. Alm,

Assistant Secretary for Environmental Management.

[FR Doc. 97-10860 Filed 4-25-97; 8:45 am]

BILLING CODE 6450-01-P

DEPARTMENT OF ENERGY

Energy Information Administration

Agency Information Collection Under Review by the Office of Management and Budget

AGENCY: Energy Information Administration, Department of Energy.

ACTION: Submission for OMB review; comment request.

SUMMARY: The Energy Information Administration (EIA) has submitted the energy information collection listed at the end of this notice to the Office of Management and Budget (OMB) for review under provisions of the Paperwork Reduction Act of 1995 (Pub. L. 104-13). The listing does not include collections of information contained in new or revised regulations which are to be submitted under section 3507(d)(1)(A) of the Paperwork Reduction Act, nor management and procurement assistance requirements collected by the Department of Energy (DOE).

Each entry contains the following information: (1) Collection number and title; (2) summary of the collection of information (includes sponsor (the DOE component)), current OMB document number (if applicable), type of request (new, revision, extension, or reinstatement); response obligation (mandatory, voluntary, or required to obtain or retain benefits); (3) a description of the need and proposed use of the information; (4) description of the likely respondents; and (5) estimate of total annual reporting burden (average hours per response x proposed frequency of response per year x estimated number of likely respondents.)

DATES: Comments must be filed by May 28, 1997. If you anticipate that you will be submitting comments but find it difficult to do so within the time allowed by this notice, you should advise the OMB DOE Desk Officer listed below of your intention to do so as soon as possible. The Desk Officer may be telephoned at (202) 395-3084. (Also, please notify the EIA contact listed below.)

ADDRESSES: Address comments to the Department of Energy Desk Officer,

Final Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project October 1996

Sections 1 through 7 of the Final Programmatic Environmental Impact Statement (PEIS) are relevant to the proposed compliance strategy for the Lakeview UMTRA site and are included in this subsection. These portions describe the basis for UMTRA Ground Water Project alternatives, comparisons of the alternatives, site prioritization and risk assessment, ground water characterization and remedial actions, and environmental impacts and analysis of these impacts at each UMTRA site. The PEIS also discusses potentially unavoidable adverse environmental impacts of the preferred alternative; the short-term uses of the environment, including the maintenance and enhancement of long-term productivity at each site; and the irreversible and irretrievable commitment of resources.

DOE prepared the PEIS for the UMTRA Ground Water Project to comply with requirements of the National Environmental Policy Act (NEPA). The PEIS provides an analysis of potential effects of the ground water compliance strategies as well as potential cumulative effects. The document is a comprehensive planning and decision-making tool that provides a basis for determining the appropriate ground water compliance strategy at each UMTRA Project site, assesses the potential programmatic effects of the UMTRA Ground Water Project, and provides a tiering document for the site-specific NEPA documents. Preparation of the PEIS is consistent with the concept of tiering, in which broad-scope environmental impact statements analyze general policy or program issues to facilitate subsequent site-specific decision making. The Record of Decision issued for the PEIS further describes the purpose.

DOE/EIS-0198

FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR THE URANIUM MILL TAILINGS REMEDIAL ACTION GROUND WATER PROJECT

VOLUME I

October 1996

Prepared by

U.S. Department of Energy
Grand Junction Projects Office

SUMMARY

This programmatic environmental impact statement (PEIS) was prepared for the Uranium Mill Tailings Remedial Action (UMTRA) Ground Water Project to comply with the National Environmental Policy Act (NEPA). This PEIS provides an analysis of the potential impacts of the alternatives and ground water compliance strategies as well as potential cumulative impacts.

On November 8, 1978, Congress enacted the Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978, Public Law, codified at 42 USC §7901 *et seq.* Congress found that uranium mill tailings ". . . may pose a potential and significant radiation health hazard to the public, and that every reasonable effort should be made to provide for stabilization, disposal, and control in a safe, and environmentally sound manner of such tailings in order to prevent or minimize other environmental hazards from such tailings." Congress authorized the Secretary of Energy to designate inactive uranium processing sites for remedial action by the U.S. Department of Energy (DOE). Congress also directed the U.S. Environmental Protection Agency (EPA) to set the standards to be followed by the DOE for this process of stabilization, disposal, and control.

On January 5, 1983, EPA published standards (40 CFR Part 192) for the disposal and cleanup of residual radioactive materials. On September 3, 1985, the U.S. Court of Appeals for the Tenth Circuit set aside and remanded to EPA the ground water provisions of the standards. The EPA proposed new standards to replace remanded sections and changed other sections of 40 CFR Part 192. These proposed standards were published in the *Federal Register* on September 24, 1987 (52 FR 36000). Section 108 of the UMTRCA requires that DOE comply with EPA's proposed standards in the absence of final standards. The Ground Water Project was planned under the proposed standards. On January 11, 1995, EPA published the final rule, with which the DOE must now comply. The PEIS and the Ground Water Project are in accordance with the final standards. The EPA reserves the right to modify the ground water standards, if necessary, based on changes in EPA drinking water standards. Appendix A contains a copy of the 1983 EPA ground water compliance standards, the 1987 proposed changes to the standards, and the 1995 final rule.

Under UMTRA, DOE is responsible for bringing the designated processing sites into compliance with the EPA ground water standards and complying with all other applicable standards and requirements. The U.S. Nuclear Regulatory Commission (NRC) must concur with DOE's actions. States are full participants in the process. The DOE also must consult with any affected Indian tribes and the Bureau of Indian Affairs.

Uranium processing activities at most of the inactive mill sites resulted in the contamination of ground water beneath and, in some cases, downgradient of the sites. This contaminated ground water often has elevated levels of constituents such as but not limited to uranium and nitrates. The purpose of the UMTRA Ground Water Project is to eliminate or reduce to acceptable levels the potential health and environmental consequences of milling activities by meeting the EPA ground water standards.

The first step in the UMTRA Ground Water Project is the preparation of this PEIS. This document analyzes the potential impacts of four alternatives for conducting the Ground Water Project. These alternatives do not address site-specific ground water compliance strategies because the PEIS is a planning document only. It assesses the potential programmatic impacts 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 impacts analyses more efficiently. Participation by affected states, tribes, and local government agencies will be encouraged during preparation of this PEIS, and during implementation of the alternative selected in the Record of Decision.

This PEIS differs substantially from a site-specific environmental impact statement because multiple ground water compliance strategies, each with its own set of potential impacts, could be used to implement all the alternatives except the no action alternative. In a traditional environmental impact statement, an impacts analysis leads directly to the defined alternatives. The impacts analysis for implementing alternatives in this PEIS first involves evaluating a ground water compliance strategy or strategies (Figure 1), the use of which will result in site-specific impacts. This PEIS impacts analysis assesses only the potential impacts of the various ground water compliance strategies, then relates them to the alternatives to provide a comparison of impacts.

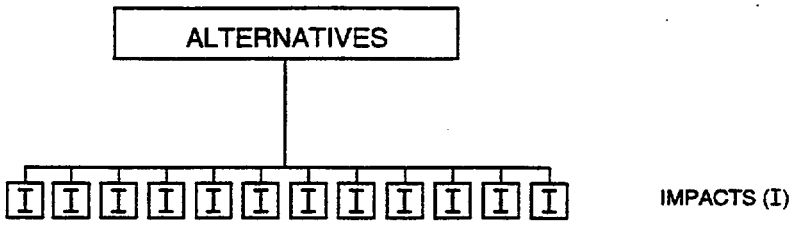
DESCRIPTION OF THE PROPOSED ACTION (PREFERRED ALTERNATIVE) AND ALTERNATIVES

The PEIS considers four programmatic alternatives for implementing the UMTRA Ground Water Project: 1) the proposed action (DOE's preferred alternative), 2) no action, 3) active remediation to background levels, and 4) passive remediation. A Record of Decision will identify the alternative that will become the programmatic foundation for conducting the Ground Water Project at all sites. All the alternatives listed except the no action alternative would use one or more ground water compliance strategies to meet the EPA ground water standards. Table 1 shows the alternatives and the strategies that are described below.

1) *Proposed action* (Preferred Alternative)

The proposed action which is DOE's preferred alternative would use ground water compliance strategies tailored for each site to achieve conditions that are protective of human health and the environment. The proposed action would consider ground water compliance decisions in a step-by-step approach, beginning with consideration of "no remediation" strategy and proceeding, if necessary, to the passive strategy, such as natural flushing with compliance monitoring and institutional controls, and to a more complex, active ground water cleanup method, such as pump and treat or other engineered approaches to cleaning up contaminated ground water. For example, under the proposed action, if a site risk assessment and site observational work plan indicate that the strategy of "no remediation" would still be protective of human health and the environment, a more complex and potentially disruptive strategy involving active cleanup methods would not be necessary.

PROJECT-SPECIFIC
ENVIRONMENTAL IMPACT STATEMENT



GROUND WATER PROJECT
PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

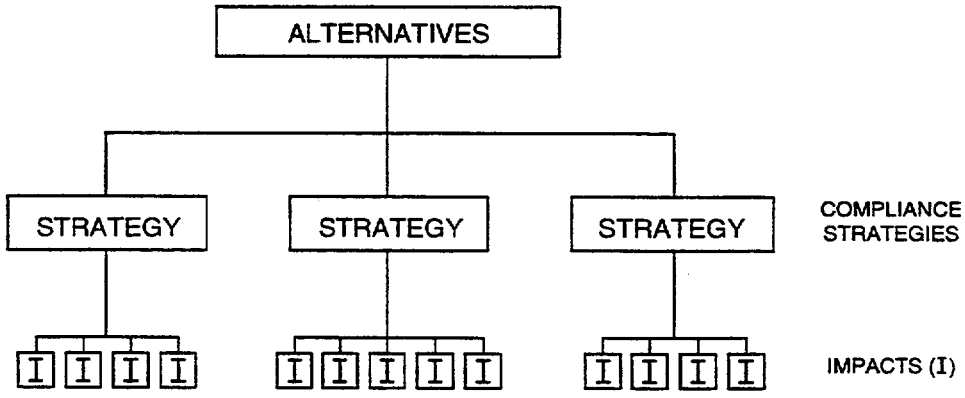


FIGURE 1
RELATIONSHIP BETWEEN ALTERNATIVES AND IMPACTS FOR PROJECT-SPECIFIC ENVIRONMENTAL IMPACT STATEMENTS AND THE GROUND WATER PROJECT PEIS

Table 1. Ground water compliance strategies that apply under each alternative

Strategy	Alternative			
	Proposed action	No action[a]	Active remediation to background levels	Passive remediation
Active ground water remediation methods	✓		✓[b]	
Natural flushing [c]	✓			✓
No ground water remediation				
- Sites that qualify for supplemental standards [d] or alternate concentration limits[e].	✓			✓
- Sites that meet maximum concentration limits or background levels (no impacts).[f]	✓			✓

[a]The analysis of the no action alternative is required by the CEQ and DOE.
[b]Active remediation methods would not be used at sites where contamination does not exceed background and likely would not be used at sites that qualify for supplemental standards based on the existence of limited use ground water.
[c]Natural flushing means allowing the natural ground water movement and geochemical processes to decrease contaminant concentrations.
[d]Supplemental standards applicable for certain site conditions, as identified in the EPA standards, that are protective of human health and the environment, and may be applied in lieu of prescriptive levels.
[e]Concentrations of contaminants that may exceed the maximum concentration limits; or, limits for those constituents without maximum concentration limits. If DOE demonstrates, and NRC concurs, that human health and the environment would not be adversely affected, DOE may meet an alternate concentration limit.
[f]"No remediation" at sites that do not exceed maximum concentration limits or background levels is not the same as "no action" because these sites would require activities such as site characterization to show that no remediation is warranted.

The proposed action is intended to establish a consistent risk-based framework for implementing the UMTRA Ground Water Project and determining appropriate ground water compliance strategies at the UMTRA Project former processing sites. The determination of site-specific ground water compliance strategies would take into account site-specific ground water conditions; human and environmental risks; participation of the tribes, States and local communities; and cost. This approach is sufficiently flexible to allow for interim actions, such as alternate water supply systems, should these activities be necessary in order to reduce risk and/or support institutional controls. The proposed action would also allow the consideration of new ground water cleanup methods that become available.

2) *No action alternative*

The Council on Environmental Quality (CEQ) regulations for implementing the NEPA require assessment of the no action alternative (40 CFR §1502.14(d)), even if the agency is under

a legislative mandate to act (51 FR 15618). The analysis of the no action alternative "provides a benchmark, enabling decision makers to compare the magnitude of environmental effects of the action alternatives" (51 FR 15618). Under the no action alternative, no further activities would be carried out to comply with EPA standards at the inactive UMTRA Project's former processing sites.

3) ***Active remediation to background levels alternative***

Under this alternative, ground water at the former processing sites would be restored to background levels or to levels as close to background as possible using active ground water remediation methods. The rationale behind this alternative is that ground water at most of the former uranium processing sites was of better quality before uranium processing activities occurred and that the ground water should be restored to its preprocessing quality. If this alternative were implemented, most of the UMTRA Project sites would require the use of active ground water remediation methods such as gradient manipulation, ground water extraction and treatment, or *in situ* ground water treatment, regardless of the quality of the unaffected background ground water. The active ground water restoration method for each site would be determined by the observational approach and site-specific analyses would appear in the site-specific observational work plans.

4) ***Passive remediation alternative***

Under this alternative, only passive remediation strategies would be used to meet the EPA ground water standards. The passive remediation strategies are 1) performing no remediation at sites that qualify for supplemental standards or alternate concentration limits or sites where contaminant concentrations are below maximum concentration limits or background levels, and 2) relying on natural flushing. Natural flushing means allowing the natural ground water movement and geochemical processes to decrease contaminant concentrations. This alternative differs from the no action alternative in that it includes site characterization, monitoring, and risk assessment activities.

Under the first strategy of this alternative, the DOE would apply supplemental standards or alternate concentration limits if maximum concentration limits and/or background concentrations were exceeded. If supplemental standards or alternate concentration limits are proposed at any site, concurrence by the NRC would be required.

Under the second strategy of this alternative, natural flushing would be used to achieve background levels or maximum concentration limits if supplemental standards and alternate concentration limits are not applied. Concurrence by the NRC would be required. According to the EPA standards, natural flushing can be used if it is shown to be protective of human health and the environment, meets the EPA standards within 100 years, and complies with the other criteria established for its use as discussed in Section 1.4.1. However, natural flushing may not meet the standards in 100 years and may not be protective of human health and the environment at all sites. For these cases, the passive remediation alternative may not result in compliance with the EPA standards.

The passive ground water compliance strategy selected for each site would be dependent on the observational approach and evaluating data gathered and included in Site

Observational Work Plans. Active ground water remediation methods would not be used, even if EPA standards cannot be met by implementing the above mentioned strategies.

EXISTING CONDITIONS

The designated UMTRA Project processing sites were active for varying lengths of time from the 1940s into the 1970s. These sites, the surrounding areas, and the underlying ground water constitute the affected environment for this PEIS. Minority or low income groups near UMTRA sites that have the potential for disproportionately high and adverse effects include those near the Tuba City and Monument Valley, Arizona; Shiprock, New Mexico; Mexican Hat, Utah; and Riverton, Wyoming, sites. Land contaminated by uranium mill tailings and other contaminants ranged from a low of 21 acres (ac) (8 hectares [ha]) at the Spook, Wyoming, site to a maximum of 612 ac (248 ha) at the Ambrosia Lake, New Mexico, site. The amount of contaminated materials ranged from 85,000 cubic yards (yd^3) (65,000 cubic meters [m^3]) at the North Continent Slick Rock, Colorado, site to 5,764,000 yd^3 (4,407,000 m^3) at the Falls City, Texas, site. The total amount of contaminated material at the sites is 39,000,000 yd^3 (30,000,000 m^3). As a result of uranium processing, contaminants have entered the ground water at most of the UMTRA Project sites. Some of the more common hazardous constituents that exceed maximum concentration limits at UMTRA sites include but are not limited to net gross alpha, molybdenum, nitrate, selenium, and uranium.

DOE currently estimates that approximately 10 billion gallons (gal) (39 million m^3) of ground water are contaminated. One site (Lowman, Idaho) shows no sign of contamination related to processing activities. The site with the largest amount of contamination, Gunnison, Colorado, has an estimated 1.9 billion gal (7.0 million m^3) of contaminated ground water.

Surface remediation of the designated sites has been in progress since the mid-1980s; surface remediation is complete at 18 sites and under way at four sites. The Belfield and Bowman, North Dakota, sites are not scheduled for surface remediation at the request of the state. Affected states are required by UMTRCA to cost share 10 percent of remedial action costs. Table 2 summarizes the environmental resources that are present at the former processing sites.

IMPACTS ANALYSIS

To evaluate the impacts of alternatives, a qualitative analysis of potential impacts of the ground water compliance strategies is used in this PEIS. This qualitative analysis compares the potential impacts of one alternative to another alternative rather than to site-specific impacts. For example, if the no action alternative is said to have a high potential for ecological risk, this potential impact is high only in relation to the other alternatives' potential for such an impact. These comparisons are not site specific; that type of assessment would be provided in the site-specific NEPA documents that tier off the PEIS. (Tiering is the process in which broad environmental issues are analyzed to facilitate subsequent site-specific decision making.) Further, this comparison treats all impacts equally so that, for example, the significance of potential impacts to human health are equated with potential impacts on cultural resources (Table 3).

Table 2. Resources at UMTRA Project processing sites

UMTRA Project Site	Site characteristics								
	Tribal lands	Urban setting	Suburban setting	Rural setting	Annual precipitation (inches/centimeters)	Wetlands	Surface water	Cultural/traditional resources	Threatened and endangered species
Monument Valley, AZ	✓			✓	6/15	✓	✓	✓	
Tuba City, AZ	✓			✓	6/15				
Durango, CO			✓		19/48		✓		✓
Grand Junction, CO		✓			8/20	✓	✓		✓
Gunnison, CO			✓		11/28	✓	✓		✓
Maybell, CO				✓	13/33	✓	✓	✓	✓
Naturita, CO				✓	9/23	✓	✓	✓	✓
Old Rifle, CO			✓		11/28	✓	✓		✓
New Rifle, CO			✓		11/28	✓	✓		✓
Slick Rock, CO (Union Carbide)				✓	7/18	✓	✓	✓	✓
Slick Rock, CO (North Continent)				✓	7/18	✓	✓	✓	✓
Lowman, ID				✓	27/69	✓	✓		
Ambrosia Lake, NM				✓	9/23			✓	
Shiprock, NM	✓		✓		6/15	✓	✓		✓
Belfield, ND			✓		16/41	✓	✓	✓	✓
Bowman, ND				✓	16/41	✓	✓	✓	✓
Lakeview, OR			✓		17/43	✓	✓		
Canonsburg, PA		✓			37/94		✓	✓	
Falls City, TX				✓	30/76	✓	✓		✓
Green River, UT				✓	6/15		✓	✓	
Mexican Hat, UT	✓			✓	6/15	✓	✓		
Salt Lake City, UT		✓			15/38	✓	✓		
Riverton, WY	✓[a]			✓	8/20	✓	✓	✓	
Spook, WY				✓	11/28		✓		✓
Total	5	3	7	14		18	22	11	14

[a] Tribal lands adjacent to the site.

Table 3. Comparison of the potential adverse environmental impacts of alternatives

Environmental factor	Alternative			
	Proposed action	No action	Active remediation to background levels	Passive remediation
Human health	Low	High	Low	Medium
Surface water	Low	High	Low	Medium
Ground water	Low	High	Low	Medium
Ecology				
Habitat destruction	Medium	Low	High	Low
Contaminated ground water	Low	High	Low	Medium
Land use				
Land acquisition	Medium	Low	High	Low
Institutional controls	Medium	Low	Medium	High
Contaminated ground water	Low	High	Low	Medium
Cultural/traditional resources				
Surface	Medium	Low	High	Low
Ground water	Medium	High	Low	High
Social and economic				
Institutional controls	Medium	Low	Medium	High
Contaminated ground water	Low	High	Low	Medium
Environmental justice	Low	High	Low	Low
Waste management	Medium	Low	High	Low

Notes:
1. High indicates high potential for negative impact relative to the other alternatives.
2. Medium indicates medium potential for negative impact relative to the other alternatives.
3. Low indicates little to no potential for negative impact relative to the other alternatives.
4. The degree of actual negative impact, if any, would be addressed once the site-specific ground water compliance strategies are determined; the analyses would appear in the site-specific NEPA document.

To give more weight to impacts that may have more significant consequences (for example, human health), long-term and short-term impacts are compared separately. Long-term impacts are those that would occur from leaving contaminated ground water in place or from implementing institutional controls for an extended period of time. Short-term impacts would usually occur only during construction activities. In general, these impacts would be potentially less significant than long-term impacts, because most (for example, habitat destruction, noise, and dust emissions) would be relatively minor and temporary, and could be mitigated. While these impacts are of concern, there is a greater concern regarding potential long-term health and environmental effects.

Potential short-term impacts of the alternatives

Potential short-term impacts to air quality, background noise levels, visual resources, transportation systems, utilities, and energy supplies would occur principally during site characterization, monitor well construction, and construction of ground water remediation facilities. There would be little or no impact on these resources due to the short duration and small scale of the ground-disturbing activities. Site characterization, monitoring, and construction activities have the potential to disturb sensitive habitats, species, and cultural/traditional resources. The probability of these disturbances would be remote because site characterization and construction activities can take place in areas away from these resources. In addition, if impacts to these resources occurred, their effects could be mitigated. Therefore, the potential for site characterization and construction activities to adversely affect these resources would be considered minor.

Potential long-term impacts of the alternatives

Potential long-term impacts could arise under the following circumstances:

- If the contaminated ground water did not comply with EPA standards and its use was not controlled. This could occur under the no action alternative.

- If the ground water compliance strategy was not protective of human health and the environment at all sites. This could occur under the passive remediation alternative.

- If institutional controls were in place for many years. This could occur under all the alternatives except the no action alternative.

Significant adverse impacts to human health and the environment could result under the no action alternative. Under this alternative, the public could be exposed to hazardous contaminants by drinking contaminated ground water or surface water that is a surface expression of contaminated ground water. Further, minority and/or low-income communities would be disproportionally impacted under no action. Adverse impacts to the environment could potentially occur if contamination enters the food chain (such as through livestock or produce) or affects sensitive habitats (such as wetlands) or threatened and endangered species. These potentially significant adverse impacts probably would not occur under the proposed action or the active remediation to background levels alternative, because these alternatives would comply with EPA standards at all UMTRA Project sites. In addition, surface and ground water monitoring would take place before and during implementation of the proposed action and the active remediation to background levels

alternative to ensure the public is not exposed to existing or potential surface and ground water contamination.

Implementation of the passive remediation alternative also could result in potential exposure of humans and the environment to hazardous contaminants. During the time required to implement the passive remediation alternative, contaminated ground water could reach potential receptors such as domestic wells or surface water features. Both the proposed action and active remediation to background levels alternatives would use hydrogeologic data and risk assessments to identify the need for implementing active remediation strategies to remediate ground water quickly or divert the flow of contamination.

Implementation of institutional controls could result in potentially significant long-term land use and social and economic impacts. The passive remediation alternative could result in the need for institutional controls for more than 100 years if protection of the public and the environment were necessary. The proposed action and the active remediation to background levels alternatives would implement strategies to achieve ground water compliance within 100 years.

In summary, the proposed action and active remediation to background levels alternatives are most effective in protecting human health and the environment from the contaminated ground water at the UMTRA Project sites. When cost is factored in, the proposed action likely would be more cost-effective than the active remediation alternative, because it can rely on less costly passive ground water compliance strategies at sites where these strategies are shown to be protective of human health and the environment. Implementing the active remediation to background levels alternative would be the most costly because active ground water remediation methods would be used at most sites. In addition, both alternatives would result in compliance with the EPA ground water standards so the active remediation to background levels, with its reliance on active ground water remediation, would provide no additional benefits to human health and the environment.

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1.0 INTRODUCTION

From 1943 to 1970, much of the uranium ore mined in the United States was processed by private companies under procurement contracts with the U.S. Atomic Energy Commission. This ore was used in national defense research, weapons development, and the developing nuclear industry. After fulfilling their contracts, many of the uranium mills closed and left large quantities of waste, such as uranium mill tailings and abandoned mill buildings, at the mill sites.

Beginning in the late 1960s and 1970s, direct gamma radiation, radon gas, and uranium decay products at the abandoned mill sites were determined to be potential health hazards. In 1972 concern for the potential long-term adverse health affects from uranium mill tailings used as fill material in construction projects in Grand Junction, Colorado, led Congress to pass Title II of Public Law 92-314, which authorized the Atomic Energy Commission to pay for 75 percent of the cost of remediating such contaminated buildings. Public concern about other abandoned uranium mill sites led to engineering and radiological studies to identify other mill sites in need of cleanup. As a result of these studies Congress passed the *Uranium Mill Tailings Radiation Control Act* (UMTRCA) on November 8, 1978 (42 USC §7901 *et seq.*).

The UMTRCA directed the U.S. Department of Energy (DOE) to stabilize, dispose of, and control, in a safe and environmentally sound manner, uranium mill tailings at the designated inactive uranium mill sites. To comply with the law, DOE established the Uranium Mill Tailings Remedial Action (UMTRA) Project. Under the UMTRA Project, DOE has been performing remedial action of the surface contamination (including uranium mill tailings and abandoned mill buildings) since 1983; this effort is called the UMTRA Surface Project. The first site to be cleaned up is in Canonsburg, Pennsylvania; surface remediation has now been completed at 18 sites and is under way at four sites. The designated uranium mill sites at Belfield and Bowman, North Dakota, will not be remediated by DOE because the state of North Dakota has declined to provide their statutorily required cost-sharing to remediate the sites. Although it is unlikely that these two sites will be part of the UMTRA Ground Water Project, discussion of the sites is still included in the programmatic environmental impact statement (PEIS). The Surface Project is responsible for controlling the exposure and dispersion of uranium mill tailings and other contaminated materials by stabilizing this material in disposal cells. However, the Surface Project does not address the remediation of contaminated ground water at the UMTRA Project sites. Information about the Surface Project is summarized in Sections 3.1 and 3.2 of this PEIS.

The UMTRA Ground Water Project addresses residual ground water contamination, if any, from the UMTRA Project processing sites. The Ground Water Project would take measures to protect human health and the environment by complying with EPA standards in a cost-effective and publicly acceptable manner. The UMTRA Ground Water Project also would address potential ground water contamination associated with vicinity properties (properties outside the processing site boundary contaminated with tailings) on a case-by-case basis.

The volume of tailings at vicinity properties is, in almost all cases, much less than the volume of the tailings at the abandoned processing sites. The volume of tailings is just one of the criteria for determining if the vicinity property would be a source for ground water contamination and would fall within the Ground Water Project. Another difference between contamination from a processing site and a vicinity property site is that processing sites had the potential to impact ground water due to the use of chemicals, water discharge, and exposed saturated tailings. In most cases, the tailings were exposed to the environment for many years before remediation. Tailings at vicinity properties were not processed and typically were not exposed to the environment for many years, which would minimize or eliminate the potential for vicinity properties to be a source of ground water contamination. Other factors include depth to ground water, magnitude of source, soil and bedrock geochemistry, ground water recharge and discharge, background water geochemistry, climate, and condition of the vicinity property.

1.1 PURPOSE OF AND NEED FOR DOE ACTION

In the UMTRCA, Congress acknowledged the potentially harmful health effects associated with uranium mill tailings. As required by the UMTRCA, the U.S. Environmental Protection Agency (EPA) developed standards to protect the public and the environment from potential radiological and nonradiological hazards from the abandoned mill processing sites; these standards include exposure limits for surface contamination and concentration limits for ground water protection. DOE is responsible for performing remedial action to bring the surface and ground water contaminant levels at the abandoned mill processing sites into compliance with EPA standards. DOE accomplishes this function through the UMTRA Project. Remedial action is conducted with the concurrence of the U.S. Nuclear Regulatory Commission (NRC) and the full participation of affected states and in consultation with Indian tribes. In addition, the NRC, Hopi Tribe, and Navajo Nation are cooperating agencies in the preparation of this PEIS.

Uranium processing activities at most of the processing mill sites designated for remediation under the UMTRCA resulted in the formation of contaminated ground water beneath and, in some cases, downgradient of the sites. This contaminated ground water often has elevated levels of hazardous constituents such as uranium and nitrates. The purpose of the DOE UMTRA Ground Water Project is to protect human health and the environment by meeting EPA standards in areas where ground water has been contaminated with hazardous constituents from former processing sites.

A major first step in the UMTRA Ground Water Project is the preparation of this PEIS. This document analyzes potential impacts of the alternatives, including the proposed action, which is DOE's preferred alternative. These alternatives are programmatic in that they are plans for conducting the UMTRA Ground Water Project. The alternatives, which are described in Section 2.0, do not address site-specific ground water compliance. This PEIS is a planning document for the Ground Water Project and assesses the potential programmatic impacts of conducting the Project. It provides a method for

determining the site-specific ground water compliance strategies and identifies data and information that are needed to prepare site-specific environmental impacts analyses more efficiently.

This PEIS satisfies a *National Environmental Policy Act* (NEPA) (42 USC §4321 *et seq.*) requirement by describing the proposed action and the alternatives and the existing conditions at the UMTRA sites, assessing potential impacts of the Ground Water Project as defined by the proposed action and the alternatives, and comparing the potential impacts of the proposed action and the alternatives.

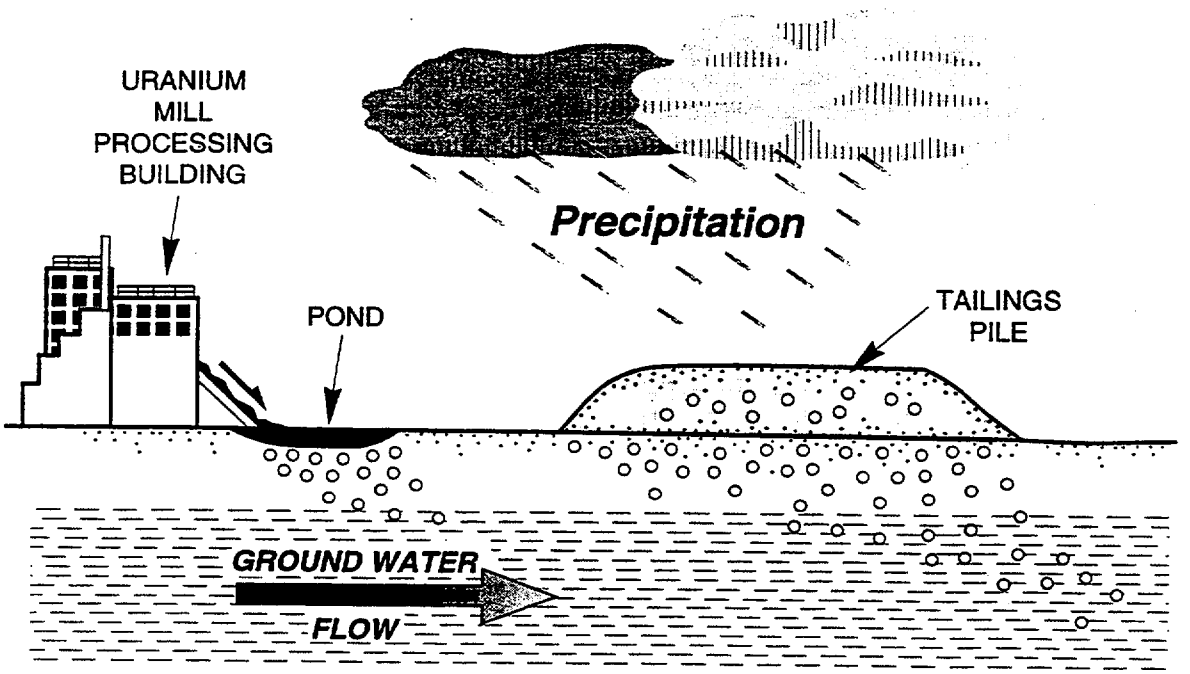
1.2 URANIUM MILL TAILINGS RADIATION CONTROL ACT

Congress passed the UMTRCA in 1978 in response to concerns raised about potential radiation health hazards to the public from long-term exposure to uranium mill tailings (Figure 1.1). The purposes of the UMTRCA are to stabilize and control uranium mill tailings at designated inactive mill sites and to regulate uranium mill tailings at active processing sites.

The UMTRCA has three parts, or "titles." Title I directs DOE to complete remedial action at 22 inactive uranium mill sites at which all or a substantial portion of uranium was processed for sale to a federal agency, and which no longer had a license to process uranium ore as of January 1, 1978. The Secretary of Energy was given the authority to add sites to the list. Designated uranium processing sites will be or have been remediated under Title I (Figure 1.2). Title II directs NRC to regulate uranium mill tailings at those processing sites having an active license on January 1, 1978. Title II sites are in various stages of surface and ground water remediation by private mill site operators (under Title II ground water remediation is conducted in conjunction with surface remediation). Title II sites are being remediated independently of one another and of the Title I sites. Title III directs NRC to study whether two New Mexico uranium mill sites should be designated by the Secretary of Energy as processing sites under Title I; the mill sites were not so designated.

In an amendment to the UMTRCA, DOE was authorized to perform ground water remediation at the designated processing sites without a time limitation (42 USC §7922(a)). Congress also directed DOE to comply with EPA's proposed ground water regulations until such time as EPA promulgates final regulations (42 USC §7918(a)(3)). EPA issued its proposed ground water protection standards on September 24, 1987 (52 FR 36000). Planning for the Ground Water Project occurred while the proposed rules were in effect. On January 11, 1995, the EPA published the final rule (60 FR 2854).

The responsibility for fulfilling the legislative mandate under the UMTRCA is divided between DOE, NRC, EPA, Indian tribes, and states. Their roles are described in the following subsections.



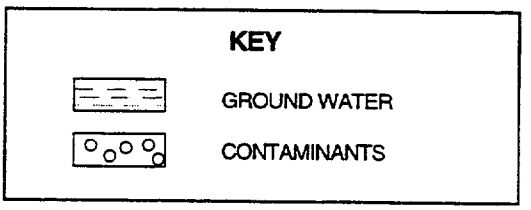


FIGURE 1.1
URANIUM MILL PROCESSING SITE

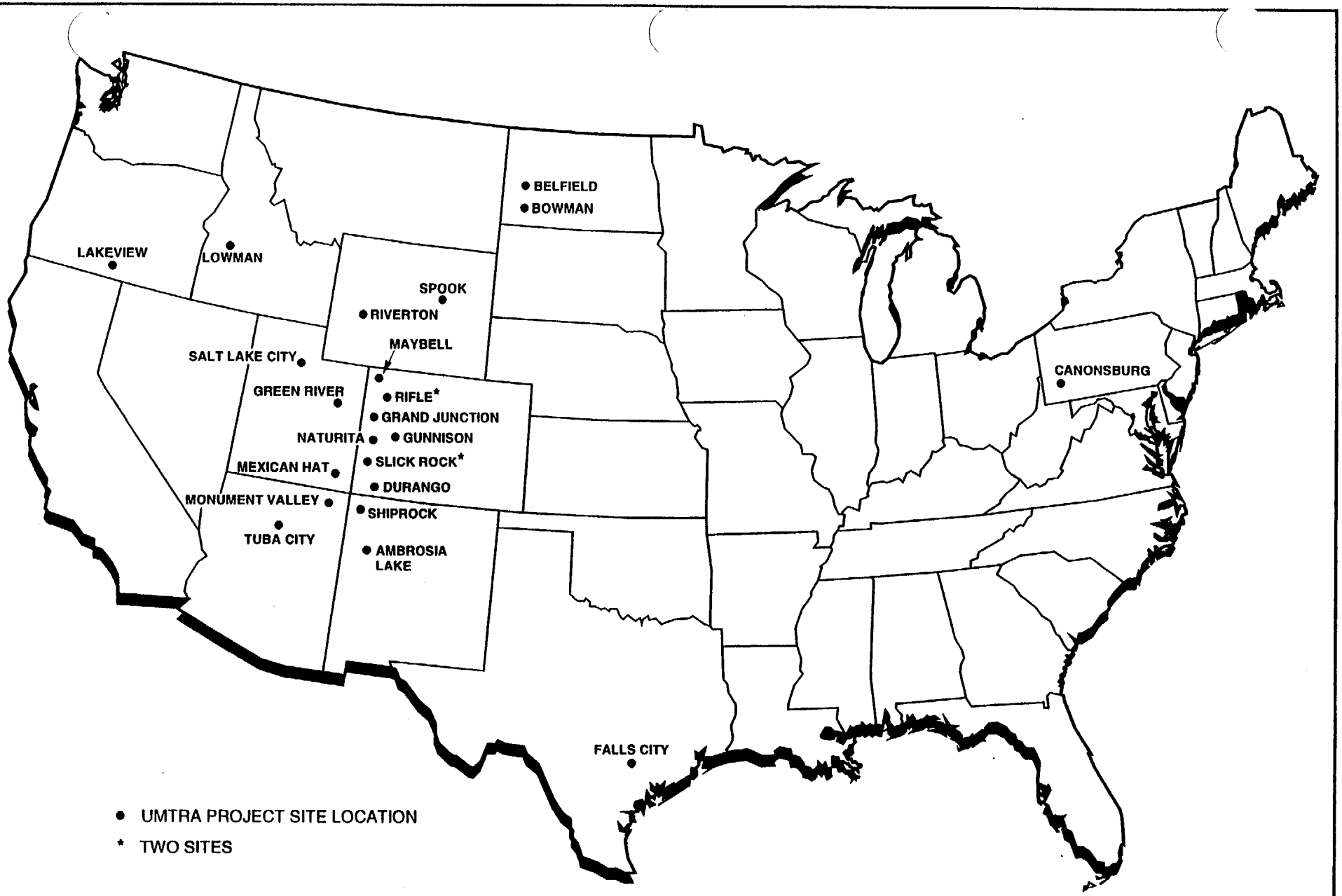


FIGURE 1.2
UMTRA PROJECT SITE LOCATION MAP

MAC: NONSITE/PEIS95/UMTRALOCMAP

1.2.1 U.S. Department of Energy

As the lead agency in the execution of the UMTRCA, DOE is responsible for the overall management of the UMTRA Project. This includes responsibility for all programmatic decisions and the review and supervision of all work completed by DOE contractors.

Within DOE, the Assistant Secretary for Environmental Management at DOE Headquarters oversees the administration of the UMTRA Project. The DOE Albuquerque Operations Office is the responsible field office, and daily operation of the UMTRA Ground Water Project is conducted by DOE's UMTRA Project Office in Grand Junction, Colorado.

DOE is committed to conducting the UMTRA Project in an environmentally sound manner that is protective of human health and the environment consistent with DOE Order 5400.1, *General Environmental Protection Program*, and in accordance with all applicable environmental laws.

1.2.2 U.S. Nuclear Regulatory Commission

The UMTRCA designated NRC as the federal regulatory oversight agency for the UMTRA Project. As part of this oversight responsibility, NRC published the *Final Generic Environmental Impact Statement on Uranium Milling* in 1980 (NRC, 1980). This document assessed the nature and extent of the impacts of uranium milling and provided information on what the regulatory requirements for management and disposal of mill tailings and mill decommissioning should be. This generic environmental impact statement is the programmatic environmental impact statement for the UMTRA Surface Project.

Remedial actions are selected and performed with the concurrence of the NRC. The NRC also licenses the completed disposal sites for long-term care. (Refer to Section 1.4, Regulatory Compliance, for a discussion of licensing.)

NRC provides technical and regulatory review of certain UMTRA Project documents, including remedial action plans, completion reports, long-term surveillance plans, and certification reports. An NRC concurrence with these documents is required to obtain a license for the disposal sites.

1.2.3 U.S. Environmental Protection Agency

As specified in the UMTRCA, EPA was required to establish standards for remediating and disposing of contaminated material from inactive uranium processing sites. Section 1.4, Regulatory Compliance, describes the EPA standards.

1.2.4 Indian tribes and states

Under the plan established by the UMTRCA, states participate fully in the selection and performance of remedial action for which states pay part of the cost (10 percent). Remedial action on Indian lands is to be selected and performed in consultation with the affected Indian tribes and the Bureau of Indian Affairs. Indian tribes are not required to pay any of the costs of remedial action.

The DOE has entered into cooperative agreements with the states and Indian tribes for the performance of the surface remedial action. New cooperative agreements for the UMTRA Ground Water Project, which would outline the new roles and responsibilities of the parties, would be negotiated between the DOE and the states and Indian tribes.

The participation of the states and Indian tribes in the UMTRA Ground Water Project would include review of major technical documents and activities related to site-specific ground water compliance. The states (including local governments) and Indian tribes also would play a key role in the implementation of institutional controls during ground water remediation, as appropriate.

The states and Indian tribes participated in the initial ground water PEIS activities, including the scoping meetings and hearings, and provided comments on the draft PEIS. In addition, the Hopi Tribe and Navajo Nation are cooperating agencies in the preparation of the PEIS.

The DOE recognizes that as a federal agency, it has a fiduciary duty to act in the best interests of the affected Indian tribes under the United States' trust responsibility with Indian nations. The DOE's policy with respect to its relationships with Indian tribes is more fully described in DOE Order 1230.2, *American Indian Tribal Government Policy*.

1.3 NATIONAL ENVIRONMENTAL POLICY ACT

The NEPA of 1969 (42 USC §4321 *et seq.*) declared a national policy for promoting efforts to prevent or eliminate damage to the environment. This act requires federal agencies to prepare a detailed statement that identifies and analyzes the environmental impacts of a proposed action that may significantly affect the quality of the human environment (42 USC §4321(c)). The Council on Environmental Quality (CEQ) regulations that implement NEPA (40 CFR Parts 1500-1508) provide requirements for carrying out the substantive and procedural elements of NEPA. The regulations also require that each federal agency develop its own implementing procedures (40 CFR §1507.3). The DOE implementing requirements for compliance with NEPA are contained in 10 CFR Part 1021.

As discussed in Section 1.2, UMTRCA directed DOE to perform remedial action that would stabilize and control the uranium mill tailings and associated

contamination at inactive uranium processing sites in 10 states and on tribal lands. Implementation of UMTRCA represents a major federal action subject to NEPA requirements. In 1982, EPA prepared an environmental impact statement that analyzed the impacts of implementing the compliance standards (40 CFR Part 192) for the UMTRA Project (EPA, 1982). The DOE NEPA documents (environmental impact statements and environmental assessments) analyzing site-specific impacts of surface remediation have been completed for the sites. These documents are referenced in Section 3.2, Site Descriptions. Site-specific NEPA documents would be prepared for ground water activities.

One approach considered to address the programmatic impacts was to assess the impacts of the UMTRA Ground Water Project in DOE's waste management PEIS. Site-specific UMTRA Ground Water Project NEPA documents would have tiered off the waste management PEIS (the concept of tiering is described in Section 1.3.1). Although the UMTRA Project is part of DOE's Environmental Restoration Program, DOE is evaluating UMTRA Ground Water Project activities in a separate PEIS for four reasons. First, the UMTRA Project is an autonomous project with a clearly defined legislative, regulatory, and technical scope that is distinct from other DOE programs. Second, the NEPA process is complete for surface disposal of tailings at most UMTRA Project sites, and the Surface Project is expected to be near completion before a Record of Decision is issued for the Environmental Management Program PEIS. Third, the Environmental Management Program PEIS will not provide the level of detail necessary so that the site-specific NEPA documents can tier off the PEIS. Fourth, the UMTRA Project is regulated by NRC, while the Environmental Management Program sites are regulated primarily by EPA and the states. This PEIS is a comprehensive planning and decision-making document that would 1) provide the basis for determining the appropriate ground water compliance strategy at each UMTRA Project processing site; 2) assess the potential programmatic impacts of the UMTRA Ground Water Project; and 3) provide a tiering document for the site-specific NEPA documents.

The regulations for implementing NEPA provide for the preparation of program-wide environmental impact statements (40 CFR §1502.4(b)) for broad federal actions such as implementation of a new program or regulation. Programmatic NEPA documents are subject to the same preparation, issuance, and circulation requirements as other NEPA documents (10 CFR §1021.330).

1.3.1 Tiering

Preparation of the UMTRA Ground Water Project PEIS is consistent with the concept of tiering (40 CFR §1508.28), in which broad-scope environmental impact statements analyze general policy or program issues to facilitate subsequent site-specific decision-making. The NEPA implementing regulations encourage this tiering approach. These regulations indicate that the issues discussed in the broad, policy-level environmental impact statement need only be summarized or incorporated by reference into the site-specific NEPA documents that are published after the policy-level environmental impact

statement. These site-specific documents focus on issues specific to actions that followed publication of the PEIS (40 CFR §1502.20). Programmatic issues that are analyzed in this ground water PEIS and would be summarized or incorporated by reference in the site-specific NEPA documents include the following:

- The framework for determining the ground water compliance strategy for meeting the EPA ground water standards at each UMTRA Project site (refer to Section 2.1)
- The categories of impacts to be assessed for each ground water compliance strategy (refer to Section 4.0)
- The assessment of impacts of programmatic alternatives (refer to Section 4.0)
- The methods for assessing risk (refer to Appendix B)
- The detailed discussions of ground water characterization and remediation methods (refer to Section 2.8 and Appendix C).

The site-specific NEPA documents would focus on issues relevant to ground water compliance decisions for a particular site. This approach would minimize the length of each site-specific NEPA document but would allow the assessment to address all pertinent environmental issues. This would include enough ground water data and analyses so the public and agencies can determine if the proposed ground water compliance strategy is appropriate.

Pollution prevention

Pollution prevention was addressed in the CEQ memorandum of January 12, 1993, "Pollution Prevention and the National Environmental Policy Act." Pollution prevention includes ". . . reducing or eliminating hazardous or other pollution inputs which can contribute to both point and non-point source pollution, . . ." and ". . . preventing the disposal and transfer of pollution from one media to another . . . ." Overall, the UMTRA Project can be considered a pollution prevention project because the Surface Project stabilizes the uranium mill tailings and other contaminated material into disposal cells, which prevents or inhibits the spread of contamination onto the land surface or into the ground water, and the Ground Water Project remediates contaminated ground water.

The Ground Water Project would address the prevention and potential spread of pollution, including contaminated ground water that has the potential to create human and ecological health risks; the discharge of contaminated sludge and water generated from ground water cleanup; the prevention of fugitive dust emissions from remedial action; and the prevention of the use of contaminated ground water through institutional controls. The site-specific environmental

documents would assess specific avenues for pollution and measures to prevent this pollution at each of the UMTRA Project sites.

1.3.2 Cooperating agencies

NEPA mandates that all federal agencies seek comments from governmental agencies that have jurisdiction or special expertise with respect to any environmental impact involved in a proposed action or alternative (42 USC §4321(c)). The extent of participation by a cooperating agency varies from active participation in developing information and analyses for the environmental impact statement to the roles of consultation and review. The Navajo Nation, Hopi Tribe, and NRC are cooperating agencies for the PEIS.

Participation by affected tribes, states, other agencies, and local governments also is encouraged in the preparation of the PEIS. Representatives of the tribes, states, local governments, other agencies, and the public participated in scoping meetings and hearings, and provided comments on the draft PEIS (refer to Section 1.6). Information obtained from these sources was used to identify issues addressed in the draft PEIS and to revise it, where necessary. The PEIS implementation plan (DOE, 1994a) discusses the comments received during scoping and how those comments were addressed in the draft PEIS. Volume II of this final PEIS contains all comments received during the hearings and comment period, and DOE's responses. The affected tribes, states, and public, along with local and federal government agencies, would continue to be actively involved in the PEIS process and the site-specific environmental documents that would tier off the PEIS.

1.4 REGULATORY COMPLIANCE

The UMTRA Project is regulated by both EPA and NRC regulations (40 CFR Part 192 and 10 CFR Part 40, respectively). 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 an overview of the regulations pertaining to ground water protection standards and describes the general requirements for long-term surveillance and monitoring at processing sites.

Decisions regarding consistency with tribal and state laws and regulations would be made by DOE, in consultation with the tribes and states. These decisions would consider cases where an approved wellhead protection area, under the Safe Drinking Water Act, is associated with the site. DOE would comply with the provisions of that legislation unless the President of the United States, through the EPA, grants an exemption.

1.4.1 EPA standards

The UMTRCA requires that EPA promulgate standards for protecting public health, safety, and the environment from radiological hazardous constituents

associated with the processing, possession, transfer, and disposal of residual radioactive materials. The UMTRCA and EPA define residual radioactive materials as tailings and other wastes that DOE determines to be radioactive that have resulted from uranium ores processing. These wastes may be in the form of tailings or other materials such as demolition debris and nonradiological hazards associated with residual radioactive materials. EPA has interpreted this definition to include sludges and captured contaminated water from the processing sites (60 FR 2854).

On January 5, 1983, EPA published standards (40 CFR Part 192) for the disposal and cleanup of residual radioactive materials. On September 3, 1985, the U.S. Court of Appeals for the Tenth Circuit set aside and remanded to EPA the ground water provisions of the standards. EPA proposed new standards to replace remanded sections and changed other sections of 40 CFR Part 192. These proposed standards were published in the *Federal Register* on September 24, 1987 (52 FR 36000). Section 108 of the UMTRCA requires that DOE comply with EPA's proposed standards in the absence of final standards. The Ground Water Project was planned under the proposed standards. On January 11, 1995, EPA published the final rule, with which the DOE must now comply. The PEIS and the Ground Water Project are in accordance with the final standards. The EPA reserves the right to modify the ground water standards, if necessary, based on changes in EPA drinking water standards. Appendix A contains a copy of the 1983 EPA ground water compliance standards, the 1987 proposed changes to the standards, and the 1995 final rule.

The EPA standards have three subparts that apply to the UMTRA Project: Subpart A, Subpart B, and Subpart C.

Subpart A—Standards for residual radioactive materials

Subpart A, "Standards for the Control of Residual Radioactive Materials From Inactive Uranium Processing Sites," addresses control or disposal of the residual radioactive materials at processing or disposal sites. Compliance with Subpart A is being met under the UMTRA Surface Project. This subpart is not discussed further in the PEIS.

Subpart B—Background levels, maximum concentration limits, alternate concentration limits, monitoring, 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 do not exceed any one of the following three standards in 60 FR 2854:

- Background levels for these constituents

- Maximum concentration limits—EPA's maximum concentration of certain hazardous constituents for ground water protection. Hazardous constituents with maximum concentration limits 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—concentrations of contaminants that may exceed the maximum concentration limits; or, limits for those constituents without maximum concentration limits. If DOE determines, and NRC concurs, that human health and the environment would not be adversely affected, DOE may meet an alternate concentration limit.

Subpart B also defines limited use ground water. Ground water may be classified as limited use if the total dissolved solids exceed 10,000 milligrams per liter (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 is less than 150 gallons (gal) (570 liters [L]) per day.

Subpart B also has provisions that allow natural flushing as a way to meet the EPA ground water standards. Natural flushing means letting natural ground water processes reduce the contamination in ground water to background levels, below the maximum concentration limits, or to alternate concentration limits. The following conditions must be met before natural flushing can be implemented:

- Natural flushing must allow standards (background levels, maximum concentration limits, or alternate concentration limits) to be met within 100 years.

- Institutional controls with a high degree of permanence that will effectively protect public health and the environment, and satisfy beneficial uses of ground water must be viable and enforceable (a description of institutional controls is provided below).

- Ground water must not be a current or projected source for a public water system during the period of natural flushing. A public water system is defined in 40 CFR §125.58 as a "system for the provision to the public of piped water for human consumption, if such system has at least fifteen (15) service connections or regularly serves at least twenty-five (25) individuals. This term (public water system) includes 1) any collection, treatment, storage, and distribution facilities under the control of the operator of the system and used primarily in connection with the system; and 2) any collection of pretreatment storage facilities not under the control of the operator of the system which are used primarily in connection with the system."

Subpart B also requires that DOE monitor the ground water contamination for compliance with Subpart B standards and define the extent of ground water contamination so that measures can be taken, if necessary, to protect human health and the environment.

The EPA standards specify a point of compliance for disposal of the surface contamination but indicate that this does not suffice for the cleanup of contaminated ground water. For the Ground Water Project, "compliance must be achieved anywhere contamination above the levels established by these standards is found or projected to be found in ground water outside the disposal area and its cover" (60 FR 2854).

Subpart C—Implementation

Subpart C, Implementation, provides guidance for implementing methods and procedures that will reasonably assure the public that the provisions of Subparts A and B are satisfied. The conditions of Subpart B should be met on a site-specific basis, using information gathered from site characterization and monitoring. The plan to meet the conditions of Subpart B should be stated in the compliance strategy document or remedial action plan. This plan should also consider future ground water plume movement. If natural flushing is the selected compliance strategy, Subpart C requires compliance monitoring to verify anticipated plume movement and the associated reduction in plume contamination. Finally, the plan should specify details of the method to be used to meet the standards and, if necessary, the remedial action.

Supplemental standards

Subpart C specifies eight conditions for which DOE may apply supplemental standards to contaminated ground water. These standards are supplemental to background levels, maximum concentration limits, or alternate concentration limits. Supplemental standards as cited below in 40 CFR §192.21 may be applied if any one of the following conditions is met:

a) Remedial actions required to satisfy Subpart A or B of the standards would pose a clear and present risk of injury to workers or to members of the public, notwithstanding reasonable measures to avoid or reduce risk.

b) Remedial actions to satisfy the cleanup standards for land and ground water, notwithstanding reasonable measures to limit damage, would directly produce health and environmental harm that is clearly excessive compared to the health and environmental benefits, now or in the future. A clear excess of health and environmental harm is harm that is long-term, manifest, and grossly disproportionate to health and environmental benefits that may reasonably be anticipated.

c) The estimated cost of remedial action to meet the standards at a "vicinity" site is unreasonably high relative to the long-term benefits, and the

residual radioactive materials do not pose a clear present or future hazard. The likelihood that buildings will be erected or that people will spend long periods of time at such a vicinity site should be considered in evaluating this hazard. Remedial action will generally not be necessary where residual radioactive materials have been placed semi-permanently in a location where minor quantities of residual radioactive materials are involved. Examples are residual radioactive materials under hard surface public roads and sidewalks, around public sewer lines, or in fence post foundations. Supplemental standards should not be applied at such sites, however, unless individuals are likely to be exposed for long periods of time to radiation from such materials at levels above those that would prevail under the standards.

d) The cost of a remedial action for cleanup of a building under the standards is clearly unreasonably high relative to the benefits. Factors that should be included in this judgment are the anticipated period of occupancy, the incremental radiation level that would be affected by the remedial action, the residual useful lifetime of the building, the potential for future construction at the site, and the applicability of less costly remedial methods than removal of residual radioactive materials.

e) There is no known remedial action.

f) The restoration of ground water quality at any designated processing site is technically impracticable from an engineering perspective.

g) 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:

- the concentration of total dissolved solids is in excess of 10,000 mg/L or,
- 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 or,
- the quantity of water reasonably available for sustained continuous use is less than 150 gal (570 L) per day. The parameters for determining the quantity of water reasonably available shall be determined by the DOE with the concurrence of the NRC.

h) Radionuclides other than radium-226 and its decay products are present in sufficient quantity and concentration to constitute a significant radiation hazard from residual radioactive materials.

The standards that most likely would apply to the Ground Water Project are b, e, f, and g above.

The EPA final rule states that if supplemental standards are applied, 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.

Institutional controls

Institutional controls are controls that effectively protect public health and the environment. They typically depend on some social order to ensure that protection is effective. On the UMTRA Ground Water Project, institutional controls would reduce exposure to or mitigate health risks by 1) preventing intrusion into contaminated ground water, or 2) restricting access to or use of contaminated ground water for unacceptable purposes. As a last resort, institutional controls could limit human access to the land above the contaminated ground water. The EPA standards allow the use of institutional controls in place of remediation only if their effectiveness can be verified and maintained. The EPA standards permit the use of institutional controls at sites where remediation can occur through natural flushing of the aquifer within 100 years. However, the standards do not limit the use of institutional controls to the sites that can meet the standards through natural flushing. Institutional controls may also be used to protect public health or the environment when DOE finds them necessary and appropriate prior to commencing active remedial action, during active remedial action, or during implementation of other compliance strategies.

The EPA standards require that institutional controls

- have a high degree of permanence.
- protect public health and the environment.
- satisfy beneficial uses of ground water.
- are enforceable by administrative or judicial branches of government entities.
- can be effectively maintained and verified.

An example of acceptable institutional controls cited in the EPA standards is deed restriction that can be enforced by a unit of government (either administratively or through judicial processes). Another example is federal or state ownership of land containing contaminated ground water. EPA recognizes that a combination of controls may be needed to adequately protect public health and safety. Measures such as signs, health advisories, or other measures

that require voluntary cooperation of private parties can be used to complement other enforceable institutional controls but cannot be considered as primary protective measures. In addition, the use of an alternate water supply in conjunction with institutional controls that would prevent human contact with contaminated ground water would be a viable institutional control.

Key to identifying, implementing, and enforcing institutional controls is participation by tribal, state, and local governments. While DOE is responsible for compliance with the EPA standards at UMTRA sites, its authority to implement and enforce institutional controls may be limited, particularly where tailings are disposed of off the processing site and land is privately owned or is owned or controlled by tribal, state, or other public agencies. Similarly, ground water contamination from uranium processing may have moved beyond the processing site to areas that are not within the DOE jurisdiction.

The need for and duration of institutional controls depends on the compliance strategy selected for a site, the type and level of risk, and existing site conditions. As risks decrease over time, so should the restrictiveness of institutional controls. Contaminated plume movement might require applying the restrictions to an extended area over time. Therefore, to ensure extended protection of public health, the environment, and beneficial uses the water could have satisfied, it is important that the effectiveness of institutional controls can be verified and modified as necessary.

Institutional controls, if any, will be selected in cooperation with the Indian tribes, states, and local governments. DOE will verify that the institutional controls are effective. Site-specific institutional controls will not be selected and implemented without DOE and NRC concurrence.

1.4.2 NRC licensing regulations and program

The UMTRCA authorized DOE to care for the uranium mill tailings disposal sites under a license issued by NRC. The UMTRCA stipulates the NRC will promulgate regulations to ensure the permanent disposal sites are monitored and maintained in accordance with the general license. Regulations in 10 CFR §40.27, *General License for Custody and Long-Term Care of Residual Radioactive Material Disposal Sites,* describe the licensing mechanism for the long-term care of each UMTRA Project disposal site, when NRC accepts the site-specific long-term surveillance plan. Long-term care includes surveillance and maintenance needed to protect public health and safety.

On-site stabilization

At former processing sites where tailings are stabilized in on-site disposal cells, contaminated ground water may require remediation. This could occur if ground water moves from below the disposal cell. The NRC may license these disposal sites in two steps. The first step is NRC's acceptance of the long-term care

program for all surface remedial action that includes compliance with the EPA standards that protect the ground water from further contamination from the tailings. In the second step, the DOE must verify, and NRC must concur, that ground water compliance has been met in accordance with 40 CFR Part 192, Subpart B. The long-term surveillance plan will be appropriately amended, signifying that the second step of the licensing process is complete.

Off-site stabilization

For the disposal cells where the residual radioactive materials were relocated off the processing site, NRC will license the disposal site in one step. The processing sites themselves will not be licensed by NRC. Compliance with EPA ground water standards will require NRC concurrence.

1.4.3 DOE requirements

DOE Order 5400.1, *General Environmental Protection Program,* established environmental protection program requirements for DOE operations, including the UMTRA Project, for ensuring compliance with executive orders and applicable federal, tribal, state, and local environmental protection laws and regulations. DOE also established requirements for the protection of the public and workers from radiological hazards in DOE Order 5400.5, *Radiation Protection of the Public and the Environment*; DOE Order 5480.11, *Radiation Protection for Occupational Workers*; and 10 CFR Part 835, *Occupational Radiation Protection*. These and all other applicable requirements are routinely incorporated into UMTRA Project activities.

1.4.4 DOE Office of Environmental Justice requirements

Executive Order 12898, *Federal Action to Address Environmental Justice in Minority Populations and Low Income Populations*, directs federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority and low-income populations. Executive Order 12898 also directs the EPA administrator to convene an interagency Federal Working Group on Environmental Justice. The Working Group is directed to provide guidance to federal agencies on criteria for identifying disproportionately high and adverse human health or environmental effects on minority and low-income populations. The Working Group has not yet issued the guidance directed by Executive Order 12898. In coordination with the Working Group, the DOE is in the process of developing internal guidance on implementing the Executive Order. Because both the Working Group and the DOE are still in the process of developing guidance, the approach taken in this analysis may depart somewhat from the guidance that is eventually issued, but will comply with the intent of the Executive Order.

1.4.5 Other Presidential Executive Order requirements

Executive Order 11990, *Protection of Wetlands*, requires all federal agencies to issue or amend existing procedures to ensure wetlands protection is considered in decision-making. This requirement is routinely incorporated into UMTRA Project activities.

Executive Order 11988, *Floodplain Management*, requires each federal agency to issue or amend existing regulations and procedures to ensure that the potential effects of any action it may take in a floodplain are evaluated and that its planning programs and budget requirements reflect consideration of flood hazards and floodplain management. The UMTRA Project activity planning routinely identifies and considers the impacts of Project actions on floodplains.

1.4.6 Tribal law requirements

The DOE shall follow all applicable tribal laws and regulations in performing ground water compliance activities on Indian lands. In the event of conflicting applications of federal, state, and tribal law, the subject activity will be carried out pursuant to the following order of priority in application: 1) federal, 2) tribal, and 3) state.

1.5 PROPOSED ACTION SUMMARY

This PEIS considers four approaches (also called "alternatives") for implementing the UMTRA Ground Water Project. These alternatives are described in Section 2.0. The proposed action (preferred alternative) is summarized below.

The proposed action provides a consistent approach, based on a health- and environmental risk-based framework, for implementing the UMTRA Ground Water Project and determining appropriate ground water compliance strategies at the UMTRA Project processing sites. The success of the proposed action in determining these strategies would depend on the analysis of site-specific data to characterize the hydrogeological conditions and determine the potential human health and environmental risks.

The following site-specific ground water compliance strategies could be used under the proposed action:

- No remediation
- Natural flushing
- Active ground water remediation.

These strategies could be used individually or in combination to meet the standards. For example, active ground water remediation methods could be used in conjunction with natural flushing.

The proposed action is flexible because it provides a framework for the Ground Water Project decision-making process if new ground water cleanup methods become available. The proposed action considers ground water compliance in a step-by-step approach, beginning with the no remediation strategy and ending with more complex, active ground water cleanup strategies. When a site baseline risk assessment for ground water contamination and a site observational work plan indicate the no remediation strategy would be protective of human health and the environment, a more complex and potentially disruptive strategy involving active cleanup methods would not be necessary. The proposed action would tailor ground water compliance strategies for each site, based on the likelihood that they would result in conditions that are protective of human health and the environment. A more detailed description of the proposed action appears in Section 2.1.

1.6 PUBLIC PARTICIPATION

An important component of the PEIS is the participation by government agencies, organizations, the public, and other interested parties in determining the scope and content of this PEIS and reviewing and commenting on the draft and final PEIS. Throughout the UMTRA Ground Water Project, the DOE will provide opportunities for productive, ongoing discussions with the public and local, state, tribal, and federal officials as part of DOE's daily activities.

Regulations that implement NEPA (in 40 CFR §1501.7) stipulate there must be an early, open, and continuing public participation process for determining the scope of the issues that will be addressed and for identifying significant issues related to the proposed action. This process is called scoping. The UMTRA Ground Water Project PEIS scoping process began with the preparation of a Notice of Intent, published in the *Federal Register* on November 18, 1992 (57 FR 54374). This notice provided dates, locations, and times of the first scoping meetings. Dates, locations, and times of the remaining public scoping meetings were published in the *Federal Register* on February 8, 1993 (58 FR 7551). Nineteen public scoping meetings in 16 communities were held between November 18, 1992 and April 15, 1993 to solicit public input regarding the scope and content of the PEIS (Figure 1.3).

The UMTRA Ground Water Project PEIS implementation plan summarizes the comments received during scoping and provides DOE's response to how the comments were addressed in the PEIS (DOE, 1994a). A complete list of all comments received is archived in the UMTRA Project Document Control Center.

The NEPA and DOE implementing regulations also require that at least one public hearing be held for the public to comment on the draft PEIS (10 CFR §1021.313). A notice of availability (NOA) of the draft PEIS was published in the *Federal Register* on May 17, 1995 (60 FR 26417). The NOA summarized the proposed action, provided background information on the UMTRA Ground Water Project, described the public comment process, and announced the dates, times, and locations of the public hearings. Nine public hearings were

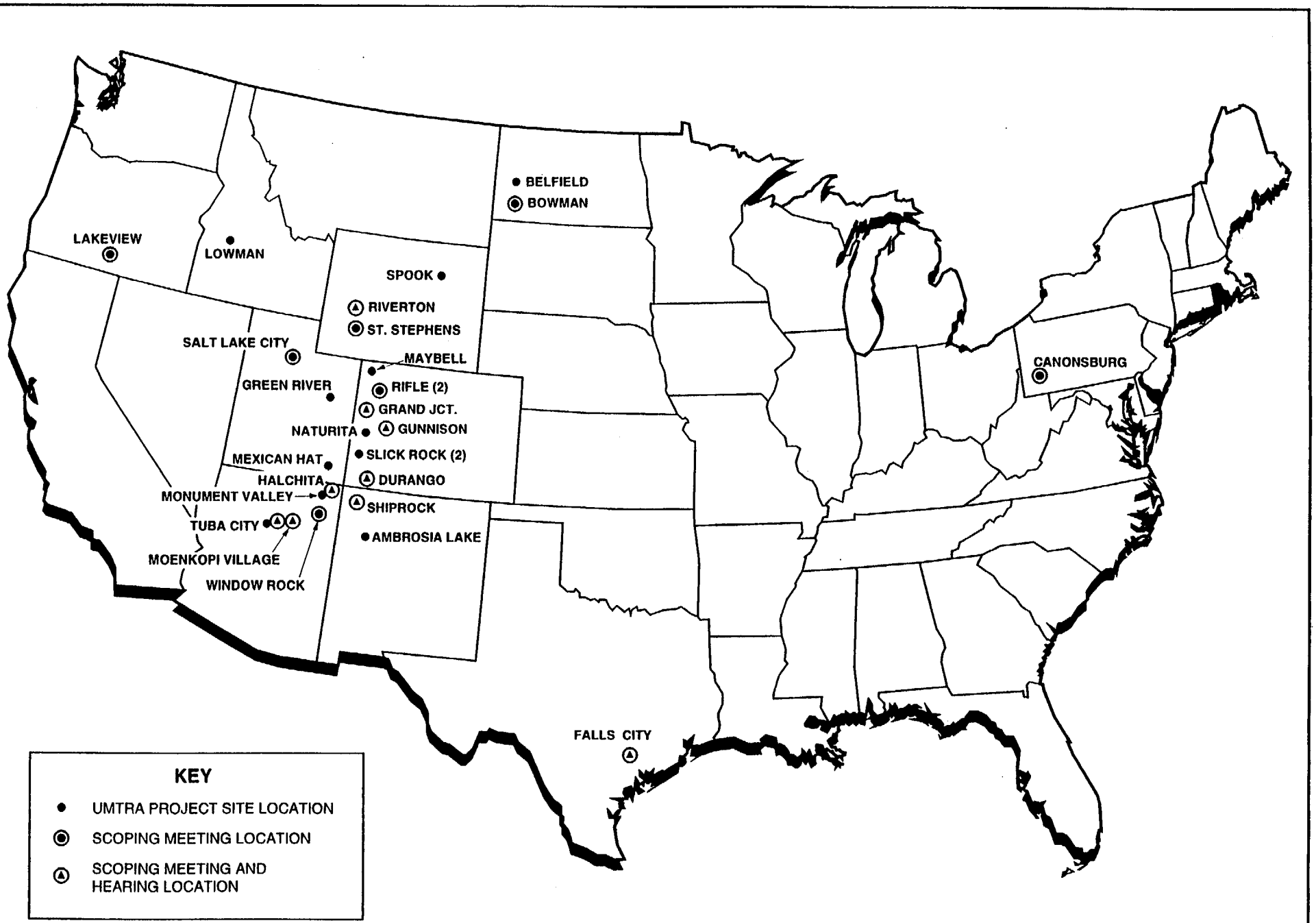


FIGURE 1.3
UMTRA PROJECT SITE AND SCOPING MEETING AND HEARING LOCATIONS

conducted in nearby site communities between June 7 and 28, 1995, to solicit public input on the draft PEIS (Figure 1.3).

The PEIS public affairs program provides continued opportunities for public involvement throughout the UMTRA Ground Water Project. This section provides an overview of the participation process for the PEIS and the planned course of action for future public participation in the Ground Water Project.

1.6.1 Scoping process and results

DOE encouraged members of the public, tribal and state representatives, and other agencies to participate in scoping. Notices announcing the start of scoping were placed in the *Federal Register* and advertisements were placed in local newspapers and on local radio stations. Orientation meetings were held at some sites to explain the scoping process to the public. Congressional representatives and state and local agencies were contacted during prescoping community assessments to determine the scoping activities that would work best in individual communities. Media briefings were held and media briefing kits were available prior to scoping meetings to announce the opportunities for public participation. UMTRA Project spokespersons were available before and after scoping meetings for interviews.

Several communication methods facilitated scoping: fact sheets were prepared and distributed that described the PEIS process, the proposed action and alternatives, ground water contamination, ground water remediation technologies, and site-specific conditions. In recognition of non-English speaking community members, DOE offered translation services upon request. At meetings held for the Navajo Nation, a Navajo language interpreter was used during the presentation and group discussions. A Navajo language audio tape of the scoping materials was produced and distributed to Navajo Nation radio stations, chapter houses, and libraries. The scoping meetings included viewgraph presentations and small group discussions with technical staff.

More than 500 scoping comments were received. Comments were accepted at the scoping meetings, through the mail, and by telephone via a toll-free number.

DOE reviewed all scoping comments. The comments generally indicated four categories of concern: human health and the environment, programmatic issues, ground water monitoring and site characterization, and site-specific Surface Project comments. The PEIS Implementation Plan (DOE, 1994a) summarizes these comments and describes how they were to be addressed in the draft PEIS.

1.6.2 Public hearings and comment period

A 120-day public comment period and nine public hearings were held after the draft PEIS was published. Information on the availability of the draft PEIS, methods for submitting comments, and the date, time, and place of the public

hearings were announced in the *Federal Register*, in local newspapers, and on radio stations.

Many of the same communication methods that were used in the scoping meetings were used to encourage participation at the public hearings. Both before and after media briefings, UMTRA Project spokespersons were available for interviews and further discussion. Fact sheets were prepared that described the PEIS and the Ground Water Project, and translation services were provided at hearings held at Navajo Nation and Hopi Tribe sites. The public hearings followed an interactive format to facilitate communications between DOE representatives and people who attended the hearings. An independent facilitator conducted the meetings following overview presentations by DOE UMTRA Project site managers and Ground Water Project managers. Oral comments were recorded on flip charts and clarified as necessary to ensure accuracy in recording. Project personnel also responded to comments and discussed issues raised during the meetings.

A total of 576 comments were received at the public hearings, through the mail, and by telephone via a toll-free number. Comment topics included, but were not limited to, the alternatives, ground water compliance strategies, EPA ground water standards, institutional controls, costs, human health and environmental risks, prioritization, ground water characterization, and future public participation. Comments were evaluated and incorporated as applicable into this final PEIS. The comments and response document (Volume II) that accompanies the PEIS provides all written and oral comments received, DOE's responses, and changes made to the document, as appropriate.

1.6.3 Future public participation activities

The final PEIS will be distributed to the public for at least 30 days before the Record of Decision is issued. The Record of Decision will announce the DOE decision regarding how to conduct the Ground Water Project. It also will summarize the mitigation measures that will be taken to avoid or minimize potential human health and environmental impacts (40 CFR §1505.2).

DOE's commitment to encouraging public participation would continue during site-specific ground water compliance activities at many UMTRA Project processing sites. This would include providing information on ground water characterization activities and risk assessments, and seeking input regarding site-specific ground water compliance decisions. DOE will use various methods of communication including announcements through local media to notify the public of opportunities to meet with DOE representatives.

Site-specific NEPA documentation (for example, categorical exclusions and environmental assessments) would be prepared. They would assess preremediation activities, the proposed ground water compliance strategy and alternatives, analyze impacts of implementing compliance actions, and specify any mitigation measures that might be necessary to reduce adverse impacts.

DOE expects that environmental assessments will be appropriate in most cases for final compliance action.

If DOE determined that an environmental assessment is appropriate, DOE would notify the host state and host tribe of the determination to prepare an environmental assessment and would involve the public to the extent practical during its preparation; early public notice of the intent to prepare this document would be provided concurrent with tribal and state notification (10 CFR §1021.301(c); 40 CFR §1501.4(b)).

Before approving any site-specific plans, DOE would make the plans available to the host state and tribe for review and comment, in compliance with NEPA and DOE. Under the Secretary of Energy's NEPA policy statement, DOE ordinarily provides enhanced opportunities for interested persons to review and comment on environmental assessments concurrently with tribal and state review.

In accordance with DOE policy, the UMTRA Project intends to conduct public meetings on the site-specific plans in the affected site communities. The DOE would solicit input from the public, local organizations, and educational institutions on site-specific issues that should be identified, considered, and analyzed in the effort to meet ground water compliance.

2.0 ALTERNATIVES

This section describes the options (alternatives) for conducting the UMTRA Ground Water Project at the inactive UMTRA Project processing sites and summarizes the comparison of the potential impacts of the alternatives. These impacts are considered in detail in Section 4.0. This section also describes alternatives considered but eliminated from further analysis, site-prioritization methodology, risk assessment methodology, ground water characterization and remediation methods, waste management methods, and costs.

CEQ requires that an environmental impact statement "rigorously explore and objectively evaluate all reasonable alternatives" (40 CFR §1502.14(a)). Reasonable alternatives include those that are practical or feasible from a technical and economic standpoint using common sense, and are not simply desirable from the standpoint of the applicant (51 FR 15618). Reasonable alternatives can be outside the jurisdiction of the lead agency and potentially in conflict with existing federal law. When there are many potential alternatives, a reasonable number of examples covering the full spectrum of alternatives must be analyzed and compared (51 FR 15618).

Numerous alternatives were evaluated during the planning stages of the PEIS. Five alternatives, including the proposed action, were included in the published Notice of Intent to prepare the PEIS (57 FR 54374). These alternatives represented a preliminary list; public comment on these and other alternatives was part of prescoping and scoping meetings (DOE, 1994a). As a result of the scoping process and other planning activities, four alternatives, including the proposed action, were selected for analysis in this PEIS.

All these alternatives, except no action, would rely on at least one of three ground water compliance strategies to meet the EPA ground water compliance standards (Table 2.1). The simplest strategy is one in which no remediation is required, and there are two conditions where this strategy can be used. The first condition where no remediation would work is if the tailings have not contaminated the ground water or if the contamination is limited and does not meet the numerical EPA standards referred to as maximum concentration limits; i.e., the contamination is so low that it is below the level allowed by EPA. Second, if the concentrations of certain constituents exceed the maximum concentration limits or background concentrations, there are two situations in which the EPA has determined that cleanup is not required. One is the use of supplemental standards. One example of Supplemental Standards is where the ground water was of such poor quality prior to the milling operation that removing the tailings-related contamination from the groundwater would not raise the quality of the water such that it would or could be used (referred to as limited-use ground water). The second is the use of alternate concentration limits. An alternate concentration limit is a numerical concentration for a contaminant that is higher than the maximum concentration limit in the EPA standards or background, but for which it can be shown that human health and the environment would not be adversely affected. If alternate concentration limits are used, the DOE must demonstrate that the higher levels of contamination do not pose excessive health and environmental risks.

A potentially more complicated ground water compliance strategy is natural flushing. Once the surface tailings and other contaminated materials are contained in disposal cells, contamination of the groundwater should greatly diminish. At some of the sites, the natural processes of nature will attenuate the contamination over time. If these natural processes can reduce the contamination to acceptable numerical levels such as maximum concentration limits, background levels, or alternate concentration limits within 100 years, and meet the other criteria for the use of natural flushing as discussed in Section 1.4.1, its use is permitted by the EPA standards. Under this strategy the DOE must demonstrate through analysis that the constituents will be reduced by natural flushing within 100 years or less. One element of implementing natural flushing that is permitted by the EPA standards is the use of institutional controls. Institutional controls, if any, will be selected in cooperation with the Indian tribes, states, and local governments. If natural flushing is implemented, a monitoring program will be established. If it is determined that natural flushing does not work as predicted, DOE would then consider implementing the active ground water compliance strategy.

Table 2.1 Ground water compliance strategies that apply under each alternative

Strategy	Alternative			
	Proposed action	No action[a]	Active remediation to background levels	Passive remediation
Active ground water remediation methods	√		√[b]	
Natural flushing [c]	√			√
No ground water remediation				
- Sites that qualify for supplemental standards[d] or alternate concentration limits[e].	√			√
- Sites that meet maximum concentration limits or background levels (no impacts).[f]	√			√

[a]The analysis of the no action alternative is required by the CEQ and DOE.
[b]Active remediation methods would not be used at sites where contamination does not exceed background and likely would not be used at sites that qualify for supplemental standards based on the existence of limited use ground water.
[c]Natural flushing means allowing the natural ground water movement and geochemical processes to decrease contaminant concentrations.
[d]Supplemental standards applicable for certain site conditions, as identified in the EPA standards, that are protective of human health and the environment, and may be applied in lieu of prescriptive levels.
[e]Concentrations of contaminants that may exceed the maximum concentration limits; or, limits for those constituents without maximum concentration limits. If DOE demonstrates, and NRC concurs, that human health and the environment would not be adversely affected, DOE may meet an alternate concentration limit.
[f]"No remediation" at sites that do not exceed maximum concentration limits or background levels is not the same as "no action" because these sites would require activities such as site characterization to show that no remediation is warranted.

Finally, the most complex strategy is active remediation. If there is excessive contamination and if natural processes will not attenuate it as required by the EPA standards, active control or removal of the contamination is necessary. The classic approach is to pump the contaminated water and treat it to remove the contamination, but other, newer, more effective technologies may also be possible.

The process of selecting a site-specific ground water compliance strategy includes several levels of analysis that are not explicitly required by the current regulations, but will help in selecting the best strategy. One of these is to prepare a baseline risk assessment. The baseline risk assessments were prepared using existing ground water quality data collected during the Surface Project and limited additional data. They provide detailed analysis of human and environmental exposures to all of the known contaminants of concern, as well as data gaps, if any. Risks can then be evaluated to determine the appropriate strategy (risk assessments are described in more detail in Section 2.7 and Appendix B). Another key document is the site observational work plan. The site observational work plan addresses the ground water conditions at a site and documents how DOE will demonstrate compliance with the standards. It includes the various techniques that will be used to further characterize a site and is the basis for making the final recommendation to the NRC.

The four alternatives analyzed in this PEIS are as follows:

- Proposed action—DOE would use a consistent, risk-based decision process to comply with the EPA standards at the processing sites. The DOE would use active, passive, and/or no remediation ground water compliance strategies to meet the EPA ground water standards at the UMTRA Project sites. The site-specific ground water compliance strategies would be based on site conditions, potential risks, and input from the affected tribes, states, and public.

- No action—DOE would not conduct the UMTRA Ground Water Project. Contaminated ground water would remain as is, and no further action would be made to protect human health and the environment.

- Active remediation to background levels—DOE would use a combination of active remediation strategies at most sites to clean up ground water quality to as close to background levels as possible and meet the EPA ground water standards.

- Passive remediation—DOE would use natural flushing or no remediation strategies, including application of alternate concentration limits and supplemental standards, to meet the EPA ground water standards.

These four alternatives are discussed in detail in Sections 2.1 through 2.4. The EPA ground water standards are described in Section 1.4.1. The potential programmatic impacts of implementing the proposed action and alternatives are provided in Section 4.0.

This PEIS differs substantially from a site-specific environmental impact statement because multiple ground water compliance strategies, each with its own set of potential impacts, could be used to implement all the alternatives except the no action alternative. In a

traditional environmental impact statement, the identification of alternatives leads directly to an impacts analysis. On the other hand, an impacts analysis for implementing alternatives in this PEIS involves an intermediate step of evaluating a ground water compliance strategy or strategies, the use of which would result in site-specific impacts. This PEIS impacts analysis assesses the potential impacts of the various ground water compliance strategies, then relates them to the alternatives to compare impacts.

2.1 PROPOSED ACTION (Preferred Alternative)

The proposed action, which is DOE's preferred alternative, would result in the selection of a ground water compliance strategy tailored for each site to achieve conditions that are protective of human health and the environment. The proposed action would consider the full range of ground water compliance strategies in a step-by-step approach, beginning with consideration of the "no remediation" strategy and proceeding, if necessary, to natural flushing with compliance monitoring and institutional controls, and to a more complex, active ground water cleanup methods, such as pump and treat or other engineered approaches to cleaning up contaminated ground water. For example, under the proposed action, if a site risk assessment and site observational work plan indicate that the strategy of "no remediation" would be in compliance with the EPA standards and be protective of human health and the environment, a more complex strategy involving active cleanup methods would not be necessary.

The proposed action is intended to establish a consistent risk-based framework for implementing the UMTRA Ground Water Project and determining appropriate ground water compliance strategies at the UMTRA Project former processing sites. The determination of site-specific ground water compliance strategies would take into account site-specific ground water conditions; human and environmental risks; participation of the tribes, states, and local communities; and cost. This approach is sufficiently flexible to allow for interim actions, such as an alternate water supply system, should these activities be necessary in order to reduce risk and/or support institutional controls. The proposed action would also allow the consideration of new ground water cleanup methods that become available.

The proposed action uses a logic framework to identify the appropriate ground water compliance strategy or strategies for a site (Figure 2.1). Each step in the decision process considers meeting the EPA standards and the protection of public health and the environment in determining the appropriate ground water compliance strategy.

The first step in the decision process would be to determine if the uranium processing activities at a specific site have resulted in ground water contamination exceeding background levels or maximum concentration limits (Figure 2.1). If ground water contamination has not exceeded these standards and is not expected to, remediation would not be required.

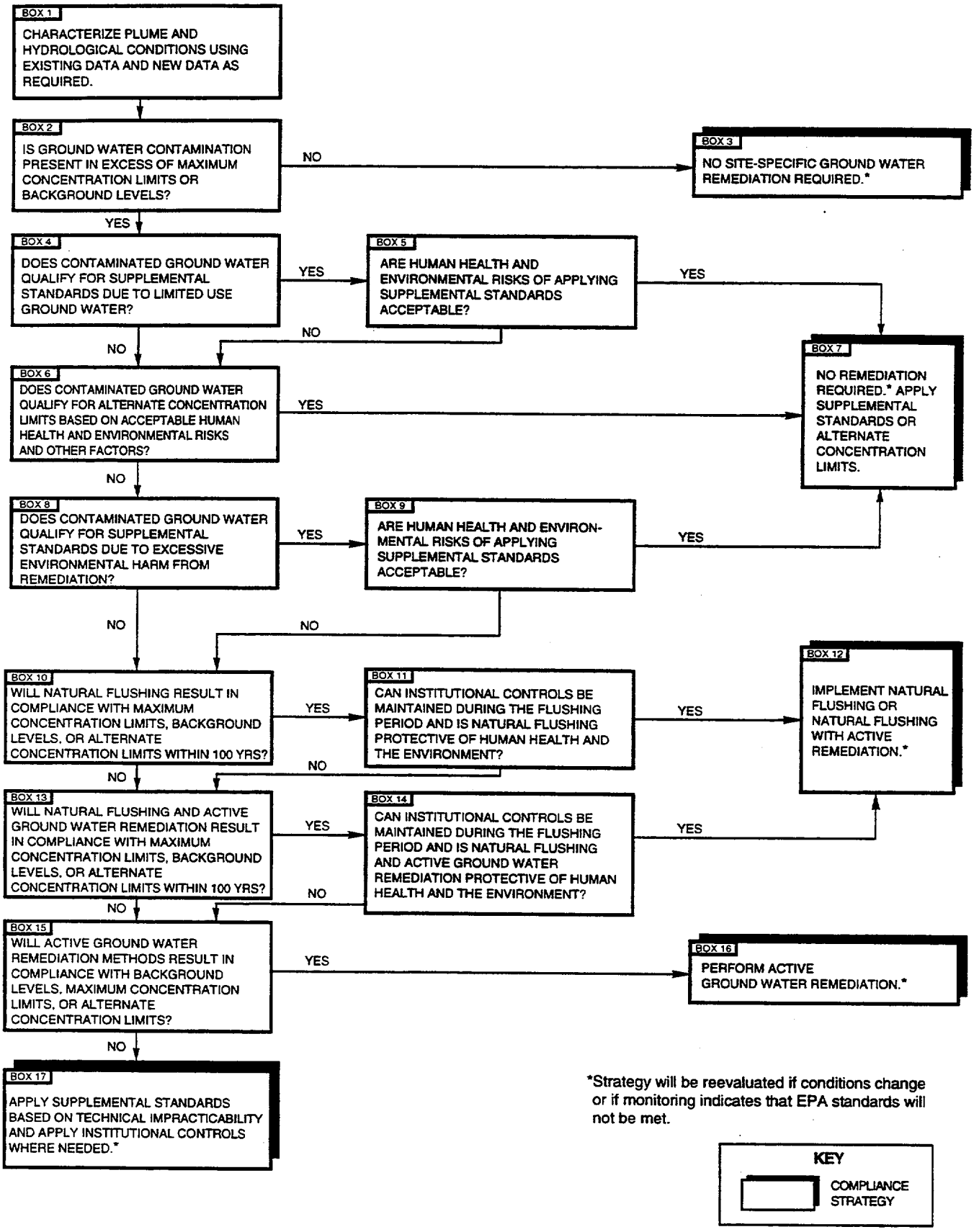


FIGURE 2.1
PROPOSED ACTION

If ground water has been contaminated by uranium processing activities and the contamination exceeds background levels or maximum concentration limits, the next step would be to determine if compliance with the EPA ground water standards could be achieved by applying supplemental standards based on the existence of limited use ground water. (Refer to Section 1.4.1 for a discussion of supplemental standards.) If limited use ground water were shown to exist and if supplemental standards were protective of human health and the environment, no site-specific remediation would be required. If supplemental standards based on limited use were not protective, the next step would be to determine whether alternate concentration limits would apply. (Refer to Section 1.4.1 for a discussion of alternate concentration limits.) If alternate concentration limits were protective of human health and the environment, alternate concentration limits would be applied. If not, it would be necessary to determine whether the contaminated ground water plume would qualify for supplemental standards based on the criterion that remediation would cause more environmental harm than benefit. At some sites where supplemental standards or alternate concentration limits may be applied, ground water monitoring and institutional controls may be required to ensure that the application of alternate concentration limits or supplemental standards would continue to be protective of human health and the environment. In addition, when limited use ground water applies, supplemental standards "shall ensure that current and reasonably projected uses of the affected ground water are preserved" (60 FR 2854). The use of supplemental standards would be determined on a site-by-site basis and the DOE would abide by the EPA ground water standards when proposing the use of supplemental standards. All proposed supplemental standards would require NRC concurrence.

If supplemental standards would not be protective, the next step would be to determine whether natural flushing would bring the contaminated ground water into compliance (i.e., within maximum concentration limits, background levels, or alternate concentration limits) within 100 years. Natural flushing is a ground water remediation strategy by which natural ground water processes result in compliance with the EPA ground water standards. (Refer to Section 1.4.1 for a discussion of EPA standards related to natural flushing.) Natural flushing could be used if it were determined that institutional controls could be implemented, maintained, and enforced during the natural flushing period; that this strategy was protective of human health and the environment; and that all other conditions, as described in Section 1.4.1, are met.

If natural flushing would not be protective, it would be necessary to determine whether natural flushing combined with active remediation methods would meet the EPA ground water standards and would be protective of human health and the environment. If so, this two-part strategy would be implemented. When combined with natural flushing, active remediation methods could be used for a short time to remove the most contaminated ground water that may occur in a restricted area; then natural flushing would be applied. Another option would be

to use low-operation and low-maintenance active methods, such as gradient manipulation or geochemical barriers, in conjunction with natural flushing.

Site characterization data may show that natural flushing combined with active remediation would not result in ground water quality that is protective of human health and the environment. That being the case, the next step in the framework would be to determine if active ground water remediation techniques would meet the EPA ground water standards and if so, to implement these techniques. Several methods of active ground water remediation could be used, including gradient manipulation, ground water extraction, and *in situ* ground water treatment. The active remediation methods could be used individually or in combination with other cleanup methods. Section 2.8 and Appendix C provide details on active ground water remediation methods. If active remediation resulted in compliance with the EPA standards, remedial action would be complete. If these methods did not result in compliance, supplemental standards based on technical impracticability of remediation would be applied, along with institutional controls where necessary.

2.2 NO ACTION

The regulations for preparing an environmental impact statement require that the no action alternative be assessed (40 CFR §1502.14(d)), even if the agency is under a legislative mandate to act (51 FR 15618). The analysis of the no action alternative "provides a benchmark, enabling decision makers to compare the magnitude of environmental effects of the action alternatives" (51 FR 15618).

Under the no action alternative, no further activities would be conducted to comply with the EPA ground water standards (40 CFR §192) at the inactive UMTRA Project processing sites. The UMTRA Surface Project would be completed but the Ground Water Project would be terminated and the contaminated ground water would be left as it is. DOE would not collect ground water data to continue characterization of ground water, no monitoring of contaminated ground water would take place, and no institutional controls would be used.

The no action alternative would comply with the EPA ground water standards only at the site where there is no ground water contamination (the Lowman, Idaho, site).

2.3 ACTIVE REMEDIATION TO BACKGROUND LEVELS

Under this alternative, the DOE would attempt to clean up ground water to background levels at the UMTRA Project processing sites, using active ground water remediation methods. This attempt would be limited by the technology available. Therefore, it may not be possible to restore some contaminated ground water to background levels. In these cases, the DOE would attempt to reduce contamination to levels as closely as possible to background levels. The

rationale behind this alternative is that ground water at most of the uranium processing sites was of better quality before the processing activities occurred and that the ground water should be restored to its preprocessing quality. At most UMTRA Project processing sites, implementation of this alternative would require the use of active ground water remediation methods such as gradient manipulation, ground water extraction and treatment, or *in situ* ground water treatment (active ground water remediation methods are summarized in Section 2.8). Active remediation methods would be used at the UMTRA Project processing sites regardless of the health and environmental effects and regardless of cost and time. Because active remediation methods would be required at most UMTRA Project processing sites, this alternative would likely reduce the potential risks associated with the ground water contamination and would be protective of human health and the environment.

If this alternative were implemented, DOE would meet the EPA ground water standards at the UMTRA Project sites. Active ground water remediation methods would not be used at sites where the ground water quality beneath the site is currently at background levels and likely would not be used at sites that qualify for supplemental standards based on the existence of limited use ground water.

Under the active remediation to background levels alternative, alternate water systems or interim actions could be used should they be necessary to reduce risk and/or to support an institutional control.

2.4 PASSIVE REMEDIATION

The implementation of this alternative would result in the use of only passive remediation strategies to meet the EPA ground water standards. The passive remediation strategies are 1) performing no remediation at sites that meet supplemental standards or alternate concentration limits, or are at background levels or below maximum concentration limits; and 2) relying on natural flushing. This alternative uses site characterization and risk assessments to determine the most appropriate passive remediation strategy for each site. However, risk assessment and other data may indicate that passive remediation strategies alone would not be protective of human health and the environment at all processing sites.

This alternative is distinct from the no action alternative because, as indicated in Section 2.2, under the no action alternative, activities would not be conducted to restore contaminated ground water at the UMTRA Project sites. In addition, the Ground Water Project would be terminated and the contaminated ground water would be left as is. Under the passive remediation alternative, site characterization would take place before the determination of the appropriate ground water compliance strategy. Ground water monitoring would take place where needed. In addition, institutional controls would be used, if necessary, to protect human health and the environment.

In general, if this alternative were implemented, DOE would follow the same initial steps as for the proposed action (Figure 2.1). However, the final step for this alternative would be to determine whether natural flushing would result in meeting background levels, maximum concentration limits, or alternate concentration limits. Institutional controls and monitoring generally would be required to restrict access to contaminated ground water (refer to Section 1.4.1 for a discussion of natural flushing and institutional controls). For sites where natural flushing would reduce the concentrations of contaminants to below the standards in less than 100 years and be protective of human health and the environment, the EPA ground water standards would be met.

Under the passive remediation alternative, active remediation would not be conducted at a site, even if compliance with the EPA ground water standards would not be met. At sites that would not meet standards within 100 years, institutional controls and monitoring would be required for more than 100 years. This would result in noncompliance with the EPA ground water standards and may not protect human health and the environment. The passive remediation alternative may not be protective of beneficial uses of the ground water, such as irrigation or livestock watering.

Under the passive remediation alternative, alternate water systems or interim actions could be used should they be necessary to reduce risk and/or to support an institutional control.

2.5 COMPARISON OF ALTERNATIVES

In accordance with CEQ regulations (40 CFR §1502.14), this document compares the four alternatives and summarizes their potential impacts. The comparison of alternatives below summarizes the detailed comparison found in Section 4.4.

The qualitative analysis of potential impacts of the ground water compliance strategies (Section 4.2) and of the no action alternative (Section 4.3) were used to compare the potential impacts of the alternatives (Section 4.4). The assumptions used to compare the alternatives also appear in Section 4.4.

The potential impacts of the alternatives can be divided into short-term and long-term impacts. Short-term impacts are associated with site characterization and the construction of ground water facilities. Long-term impacts are those that could occur if the ground water was not remediated or if ground water remediation took many years.

Short-term potential impacts

The proposed action and the active remediation to background alternative would require site characterization, monitoring, and construction of remediation facilities. The passive remediation alternative would require site characterization and monitoring.

Potential impacts to air quality, noise levels, visual resources, transportation systems, utilities, and energy supplies would occur principally during site characterization and during the construction of ground water remediation facilities for the proposed and the active remediation to background levels alternatives. As indicated in Section 4.4, the alternatives would have little or no impact on these resources due to the short duration and small scale of the ground disturbance activities. Site characterization, construction, and monitoring activities have the potential to disturb sensitive habitats, species, and cultural resources. However, these impacts potentially can be avoided by conducting site characterization and remediation activities in areas away from these resources. In addition, if impacts to these resources occurred, their effects could be mitigated. Therefore, the potential for site characterization and construction activities to adversely affect these resources would be considered relatively minor. Potential short-term impacts to land use could also occur, but would also likely be minor.

Long-term potential impacts

Based on the analysis in Section 4.0, long-term adverse impacts could arise under the following circumstances:

- If the contaminated ground water did not meet EPA standards and was not controlled. This would occur under the no action alternative.

- If the ground water compliance strategy were not protective of human health and the environment. This could occur under the passive remediation alternative.

- If institutional controls were in place for many years. This could occur under all the alternatives except the no action alternative.

Implementing the no action alternative would not comply with the EPA standards at all UMTRA Project processing sites. As a result, significant long-term adverse impacts to human health and the environment could occur under the no action alternative. For example, the public could be exposed to site-related hazardous contaminants by drinking contaminated ground water or surface expression of ground water, ingesting contaminated livestock and/or plants, or ingesting contaminated fish and/or wildlife. Adverse impacts to wildlife could occur if the contaminants entered the food chain and/or affected sensitive resources such as wetlands or threatened and endangered species.

Potentially adverse impacts would be less likely under the proposed action or the active remediation to background alternative because all UMTRA Project sites would comply with the EPA standards. In addition, surface and ground water monitoring would take place before and during implementation of the proposed action and the active remediation to background alternative to ensure that protective measures could be maintained or implemented, if necessary.

Implementation of the passive remediation alternative also could result in the exposure of humans and the environment to site-related hazardous contaminants. The potential occurrence of such impacts is less than from the no action alternative, but such impacts could occur at sites where hydrogeological data and risk assessments have demonstrated that the use of passive ground water remediation strategies would not be protective of human health and the environment. For example, this could occur at sites where institutional controls are not viable or would not effectively restrict access to contaminated ground water or at sites where the potential ecological risk from contaminated surface expression of ground water (now or in the future) cannot be avoided or prevented with passive remediation strategies. These potential long-term impacts would have a low probability of occurring under the proposed action or the active remediation to background levels alternatives.

Institutional controls can be used in conjunction with natural flushing for up to 100 years. These controls may need to be used even longer with the passive remediation alternative because contaminant plumes may still exist after 100 years of natural flushing. The use of institutional controls could result in long-term land use and socioeconomic impacts, as discussed in Sections 4.4.6 and 4.4.11. The passive remediation alternative could have the greatest impact in this area, followed by the proposed action, then the active remediation to background alternative.

In summary, the proposed action and the active remediation to background alternatives are most effective at protecting human health and the environment because under these alternatives all of the UMTRA Project sites would comply with the EPA standards. Implementing the proposed action would potentially result in fewer short-term impacts associated with construction than implementing the active remediation alternative. The proposed action would potentially be more cost-effective because it would use passive remediation strategies such as natural flushing or no remediation at sites where these strategies are shown to be protective of human health and the environment and meet the EPA standards. The active remediation alternative would be the most costly because of its widespread use of active ground water compliance methods. Under this alternative, active methods would be used at sites where active remediation is justified under the proposed action based on site-specific risk assessments. In addition, active remediation would also be used at many sites where no additional risk reduction would occur as a result of active remediation.

2.6 ALTERNATIVES ELIMINATED FROM DETAILED ANALYSIS

The CEQ regulations require that an environmental impact statement 1) evaluate all reasonable alternatives, 2) briefly discuss those alternatives eliminated from detailed impact analysis in the environmental impact analysis, and 3) provide the reasons for their elimination (40 CFR §1502.14(a)).

Reasonableness is defined as practical or feasible from a common sense, technical, and economic standpoint (51 FR 15618). Four alternatives were considered early in the PEIS planning stages but were eliminated from further evaluation. A fifth alternative, use of tribal and state standards, was considered as a result of comments received on the draft PEIS, but was eliminated from further consideration. All these alternatives and the reasons for their elimination are provided in the following subsections.

2.6.1 Delay the UMTRA Ground Water Project

Delaying the Ground Water Project until the Surface Project is completed was not considered a viable alternative because surface remediation is complete at 18 sites and resources have become available to address ground water compliance. To further delay ground water remediation at some of the processing sites may not be protective of human health and the environment.

2.6.2 Use existing data to make Ground Water Project decisions

Under this alternative, no new site characterization or risk assessment data would have been collected at any of the sites. The UMTRA Ground Water Project would have proceeded using only existing data. Existing site characterization data include geologic, hydrogeologic, geochemical, geotechnical, and radiological conditions at the processing sites. These data were collected for the purposes of designing and implementing surface remediation. This information may not have fully characterized ground water conditions, leading to the possibility of making incorrect decisions regarding site-specific ground water compliance; therefore, this alternative was not considered further.

2.6.3 Provide clean water at the point of use

This alternative would have required the DOE to provide an alternate water source at the point of any use in situations where ground water used by humans has become or soon would become contaminated. Clean water sources could have been bottled water, connection to a municipal water supply, or new wells tapping uncontaminated ground water resources. Under this alternative, the DOE would not have complied with EPA standards.

This alternative was considered because it meets the immediate purpose and need of protecting human health and agricultural applications. It was eliminated from detailed study for the following reasons:

- A basic assumption in regard to this alternative is that the DOE would provide an alternate water source at the point of human use (e.g., domestic water sources, livestock watering, and/or crop irrigation) but would do nothing to protect the biological communities from the contaminated ground water. Therefore, use of this alternative would not be protective of the environment since contaminated ground water could discharge into rivers,

streams, wetlands, and other biological systems. Furthermore, these biological systems would not be monitored so the degree of contamination, if any, would not be known. This raises the possibility of contaminants entering the biological foodchain which could include humans.

- The use of this alternative would require ground water monitoring to determine the location of the plume over time and changes in the level of contamination to determine if the plume is nearing points of use not previously protected. In some cases, this monitoring would be needed for a very long period of time because plumes at some of the UMTRA Project sites move slowly.

- This alternative would not meet the EPA standards at all sites. In one sense, this alternative would have to continue until the threat to human health no longer exists. The EPA standards stipulate that ground water contaminants must meet the standards within 100 years. Under this alternative, meeting the standards within 100 years may not occur at all sites.

- Treatment at the point of use is not excluded from the alternatives analyzed in the PEIS (except no action). If the drinking water (or other beneficial uses) is threatened at a given site during the Ground Water Project, DOE may provide an alternate source.

- Treatment at the point of use that includes institutional controls is part of the passive remediation alternative. Sites that require institutional controls for the passive remediation alternative also would require institutional controls under the treatment at the point of use alternative, so as to reduce the likelihood of using contaminated ground water.

2.6.4 Achieve ground water compliance without a programmatic approach

This alternative would have required the UMTRA Ground Water Project to proceed without a programmatic approach. This would have meant that ground water compliance would have been treated as discrete tasks for each site. Compliance with EPA's ground water standards would have been met at all processing sites. All NEPA and technical documents would have been produced independently of one another. Scheduling of site activities would have been based on preliminary risk prioritization data.

This alternative was eliminated from further analysis because it would have had many variables and the determination of potential environmental impacts would not be meaningful. In addition, it is not consistent with CEQ regulations, which consider related activities a single course of action (for example, the UMTRA Ground Water Project) that must be evaluated in a single impact statement (40 CFR §1502.4(a)).

2.6.5 Use tribal and state standards

Even though the UMTRCA requires DOE to meet the EPA standards, this alternative would require the UMTRA Project to use tribal and state standards, where they exist, rather than EPA standards. Because the UMTRA Project sites are in 10 different states and on or near lands of four different tribes, the UMTRA Project could be subject to 14 different sets of standards administered by 14 different agencies. This approach would be unacceptable because:

- The standards for specific constituents likely vary from agency to agency, which could lead to unequal treatment of the sites.
- Some agencies may have standards for specific constituents while others may not have a standard for that specific constituent. This could also lead to unequal treatment of the sites.
- Jurisdictional problems would likely arise under this alternative. For example, an UMTRA site may be on land under the jurisdiction of one agency, but a contaminated ground water plume may cross the border into the jurisdiction of another agency.
- This alternative would likely increase remedial action costs due to the DOE's having to address so many sets of standards.
- Preparing site-specific ground water compliance documents and implementing the site-specific ground water compliance strategies would be difficult, given the large number of varying standards that would have to be addressed.

2.7 SITE PRIORITIZATION AND RISK ASSESSMENT

2.7.1 Site prioritization

Site prioritization ensures that appropriate, relevant, and objective considerations are given to each site during planning stages. The cumulative scores of each site are ranked to determine which sites have the greatest urgency for early actions.

The prioritization system developed for the UMTRA Ground Water Project is based on the modified Environmental Restoration Priority System which used multiattribute utility analysis to prioritize sites. This system is described in detail elsewhere (DOE, 1991a) and is summarized here.

This prioritization approach was shared in draft with all the affected tribes and states. Comments were rigorously encouraged. The DOE conducted meetings on the application of this prioritization methodology with three states and two tribes.

The six criteria below were used to prioritize the sites; for each UMTRA site, each criteria was scored from 1 to 7. A score of 1 indicates conditions defined by the factor are acceptable, while a score of 7 indicates highly unfavorable conditions.

Population health risk

This criterion is based on annual health risks to potentially affected populations (i.e., populations consuming ground water directly or indirectly). It can be extrapolated from individual risks calculated in ground water risk assessments, or can be determined by using EPA Hazard Ranking Scores for the ground water exposure pathway.

On the population health risk scale, a score of 7 is equivalent to the occurrence or likely occurrence of 10 adverse health effects per year. The scale decreases logarithmically to 1, which signifies an annual population risk of one in 10,000,000.

Individual health risk

This criterion is based on increased individual risks over a lifetime from direct or indirect consumption of ground water. These values are calculated from worst-case, point-of-exposure wells. If the water quality in the area is unsuitable for drinking, another pathway (such as crop irrigation or livestock watering) may be calculated.

These risks are based on the EPA's Risk Assessment Guidance for Superfund documents and produce results in the form of a hazard index and carcinogenic risk. These scores are converted to a logarithmic scale of 1 to 7, where 1 signifies an individual lifetime risk of one in 10,000,000, and 7 signifies a risk of one in 10.

Timing

Timing is an important factor in prioritizing ground water restoration sites because it quantitatively incorporates the current or anticipated use of ground water. Sites where affected ground water is in use should have higher priority than sites where alternate water supplies are abundant, accessible, and inexpensive. This criterion makes the risk estimates more meaningful since it ties them to actual site factors (such as probability of ground water use).

Additionally, hydrologic factors such as aquifer flushing time, contaminant migration rate, or increased plume spread can be incorporated into the timing criterion.

Environmental risk

The baseline environmental risk scores are determined from the product of two factors:

- The sensitivity of the environmental resource at risk
- The magnitude of the threat associated with the contaminated ground water.

The definition for sensitivity of resources was adapted from the EPA's Final Hazard Ranking System (40 CFR Part 300) and includes scenic or wild rivers, unique riparian habitats, wetlands, threatened or endangered species, spawning areas, or any critical habitat. The threat to these resources is based on largely qualitative criteria (including criteria for exceedance of ambient water quality and observed contaminant uptake or toxicity in biota) and threats to the population abundance.

Socioeconomic impact

Socioeconomic impact scores are derived from three components:

- Public concern
- Cultural/traditional impacts
- Community losses/opportunity costs.

The first factor scores public and political interest. This is significant on the UMTRA Project because many stakeholders are very concerned about ground water restoration.

The second factor, cultural impacts, is significant primarily to tribal sites. It recognizes the spiritual values the Hopi Tribe and Navajo Nation associate with their ground water.

The last factor is used to score economic impacts to a community that loses the use of an affected aquifer. This factor relates to the size of the contaminant plume as well as the demand for its use.

Regulatory noncompliance

The primary criterion in this factor was compliance with applicable ground water standards, including tribal or state laws addressing ground water.

After each factor was scored, the scores were weighted as follows: 10 percent for population risk; 30 percent for individual risk; 20 percent for timing factors; 15 percent for environmental impacts; 10 percent for socioeconomic impacts; and 15 percent for regulatory impacts.

Sites were assigned to one of five groups based on this prioritization, allowing for flexibility in planning compliance activities. Category I sites with the highest priority are New Rifle, Old Rifle, and Gunnison, Colorado; Tuba City, Arizona; and Riverton, Wyoming. The Gunnison Category 1 classification does not take into account the implementation of the alternate water supply. Category II sites with the next highest priority are Monument Valley, Arizona; Lakeview, Oregon; Shiprock, New Mexico; and Durango, Colorado. Category III sites are Naturita, Slick Rock, and Grand Junction, Colorado; and Green River and Salt Lake City, Utah. Category IV sites are Bowman and Belfield, North Dakota; Canonsburg, Pennsylvania; Falls City, Texas; and Maybell, Colorado. Category V sites are Ambrosia Lake, New Mexico; Mexican Hat, Utah; Lowman, Idaho; and Spook, Wyoming. The UMTRA Ground Water Project site prioritization system took into account the likelihood that exact scores, and therefore priority, may change as additional data are gathered.

The site prioritization groups would be considered when site-specific decisions are being made. Ground water remediation at the sites would be further prioritized based on additional health or environmental risk information. The following factors would be taken into account when determining the risk at a site:

- Is the contaminated ground water likely to be used soon?
- How much contamination is present?
- How toxic is the contaminated ground water?
- Can access to the ground water be controlled?

Prioritization is one element of the Ground Water Project. It would be applied objectively to the maximum extent possible.

2.7.2 Site-specific risk assessments

The purpose of the UMTRA Ground Water Project baseline risk assessments is to determine whether there is current use of the contaminated ground water and whether ground water contamination at the former processing sites has the potential to adversely affect public health or the environment. The results of the site-specific baseline risk assessments are or would be used to:

- Evaluate potential current and future public health and ecological risks at the sites.

- Determine the need for an alternate water supply, based on the potential for adverse human health effects.

- Identify additional data, if any, needed to characterize risks at UMTRA sites.

- Determine current and potential future land uses at and near the sites.

- Inform the public of current and/or future potential public health and ecological risks.

- Help determine site-specific ground water compliance strategies.

- Determine whether access to ground water should be restricted through the use of institutional controls.

As indicated in Section 2.1 and as shown in Figure 2.1, the proposed action is a health and environmental risk-based approach for implementing the Ground Water Project. The risk assessments and the ground water characterization data would be used to help determine the appropriate ground water compliance strategies that would be implemented at each UMTRA Project site.

The baseline risk assessments have been or will be made available to the public and libraries near the sites. If the risk assessment identified a significant health risk associated with short-term use of ground water near the sites, mechanisms for restricting access to the ground water would be discussed.

Because the baseline risk assessments are being conducted in the early stages of the Ground Water Project, they may be prepared before comprehensive characterization of the contaminant plume is complete at some sites. The baseline risk assessments identify data gaps and recommend additional data collection efforts. After site characterization is completed, risk assessments may be updated, if necessary.

Risk assessments would be used in deciding how to meet the UMTRA ground water protection standards. In developing site-specific ground water compliance strategies under the proposed action, the baseline risk assessments would be used to determine if a given strategy would be protective of human health and the environment. As indicated on Figure 2.1, protection of human health and the environment is considered in the application of all ground water compliance strategies. For example, if supplemental standards based on limited use ground water were considered for a site, the risk assessment would analyze any potential health effects of consuming contaminated ground water, and consider potential adverse effects on other beneficial uses (e.g., agricultural or industrial). The assessment also would address the potential impacts of contaminated ground water on area plant and animal communities. If supplemental standards based on limited use are determined to be protective of human health and the environment and all other requirements can be met, this strategy may be proposed for a site.

Risk assessments also could be used on the Ground Water Project to assess the risks of natural flushing. As indicated in Section 1.4.1, the use of natural flushing is permitted if it would result in meeting background levels, maximum concentration limits, or alternate concentration limits within 100 years; if institutional controls would protect public health and the environment from the contaminated ground water; and if ground water is not currently or projected to

become a source of public drinking water. The risk assessment would be an important tool in determining the protectiveness of proposed alternate concentration limits; determining if the public would be protected from exposure to contaminated ground water; determining the potential for contaminated ground water to adversely affect biological resources; and determining if the contaminated ground water could be used as drinking water or for other beneficial uses.

Appendix B describes the human health and ecological risk assessment methodologies used on the UMTRA Ground Water Project.

2.8 GROUND WATER CHARACTERIZATION AND REMEDIATION METHODS

The nature and extent of ground water contamination must be evaluated before a ground water compliance strategy can be determined. The former processing sites must be characterized to the extent necessary to 1) define the physical, chemical, and biological conditions at the sites; 2) identify the sources and extent of contamination related to processing activities; and 3) obtain additional data which will be used together with historical data in evaluating potential impacts to human health and the environment. A ground water compliance strategy for a particular site would be selected only after adequate hydrogeological and geochemical characterization is completed. Hydrogeological and geochemical characterization activities would reduce uncertainties to the extent practical, to ensure the compliance strategy selected would be protective of human health and the environment.

At UMTRA Project sites, inorganic contaminants are the principal constituents that have been found in underlying aquifers. Hazardous constituents that have exceeded maximum concentration limits in ground water at UMTRA Project sites include arsenic, cadmium, chromium, lead, molybdenum, nitrate, selenium, radium-226 and -228, net gross alpha, and uranium. Additional metals that do not have maximum concentration limits have exceeded background concentrations at some sites. This section summarizes ground water characterization requirements and processes. These characterization methods may be implemented for all alternatives except the no action alternative. More detailed descriptions of ground water characterization methods are presented in Appendix C.

2.8.1 Site hydrogeologic and geochemical characterization

Ground water characterization

Under the proposed action, ground water characterization for the UMTRA Ground Water Project would be consistent with the requirements of Subpart B and Subpart C of the EPA ground water protection standards. In support of the proposed action, three programmatic documents would provide guidance for ground water characterization and compliance and ensure project continuity and consistency: the *Technical Approach to Groundwater Restoration* (DOE, 1993a),

the *Guidance Document for Preparing Water Sampling and Analysis Plans for UMTRA Sites* (DOE, 1993b), and the *UMTRA Project Technical Assistance Contractor Quality Assurance Implementation Plan for Surface and Ground Water* (DOE, 1994b). These documents would also provide guidance for the Ground Water Project if either the active remediation to background or passive remediation alternative became the proposed action. If the no action alternative became the proposed action, these documents would not be used because future work on the Ground Water Project would cease.

The *Technical Approach to Ground Water Restoration* provides technical guidance for implementing the Ground Water Project. This document addresses the regulatory basis and requirements for ground water compliance, ground water characterization and remediation methodologies, and the requirements for meeting NRC concurrence.

The *Guidance Document for Preparing Water Sampling and Analysis Plans for UMTRA Sites* provides a consistent technical approach for water sampling and monitoring activities to be performed under site-specific water sampling and analysis plans. The plans would identify and justify specific sampling locations, ground water constituents for analysis, detection limits, and sampling frequency for the ground water and surface water sampling locations.

The *Quality Assurance Implementation Plan* describes the policy, organization, functional activities, and quality assurance and quality control protocols for environmental characterization. It provides specifications for collecting and analyzing environmental samples and assessing data. It also addresses quality issues associated with data and samples related to geology, hydrology, chemistry, biology, and engineering.

Assuming that one of the PEIS alternatives other than the no action alternative is implemented, the technical guidance in these three programmatic documents would be used to prepare site observational work plans. The site observational work plan would present the initial evaluation of existing information related to each site, a conceptual site model of the hydrogeological and geochemical processes, and additional data needed to adequately characterize the ground water conditions. Further data collection would be of sufficient quality and quantity to support future project planning and the necessary activities associated with the ground water compliance strategy selection and implementation.

The impacts of the proposed ground water compliance strategy would be assessed in site-specific environmental documents. Baseline risk assessments have been prepared for most sites. When relevant and applicable, these assessments would be modified and updated as additional monitoring and site characterization data are obtained. Site-specific remedial action plans would be prepared for sites where an active ground water remediation strategy would be most appropriate, or the Surface Project remedial action plan would be modified.

The observational method would be used during the planning for and collection of site characterization data. The observational method is an approach that would establish a ground water characterization plan and remedial action based on most probable site conditions; identify reasonable variations from those conditions; identify parameters for detecting variations from the most probable conditions during characterization and compliance; and provide plans for addressing potential variations (Peck, 1969). The observational method would be an effective and economical means to manage uncertainties associated with remediating ground water resources.

Examples of currently available data for the UMTRA Project sites include information on hydrogeologic properties, background ground water quality, contaminant sources, hazardous constituents in ground water, and ground water use, value, and alternative supplies. The extent of ground water characterization during the Surface Project depended on the preferred disposal alternative. Processing sites with disposal cells within their boundaries were characterized in greater detail to justify their selection, provide data for disposal cell design, define the extent of surface contamination, and generate a defensible ground water protection strategy for surface remediation that was protective of human health and the environment. The processing sites where surface remediation activities were completed or were in progress before the EPA ground water regulations were issued generally were characterized to a lesser extent.

For processing sites where contaminated materials were or will be removed off the site, characterization efforts consist of defining tailings-related ground water contamination and determining if conditions at the processing site would adversely affect human health and the environment.

Site-specific ground water characterization would require short-term activities on or near the site. To carry out characterization activities, a crew of 10 or fewer people would be on the site temporarily to conduct activities such as drilling monitor wells, constructing access roads, and excavating test pits. Support vehicles and heavy equipment (for example, drilling rigs) may use roads around the site for brief periods. Certain ground water characterization activities would require electrical power. For example, the pumps used for long-term aquifer tests would require a continuous electrical power supply, which could be drawn from a nearby utility line.

2.8.1.1 Hydrogeologic characterization

Hydrogeologic characterization is important in defining the ground water flow system and the extent of contamination related to uranium processing activities at the UMTRA Ground Water Project sites. Hydrogeologic characterization efforts would also be essential in developing and evaluating ground water compliance strategies.

Hydrogeologic characterization would include the following:

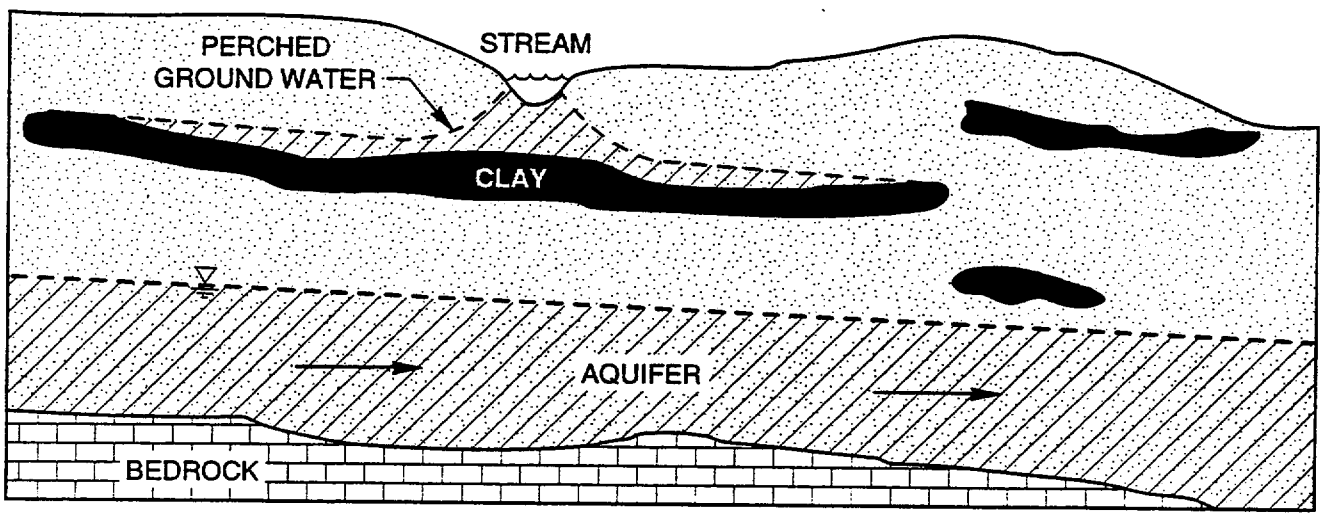
- A description of the hydrogeologic characteristics of the site and surrounding land
- A determination of aquifer hydraulic characteristics
- The quantity of ground water and the direction of ground water flow
- A determination of ground water recharge and discharge areas that may influence human health and the environment. Ground water discharge areas would include surface water bodies and water supply wells.
- The proximity and withdrawal rates of ground water users
- The current and future uses of ground water in the region surrounding the site.

Most hydrogeologic information is obtained from boreholes drilled for the installation of monitor wells. Geophysical methods may also be used to evaluate subsurface hydrogeologic conditions in the vicinity of the UMTRA Project sites. Borehole information and geophysical methods (under the appropriate conditions) can be used to characterize hydrogeologic conditions such as depth to bedrock, presence of sand and clay layers, and fracture zones that may control ground water flow and contaminant migration. Examples of some hydrogeological characterization features are shown in Figure 2.2.

Monitor wells are used for static water level measurements, ground water quality sampling, and aquifer testing (for example, aquifer pumping tests or water displacement tests). Monitor wells would be designed and installed to provide representative ground water quality samples and aquifer test results. Ground water flow patterns and velocities in the vicinity of the sites would be characterized on the basis of ground water elevations obtained from monitor wells and aquifer test data. Hydraulic parameters that describe the way ground water moves through the aquifer (including transmissivity, hydraulic conductivity, and storativity) would be calculated from aquifer test data. Figure 2.3 shows examples of a monitor well and an extraction well.

Ground water models could be used to analyze and predict ground water and contaminant plume movement. Models would be useful in determining points of exposure at land surface, estimating arrival times at specific downgradient locations or points of exposure, and estimating contaminant concentrations at points of compliance or points of exposure. These models would support risk assessments and ground water compliance strategy development.

Ground water models could also be used in remediation activities. For example, models could be used to assess ground water compliance strategies, compare long-term effects of ground water remediation designs, and optimize performance of aquifer remediation systems.



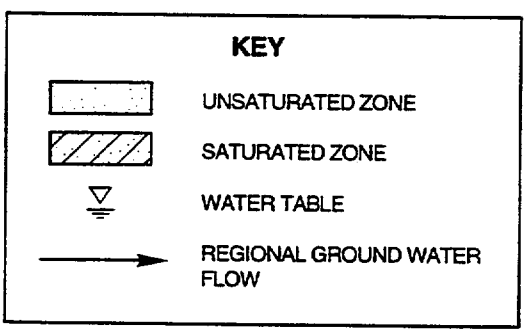
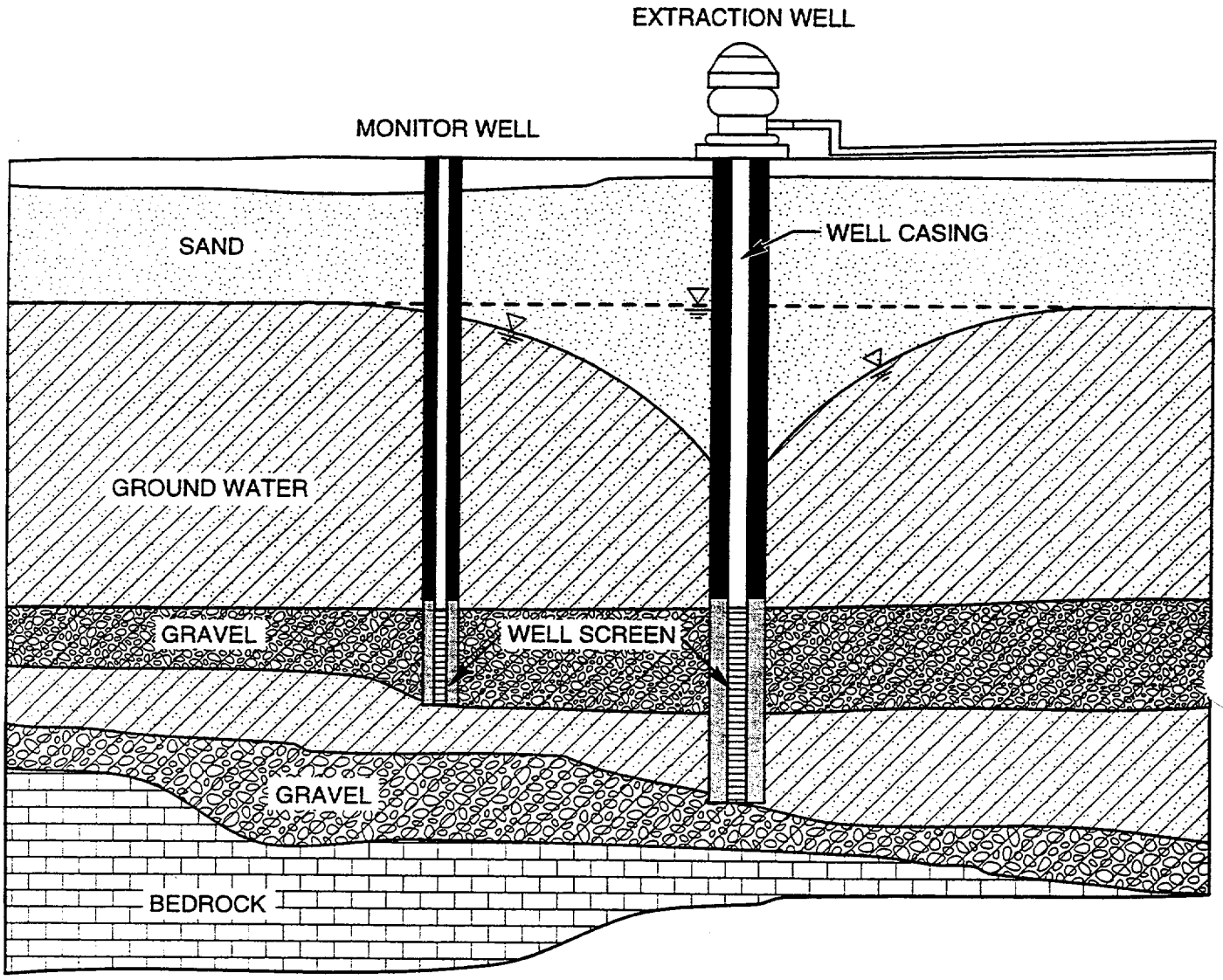


FIGURE 2.2
HYPOTHETICAL CROSS SECTION OF AQUIFER MATRIX, PERCHED GROUND WATER, AND REGIONAL GROUND WATER



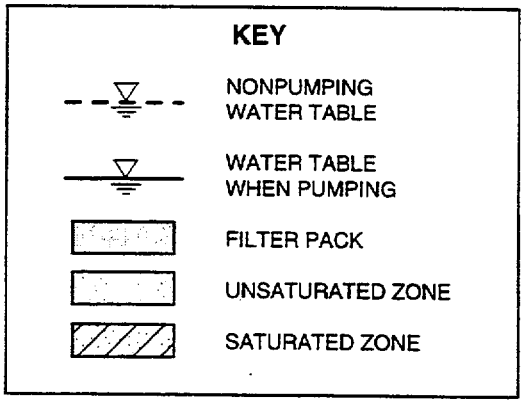


FIGURE 2.3
SCHEMATIC DIAGRAM OF A MONITOR WELL AND AN EXTRACTION WELL

Site-specific environmental impact statements, environmental assessments, and remedial action plans for the Surface Project have previously described existing and potential future water uses in the vicinity of the processing sites. As the UMTRA Ground Water Project progresses, water uses and alternative supplies would be monitored and addressed as needed.

2.8.1.2 Geochemical characterization

Geochemical characterization is important in defining ground water contaminants related to uranium processing activities and in determining contaminant interactions with the aquifer matrix. Geochemical characterization efforts are essential to developing ground water compliance strategies because the geochemical composition of the aquifer matrix affects the quality of ground water and the rate of contaminant migration.

The scope of geochemical characterization would include the following:

- A review of the historical record of chemicals used in the milling operation
- A determination of the source of contamination and its cumulative impact on the ground water quality
- A determination of the contaminated and uncontaminated ground water quality
- A determination of the geochemistry of the sediment or rock that contains the ground water (known as the aquifer matrix material).

Ground water quality

Existing ground water characterization data would be used to determine the need, if any, to collect additional data for ground water characterization and risk assessments. In some cases, additional background and downgradient ground water quality characterization data would be collected to reduce uncertainties in the conceptual risk model.

Background ground water quality is the water quality in an aquifer that would be expected at a site if contamination from the uranium processing had not occurred. Background ground water quality is determined from hydrologically upgradient locations or adjacent areas that have not been affected by uranium processing activities. Some UMTRA Project sites have naturally poor background ground water due to their proximity to uranium ore bodies. An assessment of background ground water quality would provide a comparison for determining the magnitude and extent of ground water contamination caused by processing. At processing sites with surface water in the area, background surface water quality would also be defined upstream. See Appendix B for an expanded discussion regarding the determination of background water quality.

The distribution of hazardous constituents in the unsaturated zone, ground water, and surface water would be defined on the site and downgradient from the processing sites. Figure 2.4 shows an example of a ground water contaminant plume moving downgradient from a processing site. This information would be used to predict contaminant migration for each site, assess risk, and select ground water compliance strategies.

Geochemistry of aquifer matrix material

Through the geochemical processes of dissolution, precipitation, adsorption, desorption, and ion exchange, geochemical interactions between the ground water contamination and the aquifer matrix influence the rate at which chemical elements and compounds migrate through the aquifer (Table 2.2). Therefore, geochemical characterization of the aquifer matrix would allow for more accurate predictions of contaminant migration velocities. Contaminant migration velocity estimates would be critical for selecting natural flushing versus active ground water remediation and for assessing active remediation designs. Therefore, a detailed knowledge of the aquifer matrix chemistry would play an important role in ground water compliance.

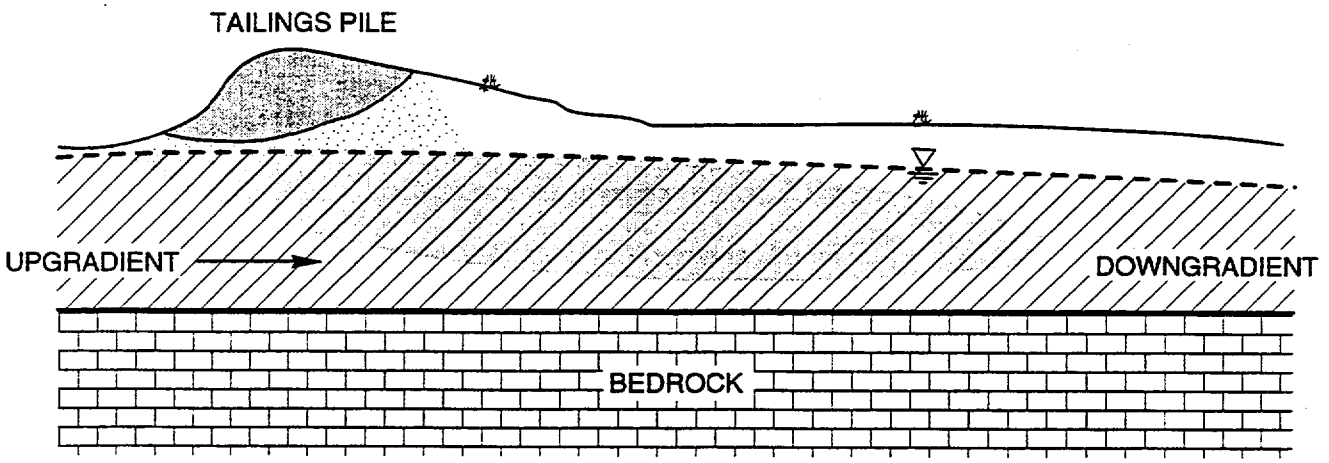
Geochemical characterization methods

Water quality would be assessed by collecting and analyzing water samples from ground water monitor wells, springs, seeps, and surface water bodies. Some basic ground water quality characteristics could be determined in the field. Concentrations of major and minor chemical components in the ground water would be determined in the laboratory. Ground water quality would be evaluated using statistical procedures such as those recommended by EPA (EPA, 1989).

The geochemistry of the aquifer matrix material is characterized to determine mechanisms and the nature of ground water constituent interactions with aquifer matrix material. These data could be used in geochemical models to predict interactions and changes in contaminated ground water as it moves downgradient. Where the ground water compliance strategy depended on the aquifer matrix geochemistry, geochemical modeling could be used in conjunction with ground water flow and contaminant transport models to assess contaminant mobility in the ground water and to predict reactions with minerals in the unsaturated and saturated zones.

2.8.2 Ground water remediation methods

Two ground water compliance strategies are described in this section: natural flushing and active ground water remediation. Natural flushing is passive because it does not involve manipulation of ground water flow, quantity, or quality. Natural flushing means letting the natural ground water processes reduce the contamination in ground water. This process is commonly referred to as natural attenuation and often involves some or all of the geochemical



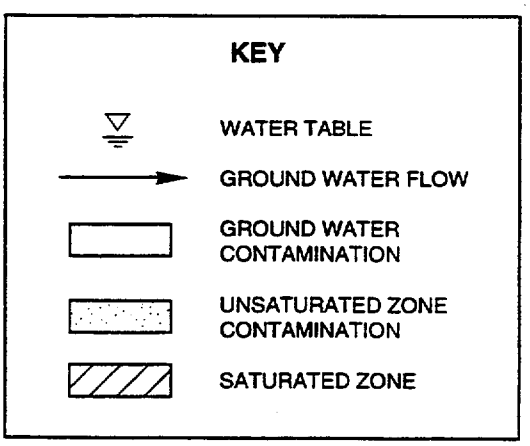


FIGURE 2.4
HYPOTHETICAL CROSS SECTION OF GROUND WATER CONTAMINATION PLUME

MAC: NONSITE/PEIS95/GWCONTPLU

Table 2.2 Geochemical processes that control contaminant migration through an aquifer

Process	Definition
Dissolution	The process of dissolving minerals from the aquifer matrix.
Precipitation	The separation of chemical constituents from ground water to form new minerals on the aquifer matrix.
Adsorption	The adhesion of chemical constituents on minerals within the aquifer matrix.
Desorption	The removal of a chemical constituent from the aquifer matrix by the reverse of adsorption.
Ion exchange	The replacement of adsorbed chemical constituents by constituents in the ground water.
Biological	The process of transforming chemical compounds into different chemical compounds.

processes identified in Table 2.2. To effectively meet EPA standards, natural flushing must reduce contamination to background levels, to maximum concentration limits, or to alternate concentration limits within 100 years. Active remediation methods involve the engineered manipulation of ground water flow, quantity, or quality to achieve ground water quality standards in a specified period of time. Active remediation methods could be used in combination with natural flushing to minimize remediation costs and to expedite remediation.

Natural flushing

Natural flushing allows the natural ground water movement and geochemical processes (Table 2.2) to decrease contaminant concentrations. EPA ground water standards require that natural flushing must reduce contamination to levels within regulatory limits within 100 years. To select natural flushing at a specified UMTRA Project ground water site, investigations described in Section 2.8.1 would take place to demonstrate its potential effectiveness at achieving EPA ground water standards in 100 years (Figure 2.5). Under Subpart B of the EPA ground water standards, natural flushing may be used if compliance with the standards would occur within a period of 100 years or less; if adequate monitoring and institutional controls were established and maintained throughout the flushing period; if institutional controls resulted in conditions that were protective of human health and the environment; and if the ground water

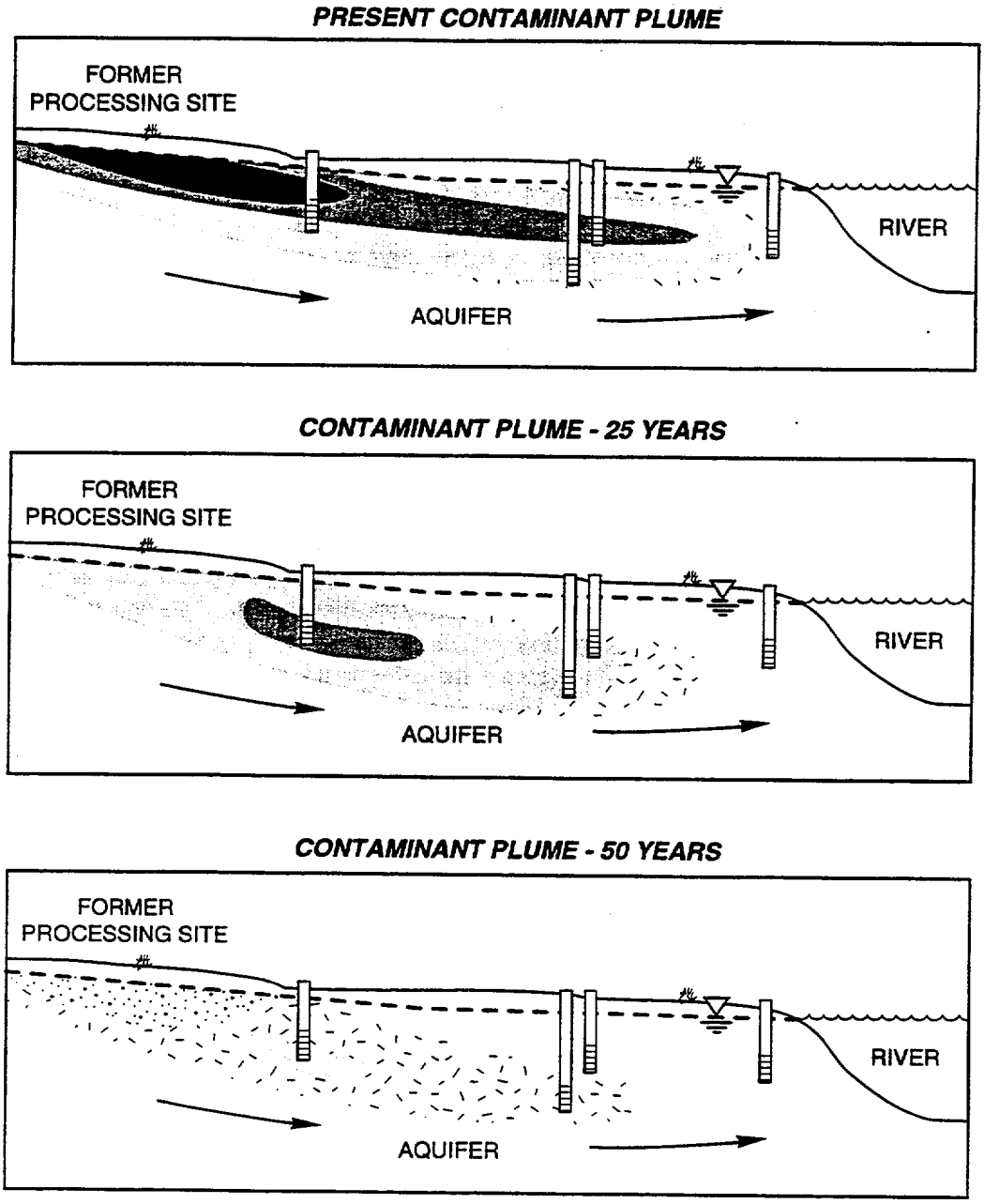


FIGURE 2.5
HYPOTHETICAL CROSS SECTION VIEW OF NATURAL FLUSHING

were not currently nor projected to be a source for a public drinking water system.

Active ground water remediation methods

Active ground water remediation includes several methods that could be used in the Ground Water Project. These methods are described in detail in Appendix C and are summarized below.

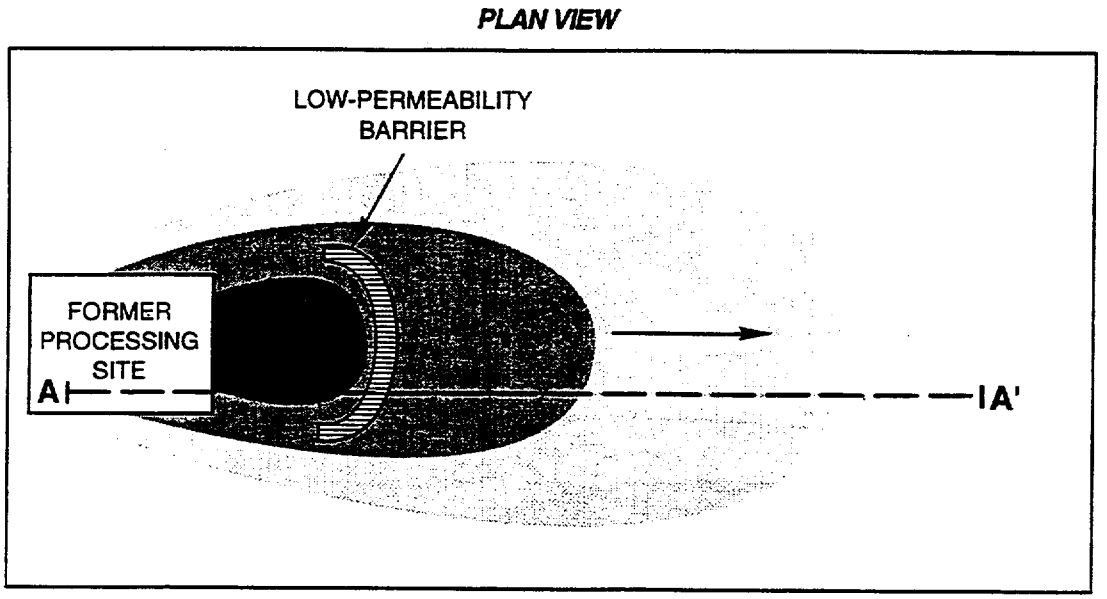
Gradient manipulation—Gradient manipulation uses either wells or trenches to add water to an aquifer to increase ground water velocity in a specific direction. Gradient manipulation could be used to accelerate the process of natural flushing. Conversely, gradient manipulation could be used to temporarily prevent discharge of a contaminant plume into surface water bodies by creating a hydraulic diversion to contaminated ground water flow. Gradient manipulation could be used in conjunction with natural flushing to decrease concentrations over a unit area at a faster rate and to temporarily prevent the migration of contaminants into areas where ground water was not previously contaminated or where institutional controls cannot be effectively applied.

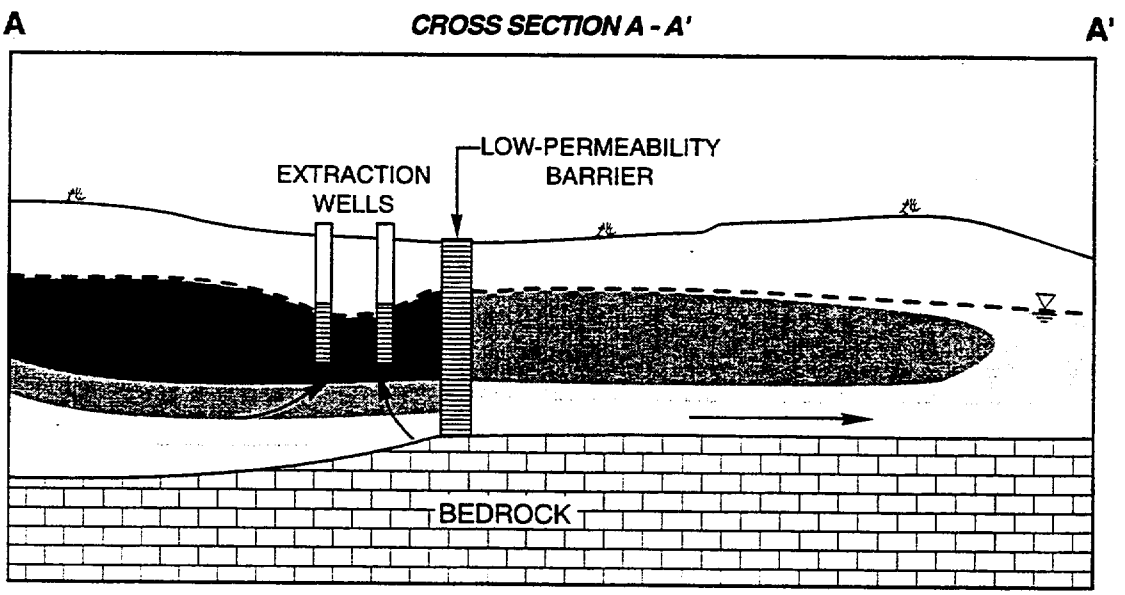
Contaminant isolation—Ground water contamination sources are the tailings and associated highly contaminated water or adsorbed hazardous constituents in the unsaturated zone above the water table. Zones of highly contaminated ground water below a processing site are the result of the contamination source. Ground water contamination sources could be mitigated or eliminated through engineered measures to control or contain their hazardous constituents.

Hydrologic, geochemical, and reactive barriers could be used to keep a contaminant source from entering the ground water. These technologies could prevent hazardous constituents from migrating into the ground water. In areas of highly contaminated ground water under a former tailings pile, a barrier could be used for more efficient ground water extraction (Figure 2.6). Because of the expense involved, these techniques would be limited to small areas of highly contaminated material or ground water.

Ground water extraction—Ground water extraction controls movement of contaminated ground water and removes it from the aquifer. In many cases, it would be necessary to extract ground water only from the most highly contaminated zones (Figure 2.7). Ground water flow information and ground water hydraulic parameters would be used in conjunction with optimization codes to design the extraction network including well numbers, depths, spacing, and pumping or injection rates. With the aid of ground water models, the time required for the remedial actions could be estimated.

Well systems could be used to extract contaminated ground water for treatment or to create hydraulic barriers to ground water flow and increase the efficiency of extraction. These wells would then be pumped at specified rates to control the movement of contaminated ground water. In some cases, it could be





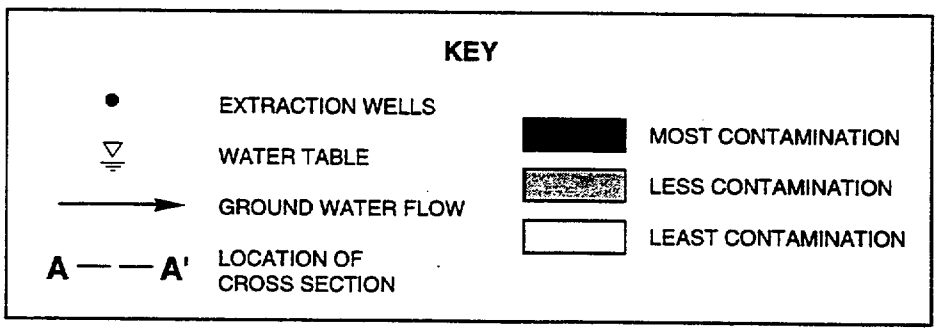


FIGURE 2.6
LOW-PERMEABILITY BARRIER TO ENHANCE GROUND WATER EXTRACTION

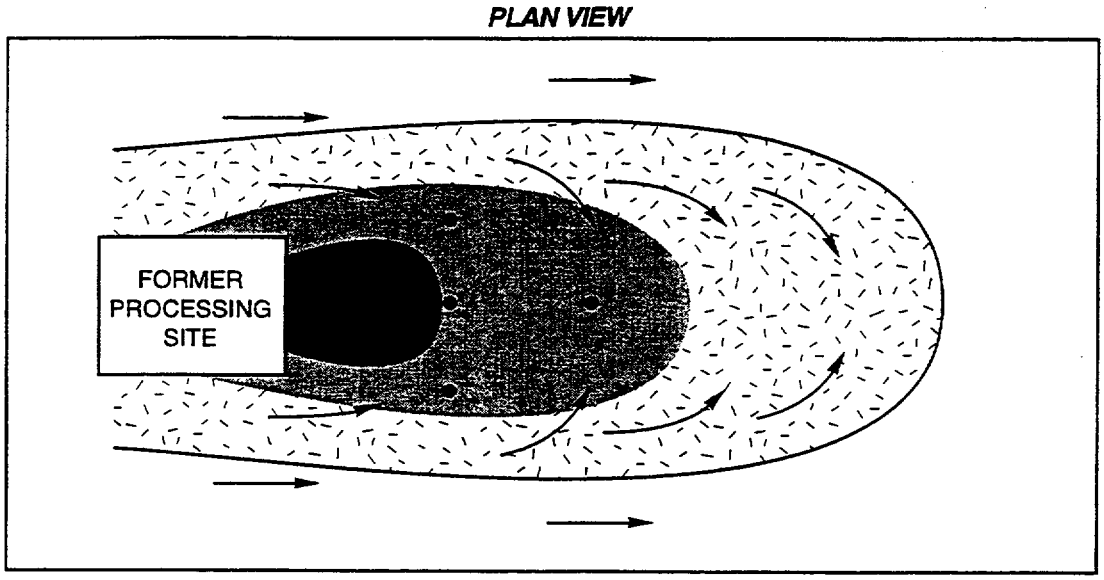


FIGURE 2.7
HYPOTHETICAL VIEW OF GROUND WATER EXTRACTION

necessary to combine periods of well pumping with periods of no pumping. When pumping has stopped, contaminants can diffuse out of less permeable (fine grain) zones or desorb from the aquifer matrix until equilibrium concentrations are reestablished in the ground water. Subsequent pumping would remove the minimum volume of contaminated ground water at the maximum possible concentration.

In shallow ground water systems, a well point network consisting of closely spaced, shallow wells connected to a pipe with a centrally located suction lift pump could be used. These systems can create an effective hydraulic barrier by capturing contaminated ground water. Well point networks would be used mainly for shallow water table aquifers because the maximum drawdown obtainable by suction lift is limited to approximately 25 feet (ft) (8.0 meters [m]) at sea level. Because well points are smaller in diameter and shallower than monitor wells, they are simpler and cheaper to install. This method is temporary (i.e., when the pumping is stopped the barrier ceases to function).

The land application option of ground water disposal would use extracted ground water for agricultural irrigation. Extracted ground water would undergo treatment before use as irrigation water when necessary. This option would be used at processing sites located close to agricultural lands. Processing sites with ground water contaminant plumes containing nitrates would be the most likely candidates for this type of water disposal design.

Contaminated ground water treatment—Once contaminated ground water is extracted from an aquifer, it may be necessary to treat it to protect human health and the environment. The need for treating extracted contaminated ground water before it is discharged depends on the concentrations of contaminants in the extracted ground water and the regulations regarding discharge of effluent to the surface and ground water. Once treated, ground water could be discharged to surface water bodies, recharged back into a shallow aquifer, or used as irrigation water for agricultural purposes.

Contaminants in water and wastewater could be removed by physical, chemical, and biological methods. These methods are discussed in detail in Appendix C.

In situ ground water treatment—*In situ* (in place) treatment uses chemical agents in the affected soil or ground water to degrade, remove, or immobilize the contaminants. It also includes methods for delivering solutions to the subsurface and for controlling the spread of contaminants and chemical agents beyond the treatment zone.

In situ treatment processes are generally divided into three categories: biological, chemical, and physical. *In situ* bioremediation accelerates or enhances the rate of microbial reactions to transform the contaminants into benign or insoluble compounds. At UMTRA Project sites, *in situ* treatment could be used to reduce nitrates through denitrification or to remove metals using sulfate. With chemical *in situ* treatment, specific chemicals are injected

into the soil or ground water to degrade, immobilize, or release contaminants that are in the ground water or attached to the soil particles. Physical *in situ* methods physically change the soil or ground water using heat, electric energy, or other means to immobilize or to expedite the release or movement of contaminants from the soil or water. In most instances, *in situ* treatment would be combined with aboveground treatment to achieve the most cost-effective treatment at the UMTRA Project sites.

In some cases, geochemical barriers may be effective in eliminating or reducing ground water contamination. A subsurface permeable barrier would be placed to intercept the flow of contaminated ground water for shallow ground water systems. As the ground water passes through the barrier, the contaminants interact with the barrier material and are removed from the ground water by precipitation or adsorption.

2.9 WASTE MANAGEMENT METHODS

Various types of wastes may be generated during ground water characterization, monitoring, and remediation. The UMTRA Project would follow the *Technical Approach for the Management of UMTRA Ground Water Investigation-Derived Wastes* to manage field-generated wastes from well drilling, well development, sampling, testing, ground water monitoring, and remediation (DOE, 1994c). This report also provides details on the regulatory requirements for managing and disposing of ground water investigation-derived wastes. The information below summarizes this report (DOE, 1994c). When a ground water compliance strategy is determined and has the potential to form waste material, the management and regulation of this waste would be analyzed on a site by site basis in the site-specific environmental document.

The proposed action, the active remediation to background alternative, and the passive remediation alternative have the potential of generating the following materials that may be contaminated:

- Well development water—Well development water is generated when new wells are drilled for site characterization, installation of a monitoring system, and active remediation field operations. If necessary, well development water would be treated, and either reinjected into the ground water, applied to the land, or transported to an open UMTRA Project cell or other licensed facility for disposal in a manner consistent with UMTRA Project standards and/or DOE orders.

- Drill cuttings and drilling muds—Drill cuttings and drilling muds are the soil and rock brought to surface by the drill when drilling a well. These materials are generated during site characterization, installation of a monitoring system, and drilling during active remediation. Drill cuttings and drilling muds would be analyzed and either applied to the land or transported to an open UMTRA Project cell or other licensed facility for disposal in a manner consistent with UMTRA Project standards and/or DOE orders.

- Purge water—Purge water is generated prior to ground water sampling. Ground water sampling from wells would occur during site characterization and monitoring. Purge water would be analyzed and either be evaporated, applied to the land, or discharged in a manner consistent with UMTRA Project standards and/or DOE orders.

- Sludge and brine—Sludge and brine result from the treatment of contaminated ground water. Sludge and brine could be generated during site characterization or active remediation field operations. Sludge and brine would be analyzed and disposed of at an open UMTRA Project cell or at an alternate disposal site in a manner consistent with UMTRA Project standards and/or DOE orders.

- Ground water and soils—Contaminated ground water and soils may be generated during active remediation field operations. If necessary, contaminated ground water would be analyzed and treated. Ground water would then either be reinjected into the ground water, applied to the land, or discharged to a surface water body in a manner consistent with UMTRA Project standards and/or DOE orders. Soils would either be applied to the land or transported to an open UMTRA Project cell for disposal in a manner consistent with UMTRA Project standards and/or DOE orders.

Prior to disposal in an UMTRA Project disposal cell, wastes would be evaluated to ensure they would not compromise the cell design. If the quantity of liquid wastes exceeds the design parameters of a disposal cell, the liquid waste quantity would be reduced. Waste that could not be accommodated in an UMTRA Project disposal cell would be disposed of at a licensed disposal facility.

All these materials would have the potential of being contaminated with constituents typical of uranium mill processing and being considered residual radioactive materials. These materials would be managed in accordance with the requirements of the UMTRCA, the DOE, EPA, and the appropriate Indian tribes and states. Current data from most sites do not suggest contaminated materials from sources other than uranium processing activities would be encountered, although at some sites naturally occurring ore bodies may be encountered. However, all contaminants from non-UMTRA sources, if encountered, would be managed in accordance with the appropriate requirements.

2.10 COST ESTIMATE METHODS

Since a budget must be developed to obtain yearly federal appropriations, assumptions concerning site-specific compliance strategies must be made in advance to derive a cost estimate that will support budget submittals. These assumptions are for budgetary reasons only and in no way indicate that site-specific ground water compliance strategy decisions have been made prior to completion of the PEIS or a site-specific environmental document.

In estimating costs for each of the three ground water compliance strategies (no remediation, natural flushing, and active remediation), certain generic activities are assumed to support all three. However, the duration, complexity, and cost range of these generic activities vary with the type of compliance strategy selected. These activities include 1) preparing baseline risk assessments, site observational work plans (considered part of detailed site characterization), environmental assessments, and remedial action plans or modifications; 2) conducting a limited monitoring program until implementation of a compliance strategy or closeout activity; 3) performing some type of closeout activity, such as a certification report, a modification to the long-term surveillance plan, and/or licensing; and 4) performing program support activities. The cost estimates include escalation and contingency.

Activities for the no remediation compliance strategy would include those listed above plus, in certain cases, additional site characterization, wells, and revisions to the site observational work plans. Activities for the natural flushing compliance strategy would include longer durations of the same activities plus various phases of monitoring (calibration monitoring and verification monitoring) and a longer period to close out the site following verification monitoring and prior to turning the site over to another DOE project for compliance monitoring. Natural flushing also would include institutional controls. In addition to the above, active compliance strategy sites require detailed construction estimates. In developing these estimates, the Project used a software package called the "G-2 Estimator" in conjunction with environmental construction databases based on UMTRA Surface Project experience. All major cost elements were priced separately using historical data and supplier quotes. Cost elements included utility installation, numbers of wells required, collection systems, installation of water treatment plants, plant operations, testing, land application of treated or untreated water, closure, demobilization, and site restoration. The plant size and length of operations were generated on a site-specific basis using current assumptions on technical parameters of the plume, soil, and contaminants.

Each activity was individually reviewed. Cost estimates were developed based on related historical actuals (approximately 10 years on the UMTRA Surface Project), similar experience on other projects, and/or best professional estimates. The activities were then tailored to each site based on such site-specific attributes as the estimated volume of the plume and contaminants present. A critical path method analysis was then used to develop sequential logic for each compliance strategy, since some activities occur concurrently while others are sequential, and then summarized to develop an overall schedule. The overall Project schedule supported development of non-site-specific Project support activities, processes, or deliverables. The non-site-specific cost estimates were allocated against activities each year and combined to develop a total Project cost.

The last step in developing the cost estimates was to apply contingency to the base estimates to cover uncertainties. Acceptance of the proposed strategies

used for the federal budgeting exercise accounts for the largest share of the Project's identified contingency. Other uncertainties to the UMTRA Project's estimates include 1) delays in state-share funding; 2) perturbations and delays in federal funding; 3) lack of access to existing site wells or the inability to drill new wells due to lack of access; 4) changes in currently understood plume size and contaminant concentrations; and 5) unknowns. The basis of estimates has attempted to cover a portion of the above risks; however, each time a project estimate is made, the DOE reexamines contingency application.

The basis of estimates for costs is reviewed several times during the fiscal year beginning in January. The estimates are continually reviewed for reasonableness, adaptability to the technical and political environment, and sound estimating practices.

3.0 AFFECTED ENVIRONMENT

This section describes the environment that could be affected by implementing any of the alternatives described in Section 2.0. Section 4.0 analyzes the potential impacts of implementing these alternatives. Section 3.1 describes the resources that may be affected during the Ground Water Project; this information was derived from NEPA documents and other reports generated during the Surface Project. Section 3.2 describes the UMTRA Project sites. Site-specific NEPA documents that would tier off this PEIS would provide additional details about the affected environment.

3.1 ENVIRONMENT OVERVIEW

The UMTRA Project processing sites were active for varying lengths of time from the 1940s into the 1970s. These sites, the surrounding areas, and the underlying ground water comprise the affected environment for this PEIS.

Land contaminated with uranium mill tailings and other hazardous constituents ranged from 21 ac (8 ha) at the Spook, Wyoming, site to 612 ac (248 ha) at the Ambrosia Lake, New Mexico, site (Table 3.1). In total, about 3900 ac (1600 ha) of land were contaminated at the sites. The amount of contaminated materials ranged from approximately 85,000 cubic yards (yd^3) (65,000 cubic meters [m^3]) at the North Continent Slick Rock, Colorado, site to 5,764,000 yd^3 (4,407,000 m^3) at the Falls City, Texas, site. The total amount of contaminated material at the sites is approximately 39,000,000 yd^3 (30,000,000 m^3).

The stabilization of the surface contamination at the sites was almost evenly divided between on-site and off-site disposal (Table 3.1). Most sites that had or will have uranium tailings transported off the site are either in urban settings or in river floodplains.

Surface remediation of the sites has been in progress since the mid-1980s. Canonsburg, Pennsylvania, the first site to undergo remediation, was completed in December 1985 (Table 3.1). Surface remediation is completed at 18 sites, and is under way at 4 sites. The Canonsburg, Shiprock, and Salt Lake City disposal cell designs were based on EPA standards that were remanded, in part, in 1983. The EPA has determined, based on information from the DOE, that modifications of these disposal cells are not warranted; the final determination will be made by DOE with the concurrence of the NRC (60 FR 2854).

3.1.1 Resources

This section summarizes the environmental resources at or near the processing sites. In general, "near" refers to a location where the resource has the potential to be affected by site-related contamination or remedial action.

Table 3.1 UMTRA Project surface remedial action status

UMTRA Project Site		On-site disposal	Off-site disposal	Cubic yards of contaminated materials (thousands)	Cubic meters of contaminated materials (thousands)	Acres of contaminated land	Hectares of contaminated land	Estimated amount of contaminated ground water[a] Gallons (millions)	Estimated amount of contaminated ground water[a] Cubic meters (thousands)
Monument Valley, AZ	5/94		✓	942	720	83	34	1200	4,500
Tuba City, AZ	5/90	✓		785	600	327	132	780	3,000
Durango, CO	5/90		✓	2534	1937	127	51	100	380
Grand Junction, CO	8/94		✓	4655	3559	114	46	330	1,300
Gunnison, CO	12/95		✓	719	550	68	28	1900	7,000
Maybell, CO	7/97[b]	✓		3500	2700	214	87	230	870
Naturita, CO	9/97[b]		✓	547	418	247	100	100	380
Old Rifle, CO	10/96		✓	661	505	88	36	70	260
New Rifle, CO	10/96		✓	3474	2656	238	96	600	2,300
UC Slick Rock, CO	12/96[b]		✓	488	373	92	37	26	100
NC Slick Rock, CO	12/96[b]		✓	85	65	47	19	12	50
Lowman, ID	6/92	✓		128	98	30	12	0	0
Ambrosia Lake, NM	6/95	✓		3759	2874	612	248	320[c]	1,200
Shiprock, NM	9/86	✓		1600	1200	130	53	160	610
Belfield, ND	—[d]		✓	58	44	31	13	4.7	18
Bowman, ND	—[d]	✓		128	98	71	29	58	220
Lakeview, OR	10/89		✓	926	708	116	47	1200	4,500
Canonsburg, PA[e]	12/85	✓		226	173	79	32	5.3	20
Falls City, TX	6/94	✓		5764	4407	593	240	1200	4,500
Green River, UT	10/89	✓		382	292	48	19	180	680
Mexican Hat, UT	1/95	✓		2810	2150	250	101	110[c]	420
Salt Lake City, UT	6/89		✓	2710	2070	128	52	350	1,300
Riverton, WY	11/89		✓	1793	1371	140	57	500	1,900
Spook, WY	11/89	✓		315	241	21	8	1000	3,800
Total		11	13	38989	29809	3894	1577	10,436	39,318

[a]From TAC, 1995.
[b]Anticipated completion date.
[c]Areas of saturation of contaminated ground water in geologic formations beneath the site that previously did not contain ground water.
[d]At the request of the state, DOE plans to revoke the designation of these two sites and surface remediation will not take place
[e]Includes Burrell, Pennsylvania, vicinity property disposal cell volume and area.
UC—Union Carbide. NC—North Continent.

3.1.1.1 Human health

The human environment at each UMTRA Project site includes everyone who lives in or near the direction of the contaminated ground water plume. The Surface Project addresses human exposure to the tailings, and the Ground Water Project addresses human exposure to ground water contamination.

3.1.1.2 Climate

All UMTRA Project sites except the Canonsburg, Pennsylvania, site and the associated Burrell vicinity property are in the western United States, generally in arid or semiarid environments. Fifteen sites are in dry climates and receive less than 12 inches (30 centimeters [cm]) of precipitation annually; six sites receive 12 to 20 inches (30 to 50 cm) annually; and three sites receive more than 20 inches (50 cm) annually (Table 3.2).

3.1.1.3 Surface water

Twenty-two sites are near surface water bodies, including major rivers such as the Colorado, Dolores, San Juan, and Yampa Rivers (Table 3.2). Perennial streams and ponds occur near a few sites. Ephemeral and intermittent washes and arroyos occur near many of the sites.

3.1.1.4 Ground water

Ground water contamination in varying degrees has been observed at all but one of the sites. Lowman, Idaho, is the only site where ground water contamination does not exist. Milling at the Mexican Hat, Utah, and the Ambrosia Lake, New Mexico, sites created areas saturated with contaminated ground water in geological formations that previously did not contain ground water; however, contamination of naturally occurring ground water has not been observed. Seepage of contaminated water has affected the naturally occurring underlying aquifers at the remaining 21 sites. Some of the more common hazardous constituents that exceed maximum concentration limits at UMTRA sites include uranium, molybdenum, and selenium. Table 3.3 shows constituents that have exceeded maximum concentration limits at least twice. This summary includes only the constituents for which EPA has established an UMTRA Project maximum concentration limit; other constituents associated with uranium processing exceed background levels at some sites and may be detrimental to human health and the environment. Ground Water Project documents that will address all site-specific constituents of concern include the baseline risk assessments and site observational work plans.

The estimated total amount of contaminated ground water at the UMTRA sites is 10,436,000,000 gal (39,318,000 m^3) (Table 3.1). The volume of contaminated ground water ranges from none at the Lowman site to approximately 1,900,000,000 gal (7,000,000 m^3) at the Gunnison site. At sites with contaminated ground water, the percent of off-site contamination

Table 3.2 Resources at UMTRA Project processing sites

UMTRA Project Site	Site characteristics								
		Setting							
	Tribal lands	Urban	Suburban	Rural	Annual precipitation (inches/cm)	Wetlands	Surface water	Cultural resources	Threatened and endangered species
Monument Valley, AZ	✓			✓	6/15	✓	✓	✓	
Tuba City, AZ	✓			✓	6/15				
Durango, CO			✓		19/48		✓		✓
Grand Junction, CO		✓			8/20	✓	✓		✓
Gunnison, CO			✓		11/28	✓	✓		✓
Maybell, CO				✓	13/33	✓	✓	✓	✓
Naturita, CO				✓	9/23	✓	✓	✓	✓
Old Rifle, CO			✓		11/28	✓	✓		✓
New Rifle, CO			✓		11/28	✓	✓		✓
Slick Rock, CO (Union Carbide)				✓	7/18	✓	✓	✓	✓
Slick Rock, CO (North Continent)				✓	7/18	✓	✓	✓	✓
Lowman, ID				✓	27/69	✓	✓		
Ambrosia Lake, NM				✓	9/23			✓	
Shiprock, NM	✓		✓		6/15	✓	✓		✓
Belfield, ND			✓		16/41	✓	✓	✓	✓
Bowman, ND				✓	16/41	✓	✓	✓	✓
Lakeview, OR			✓		17/43	✓	✓		
Canonsburg, PA		✓			37/94		✓	✓	
Falls City, TX				✓	30/76	✓	✓		✓
Green River, UT				✓	6/15		✓	✓	
Mexican Hat, UT	✓			✓	6/15	✓	✓		
Salt Lake City, UT		✓			15/38	✓	✓		
Riverton, WY	✓[a]			✓	8/20	✓	✓	✓	
Spook, WY				✓	11/28		✓		✓
Total	5	3	7	14		18	22	11	14

[a]Tribal lands adjacent to the site.

Table 3.3 Constituents that have exceeded UMTRA Project maximum concentration limits at least twice in ground water beneath UMTRA Project processing sites (1990-1995)

UMTRA Project Site[b]	Hazardous constituent[a]													
	Off-site migration	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Molybdenum	Net gross alpha	Nitrate	Radium-226/228	Selenium	Silver	Uranium
Monument Valley, AZ	✓								✓	✓	✓			✓
Tuba City, AZ	✓							✓	✓	✓	✓	✓		✓
Durango, CO				✓		✓		✓	✓		✓	✓		✓
Grand Junction, CO	✓							✓	✓					✓
Gunnison, CO	✓								✓		✓			✓
Maybell, CO		✓		✓				✓	✓	✓	✓	✓		✓
Naturita, CO	✓	✓						✓	✓		✓	✓		✓
Old Rifle, CO	✓	✓						✓	✓		✓	✓		✓
New Rifle, CO	✓	✓		✓				✓	✓	✓	✓	✓		✓
Slick Rock, CO (UC)	✓							✓	✓	✓	✓	✓		✓
Slick Rock, CO (NC)	✓								✓		✓			✓
Lowman, ID														
Ambrosia Lake, NM[c]	✓							✓	✓	✓		✓		✓
Shiprock, NM	✓			✓					✓	✓	✓	✓		✓
Lakeview, OR	✓	✓						✓	✓					
Canonsburg, PA									✓					✓
Falls City, TX	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
Green River, UT	✓							✓	✓	✓	✓	✓		✓
Mexican Hat, UT[c]	✓	✓			✓					✓				
Salt Lake City, UT	✓							✓	✓					✓
Riverton, WY	✓							✓	✓		✓			✓
Spook, WY	✓			✓	✓			✓	✓	✓	✓	✓	✓	✓
Total	18	7	0	6	3	2	1	15	20	11	15	12	1	19

[a]Some of the constituents that exceed the maximum concentration limits may be naturally occurring and not from uranium milling activities. For regulatory compliance purposes, the mean exceedance would be used with all alternatives except no action.

[b]The Belfield and Bowman, North Dakota, processing sites are not shown. They will not be remediated by DOE since the state has declined to provide their statutorily required cost-sharing to remediate the sites.

[c]Areas of saturation of contaminated ground water were created in geological formations beneath the site that previously did not contain ground water.

UC - Union Carbide.
NC - North Continent.

ranged from none at the Belfield, Canonsburg, and Slick Rock Union Carbide sites to 98 percent at the Gunnison site.

3.1.1.5 Ecological resources and wetlands

Most UMTRA Project sites are in areas dominated by desert shrub or desert grassland plants. Riparian plant communities along rivers, streams, washes, and arroyos occur at or near most sites. Threatened, endangered, and other species of concern occur at or near 14 sites, including several species of plants, endangered fish, and birds such as the bald eagle and peregrine falcon. Wetlands have been identified at or near 18 sites (Table 3.2). Wetlands at 10 of these sites have been or will be affected by the Surface Project; these impacts have been or will be mitigated.

3.1.1.6 Land use

Land use in and around UMTRA Project sites in urban areas ranges from industrial and commercial to residential and public. In rural settings, land use includes farming and ranching. Some rural lands are managed by the Bureau of Land Management.

3.1.1.7 Cultural/traditional resources

Areas at or near 11 of the UMTRA Project sites contain cultural resources (Table 3.2). These include archaic Native American lithic scatters, Anasazi ruins, and limited property from historical industrial and mining activities. In addition, water resources, including ground water and seeps, have traditional value to Native Americans. Many UMTRA Project sites fall within or near boundaries of tribal lands. Cultural resource investigations conducted primarily for the UMTRA Surface Project have identified cultural resources at two sites associated with tribal lands (Monument Valley, Arizona, and Riverton, Wyoming). Other resources of cultural interest to Native Americans may occur on other sites located on tribal lands (such as Tuba City, Arizona; Shiprock, New Mexico; and Mexican Hat, Utah) or lands associated with historic Indian occupation. More detailed information on cultural resources would be included in site-specific Ground Water Project environmental documents. Additional cultural resource investigations would be conducted, if required, prior to any site-disturbing activities associated with ground water compliance actions.

3.1.1.8 Transportation

Existing transportation networks at and near the processing sites accommodate local uses. All sites are accessible to vehicles. Remote areas that may be affected by the Ground Water Project may not be readily accessible to vehicular traffic.

3.1.1.9 Social and economic resources

Of the designated UMTRA Project sites, three are in cities, seven are at the edge of towns or cities, and 14 are in rural areas or remote settings (Table 3.2); five sites are on tribal lands representing four Native American tribes. Typically, the population characteristics and economies of the more rural, sparsely populated site areas are related primarily to agricultural activities such as ranching, grazing, and dryland farming, or to mining and energy exploration and development. Two sites in forested areas also are involved in forest-related uses such as logging. Suburban or urban sites have more diverse population and economic bases that include light industrial and commercial activities; residential areas also are located near these sites. Site ownership includes private, tribal, and public lands managed by the U.S. Forest Service and the Bureau of Land Management.

3.1.1.10 Environmental justice

Achieving environmental justice is part of DOE's mission. DOE identifies and addresses the disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations. For the UMTRA Ground Water Project, the potential exists for disproportionately high and adverse effects on five sites that are on or partially on tribal lands. The sites on tribal lands are the Tuba City and Monument Valley, Arizona, sites; Shiprock, New Mexico, site; and the Mexican Hat, Utah, site. The contaminated ground water at the Riverton, Wyoming, site has migrated off-site and underlies tribal lands. This PEIS addresses the potential programmatic effects of the ground water compliance strategies and alternatives. Site-specific NEPA documentation would further analyze potential effects.

3.1.2 Policy issues context

The policy issues identified below define the fiscal and regulatory context of the UMTRA Ground Water Project. These issues may affect or be affected by implementing the proposed action or alternatives.

3.1.2.1 Fiscal context

The UMTRA Project participates in the federal budget development process by requesting annual requirements which are included in the annual budget requests from DOE that the President submits to Congress. Because Congress cannot appropriate funds without a fully justifiable estimate, assumptions concerning site-specific compliance strategies must be made so as to derive cost estimates that will support budget submittals. These assumptions are for budgetary purposes only and in no way indicate that site-specific ground water compliance decisions have been made prior to completion of the PEIS or site-specific environmental documents.

With input from UMTRA Project contractors, budget development is managed by the DOE in accordance with DOE orders and guidance. Budget development includes preparing a "bottom-up" budget for the annual field budget submittal, developing and controlling contingencies, and examining and reestimating budget requirements through Project completion. The budget development process ensures that the DOE adequately plans for its fiscal year requirements and conducts and assesses the long-range planning needed to complete the Project. To accomplish these objectives, a total Project (or life-cycle) budget is developed each year with input from all Project participants/contractors. Although congressional appropriations are for only one year, the estimated budget for the entire UMTRA Project must be presented to DOE Headquarters, the Office of Management and Budget, and finally, to Congress to identify future budget requirements. The current Ground Water Project cost projection is $497 million with a completion date of 2014; these estimates are based on the fiscal year 1997 field budget.

At times, the field budget submitted by the UMTRA Project is not fully funded. This can be the result of budget changes as program priorities are balanced at the DOE Headquarters level. Reductions in the requested funds can and often do affect the Project schedule, such as pushing work further into the future. These schedule slips have the potential to increase the overall Project cost due to escalation; schedule slips that extend work beyond the currently identified completion date can add additional Project management costs. Section 2.10 describes the basis for estimates of the ground water compliance strategies analyzed in Section 4.0.

3.1.2.2 Regulatory context

Section 1.4, Regulatory Compliance, describes the EPA, NRC, DOE, Executive Order, and tribal law requirements with which the UMTRA Project must comply.

3.2 SITE DESCRIPTIONS

Numerous documents, including environmental impact statements, environmental assessments, and remedial action plans, have been published or are being prepared that describe the existing site environment and surface remediation construction conditions at the UMTRA Project sites. These documents form the basis for the site descriptions presented in this document. The descriptions focus on factors most relevant to ground water remediation, including existing ground water data, local population and private well information, and other sensitive resources (for example, surface water bodies and wetlands) that may be affected by contaminated ground water. Descriptions of ground water quality were based on the *1992 Annual Environmental Monitoring Report* (DOE, 1993c) for sites where remedial action is under way or complete. Other ground water quality information was obtained from the latest site-specific Surface and Ground Water Project documents.

The discussion of ground water is limited to ground water in the uppermost aquifer, background ground water quality, and water-bearing units and aquifers that have been contaminated by milling activities. At some sites, contaminated ground water has migrated downward into previously unsaturated geologic formations above the natural water table. These formations contain small zones of saturation that resulted from milling activities. At most of the remaining sites, milling-related contaminants have entered only the shallow aquifers beneath the sites. Deeper aquifers are discussed only if they represent the uppermost aquifer or have been contaminated. Background ground water quality at some UMTRA Project sites is naturally poor due to uranium ore bodies and past mining activities, and natural highly mineralized aquifer matrix material.

3.2.1 Monument Valley, Arizona

The Monument Valley UMTRA Project site is in Apache County, Arizona, in an isolated setting along Cane Valley Wash on tribal land. The county per capita income is $5399; the population is predominantly Native American (DOC, 1990). The site is approximately 13 miles (mi) (21 kilometers [km]) east of the scenic Monument Valley tribal park. Comb Ridge, the most prominent topographic feature, is east of the site. The Monument Valley tailings site consisted of two tailings piles, windblown-contaminated soil, and piles of debris. The total amount of contaminated material at the site was 942,000 yd^3 (720,000 m^3) on 83 ac (34 ha). All the contaminated material has been moved to the Mexican Hat, Utah, disposal cell 17 road mi (27 km) to the north, and surface remedial action was completed in May 1994.

The Monument Valley site is in a sparsely populated area. The nearest town is Dennehotso, about 5.0 mi (8.0 km) south, in Apache County; the county population is 61,591 (DOC, 1990). The climate is arid, with an average annual precipitation of 6.0 inches (15 cm) and an average annual snowfall of 3.3 inches (8.4 cm) (DOE, 1993d). Six cultural resource sites have been identified near the site and are eligible for inclusion on the National Register of Historic Places (DOE, 1989a). The region is characterized by a desert shrub habitat with scattered junipers occurring on higher terrain and rocky areas. There are no known threatened or endangered species at or near the site (DOE, 1989a).

Surface water features at the Monument Valley site consist of Cane Valley Wash and several small ephemeral drainages. These drainages flow northeast into Cane Valley Wash (DOE, 1989a). A series of spring-fed wetlands and ponds occur along Cane Valley Wash, northeast of the tailings site area and extending at least 3.0 mi (4.8 km) north. The Frog Pond is the surface water body closest to the site (2000 ft [600 m] to the east); this pond has not been contaminated. Downstream from the site (2.2 mi [3.5 km]), are additional surface water bodies and wetlands that have not been affected by site-related contaminated ground water.

Ground water occurs in the alluvium and dune sand underneath the Monument Valley site and in the underlying bedrock formations. The depth to ground

water in the alluvium is from a few feet in Cane Valley Wash to slightly more than 10 ft (3.0 m) under the site. This ground water is recharged by occasional infiltration from precipitation and upward leakage from the underlying aquifers. The ground water in the alluvium flows north at an estimated velocity range of 90 to 200 ft (27 to 61 m) per year. Below the alluvial aquifer, ground water occurs in the Shinarump Conglomerate and the confined De Chelly Sandstone aquifer. Ground water flows north at an estimated rate of 6.0 to 100 ft (2.0 to 30 m) per year in the Shinarump Conglomerate and 150 ft (46 m) per year in the De Chelly Sandstone.

Background ground water quality in these three aquifers shows no statistical evidence that any hazardous constituent exceeds maximum concentration limits. Contamination in the alluvial ground water beneath the site has exceeded the maximum concentration limits for net gross alpha, nitrate, radium-226 and -228, and uranium twice since 1990. A nitrate plume approximately 3000 ft (900 m) extends north of the site. The estimated amount of contaminated ground water at the Monument Valley site is 1.2 billion gal (4.5 million m^3). Concentrations of nitrate, net gross alpha, and radium-226 and -228 have exceeded the maximum concentration limits in the Shinarump at least twice since 1990. The maximum concentration limits for gross alpha and uranium have been exceeded in the De Chelly at least twice since 1995.

Two domestic wells are completed in the alluvial aquifer just south and upgradient of the site. Other residents near the site use artesian ground water from the De Chelly Sandstone that flows from monitor wells or former production wells. Ground water analyses from all these sources show no sign of contamination (DOE, 1993d).

3.2.2 Tuba City, Arizona

The Tuba City UMTRA Project site is in Coconino County, Arizona, 6.0 air mi (10 km) east of Tuba City (population 7300) (DOC, 1990) on tribal land. The county per capita income is $8683; the population in the vicinity is predominantly Native American (DOC, 1990). The site is on the Kaibito Plateau in the desert shrub vegetation zone. The surrounding terrain is dominated by dissected sandstone formations, mesas, and alluvial terraces. The tailings, windblown and waterborne deposits, demolished mill building, and other contaminated material, which totaled 785,000 yd^3 (600,000 m^3) on 327 ac (132 ha), were stabilized on the site in a 50-ac (20-ha) disposal cell (DOE, 1989b). Surface remediation was completed in May 1990.

The site is arid, with an average annual precipitation of 6 inches (15 cm) and an average annual snowfall of 4.0 inches (10 cm) (DOE, 1986a). There are no known cultural resources or threatened or endangered species at the site (DOE, 1986a). The site is approximately 7000 ft (2100 m) northwest of Moenkopi Wash, an intermittent stream that joins the Little Colorado River to the southwest. No other watercourses exist in the vicinity of the site. A natural spring and seeps appear along the base of an escarpment, approximately

6000 ft (1800 m) east-southeast of the site. The largest of these is used to water livestock. The other seeps have very little flow and are evident most often by the occurrence of riparian plant species and damp areas on the cliff face. Analysis of water and saturated soil samples from one seep south of the site indicates these seeps are not contaminated. The flow in Moenkopi Wash varies from periods of no flow to flows of more than 14,500 cubic feet per second (ft^3/s) (411,000 L per second) (DOE, 1986a). Surface water and sediment sample analysis from Moenkopi Wash indicates this wash is not affected by contaminants from the Tuba City site (DOE, 1986a).

The uppermost aquifer at the Tuba City site is in the Navajo Sandstone. This formation is up to 430 ft (130 m) thick in the site area. The water table ranges from 20 to 150 ft (6.0 to 50 m) deep. Ground water in this aquifer flows southeast toward Moenkopi Wash at an estimated average velocity of 2.0 to 100 ft (0.6 to 30 m) per year. Ground water beneath the site is contaminated, and levels of molybdenum, nitrate, selenium, uranium, and net gross alpha and radium-226 and -228 activity have exceeded the maximum concentration limits at least twice since 1990. The plume of contamination extends approximately 1500 ft (460 m) downgradient from the site. The estimated amount of contaminated ground water at the Tuba City site is 780 million gal (3.0 million m^3). Ground water is not withdrawn from the plume area. Water is taken from springs near Moenkopi Wash and from the wash itself, downgradient of the site. These use areas are all greater than 1.0 mi (1.6 km) from the Tuba City site (DOE, 1989b).

3.2.3 Durango, Colorado

The Durango processing site is in La Plata County, Colorado, just southwest of the city of Durango. The site is on the west side of the Animas River, extending from the floodplain to the base of Smelter Mountain. The site consisted of two areas: the tailings piles in the milling area and the raffinate pond area about 0.5 mi (0.8 km) to the south. Approximately 2,534,000 yd^3 (1,937,000 m^3) of contaminated material were removed from the 127-ac (51-ha) site and associated vicinity properties (DOE, 1985a). The contaminated material was transported to the Bodo Canyon disposal site, approximately 3.5 mi (5.6 km) from the processing site. Surface remedial action was completed at the Durango processing site in May 1990.

The Durango site was revegetated after the completion of remedial action and contains a healthy stand of vegetation. Surface water bodies include the Animas River and Lightner Creek, both of which border the site. Surface water and sediment samples indicate contaminated ground water from the site has not contaminated these water bodies or their sediments. Riparian vegetation along the Animas River consists of cottonwoods and box elders. Threatened or endangered species are known to exist at or near the site (DOE, 1985a). These species include the bald eagle, which winters along the river, and the peregrine falcon, which nests about 1.0 m (1.6 km) from the site.

The Durango area has a semiarid climate, with an average annual precipitation of 19 inches (48 cm). The processing site is near the city of Durango, with an estimated 1990 population of 12,430. La Plata County had an estimated 1990 population of 32,284 (DOC, 1990). The nearest year-round resident is immediately west of the site. The processing site contains no known cultural resources (DOE, 1985a).

The Durango processing site is underlain by approximately 1760 ft (520 m) of Mancos Shale bedrock. The Mancos Shale bedrock is truncated along the Smelter Mountain fault at the south end of the terrace supporting the site. The bedrock is overlain by approximately 5.0 to 20 ft (1 to 6 m) of alluvium and man-made fill. Ground water moves through the alluvium (uppermost aquifer) as a thin (less than 3.0-ft [1.0-m]-thick) layer on top of the almost impermeable shale. The depth to ground water ranges from less than 3.0 ft (1.0 m) along the river to more than 40 ft (12 m) near the mountain. The ground water moves toward Lightner Creek and the Animas River, but the irregular surface of the bedrock makes it impractical to calculate a hydraulic gradient or the rate of ground water movement.

The former raffinate pond area is underlain by alluvium similar to the mill and tailings piles area and overlies relatively permeable sandstone. Ground water moves toward the Animas River through both the alluvium and the bedrock. The rate of ground water movement is estimated to be 800 ft (240 m) per year in the alluvium and 75 ft (22 m) per year in the sandstone. The amount of discharge to the Animas River is probably minimal compared to flow in the river. The minimum seven-day low flow recorded in the Animas River was 100 ft^3/s (3.0 m^3 per second) in December 1917.

Analysis of background water quality of the alluvial aquifer indicates that concentrations of cadmium, chromium, molybdenum, net gross alpha, and selenium have exceeded the maximum concentration limits several times. Seven hazardous constituents have exceeded the EPA maximum concentration limits in the alluvial aquifer beneath both areas of the site at least twice since 1990: cadmium, lead, molybdenum, net gross alpha, radium-226 and -228, selenium, and uranium. The estimated amount of contaminated ground water at the Durango site is 100 million gal (0.38 million m^3).

Water beneath the former processing site is not used for human consumption, and there is no evidence of elevated hazardous constituents in the Animas River as a result of alluvial aquifer discharge into the river. The city of Durango and properties near the site are served by a municipal water supply system. Water for this system is withdrawn from the Animas River upstream of the Durango UMTRA Project site. In addition, the water intake for a planned irrigation project will be in the river in the southern portion of the Durango site.

3.2.4 Grand Junction, Colorado

The Grand Junction site is on state-owned land in the city of Grand Junction, in Mesa County, Colorado, along the north side of the Colorado River. Approximately 4,655,000 yd^3 (3,559,000 m^3) of contaminated material were on 114 ac (46 ha) at the processing site (Sanders, 1993). During surface remedial action, all the contaminated material was moved to the Cheney disposal cell, 18 mi (29 km) southeast of the Grand Junction site (DOE, 1986b). The transportation of this material began in 1991; remedial action was completed in August 1994.

The population of Grand Junction is 29,034 (DOC, 1990). There are no cultural or historic resources at the Grand Junction site (DOE, 1986b). The site was constructed in the floodplain of the Colorado River, and a series of small islands and river side channels occurs between the site and the river. This area supports a dense growth of riparian vegetation and a diverse wildlife species. Other than 8.0 ac (3.0 ha) that were cleaned up during surface remediation, there is little or no site-related contamination in the area (based on analysis of surface water and sediment samples).

The Grand Junction site is arid, with an average annual precipitation of 8.0 inches (20 cm). Snowfall averages 27 inches (69 cm) annually (DOE, 1986b). Threatened or endangered species have been identified near the site (DOE, 1986b). These include the bald eagle, which winters along the river, and the Colorado squawfish, which may occur in the side channels of the Colorado River next to the site.

The Grand Junction processing site is underlain by Colorado River alluvium (uppermost aquifer) that ranges in saturated thickness from less than 10 ft (3.0 m) to more than 20 ft (6.0 m). Alluvial ground water levels beneath the site vary from 2.0 to 5.0 ft (1.0 to 2.0 m) annually, with the lowest levels occurring during the fall and winter. Ground water in the alluvial aquifer flows west and southwest, depending on the stage of the Colorado River, and eventually discharges to the river. The estimated ground water velocity is 73 to 1800 ft (22 to 550 m) per year. The uppermost aquifer is underlain by the Mancos Shale, which functions as an aquitard in the area.

At this time, there is some uncertainty regarding background ground water quality at the Grand Junction site. The background water in the alluvial aquifer has high concentrations of salts such as sulfate. Concentrations of molybdenum, selenium, and uranium and activities of net gross alpha exceeded maximum concentration limits in background ground water at least once. Seeping tailings fluids have contaminated ground water in the alluvium beneath the processing site. This contaminated ground water extends west from the site for approximately 2500 ft (760 m). Concentrations of molybdenum and uranium and activities of net gross alpha have exceeded the maximum concentration limits beneath and downgradient from the site at least twice since 1990. The estimated amount of contaminated ground water at the Grand

Junction site is 330 million gal (1.3 million m^3). The Mancos Shale aquitard prevents contaminated ground water from moving any deeper (DOE, 1991b).

3.2.5 Gunnison, Colorado

The Gunnison processing site is on state-owned land and is adjacent to the city of Gunnison in Gunnison County, Colorado. In 1990 the city of Gunnison had an estimated population of 4636, while Gunnison County had an estimated population of 10,273 (DOC, 1990). The site is on a drainage divide between the Gunnison River and Tomichi Creek in the Gunnison River valley. Approximately 719,000 yd^3 (550,000 m^3) of contaminated material were on 68 ac (28 ha). The contaminated material was moved to the Gunnison disposal site approximately 6.0 mi (10 km) from the processing site. Surface remedial action began in May 1992 and was completed in December 1995.

The processing site is on the floodplain alluvium between the Gunnison River and Tomichi Creek. The site is about 0.4 mi (0.6 km) east of the Gunnison River and 0.4 mi (0.6 km) west of Tomichi Creek. It is bounded on the west by small storm drainage ditches and on the south and west by irrigation ditches. Surface water and sediment samples have been collected from the Gunnison River and Tomichi Creek upstream and downstream from the processing site and from shallow ponds near the site. No site-related contaminants have adversely affected the surface water and sediments in surface water bodies near the site.

An analysis of threatened and endangered species indicates the Gunnison River contains no endangered fish species (DOE, 1992a). Endangered species near the site include the whooping crane, which stops and feeds in the floodplain of Tomichi Creek during migration, and the bald eagle, which occurs along the Gunnison River during the winter. The Gunnison milk vetch, a federal candidate plant species, was growing on the tailings pile. There are no known cultural resources at the site (DOE, 1992a). The site is semiarid, receiving an average annual precipitation of 11 inches (28 cm) and an average annual snowfall of 58 inches (147 cm) (DOE, 1992a).

The uppermost aquifer at the site is in the alluvial deposits of the Gunnison River and Tomichi Creek. These floodplain alluvial deposits extend to at least 110 ft (34 m) beneath the processing site. This aquifer is recharged from rain, snowmelt, the Gunnison River, Tomichi Creek, and seasonal recharge from irrigation ditches around the site. Ground water discharges into the Gunnison River and Tomichi Creek. The average depth to ground water beneath the site is 5.0 ft (2.0 m). This ground water flows southwest at an average of 270 ft (80 m) per year.

Background ground water quality in the alluvial aquifer does not exceed EPA ground water standards. Tailings seepage has contaminated the alluvial ground water beneath the processing site; net gross alpha, radium-226 and -228, and uranium have exceeded the maximum concentration limits at least twice since

1990. The uranium plume extends approximately 7000 ft (2000 m) southwest from the site to the Gunnison River. The estimated amount of contaminated ground water at the Gunnison site is 1.9 billion gal (7 million m^3).

Downgradient of the site, 311 private wells are completed in the alluvial aquifer. Twenty-two of these private wells are known to contain elevated levels of uranium from the processing site plume. A permanent alternate water supply system was constructed for the residents who have wells in and adjacent to the contaminant plume. The municipal water supply for the city of Gunnison is unaffected by the contamination because it comes from wells in the alluvial aquifer upgradient of the processing site (DOE, 1991c).

3.2.6 Maybell, Colorado

The Maybell processing site is in Moffat County, Colorado, 25 mi (40 km) west of the city of Craig and 5.0 mi (8.0 km) northeast of the unincorporated village of Maybell. Approximately 3,500,000 yd^3 (2,700,000 m^3) of contaminated material are at the processing site and in the windblown contaminated areas on 214 ac (87 ha). In addition, 1.9 mi (3.0 km) of Johnson Wash and 1.0 mi (1.6 km) of Lay Creek were contaminated by the inadvertent discharge of 200,000 to 400,000 pounds (90,000 to 180,000 kilograms) of tailings and the routine discharge of tailings pond effluent into these streams in the early 1960s. The surface remedial action will stabilize all contaminated material in place, and is expected to be completed in July 1997.

The Maybell processing site is in a remote area of sagebrush and piñon-juniper habitat. The site is partly on Bureau of Land Management land and partly on private land. The principal land uses are grazing and hunting (for mule deer, pronghorn antelope, and sage grouse). Wetlands occur along Johnson Wash and Lay Creek near the site. Johnson Wash is a dry arroyo that runs near the eastern border of the site. This wash joins Lay Creek about 1.0 m (1.6 km) south of the site. This creek is a tributary of the Yampa River and the confluence is about 5.0 mi (8.0 km) southwest of the site. No site-related contaminated ground water has entered or is expected to enter these bodies of water. The population of Moffat County is 11,357 (DOC, 1990). Although one historic site occurs near the site, it is not considered eligible for inclusion on the National Register of Historic Places (DOE, 1995a).

The Maybell site is semiarid. The average annual precipitation is more than 13 inches (33 cm); snowfall averages more than 80 inches (200 cm) annually (DOE, 1995a). Threatened or endangered species that occur near the site along the Yampa River include wintering bald eagles and the Colorado squawfish (DOE, 1995a).

The processing site is underlain by the Browns Park Formation. The uppermost aquifer is in the upper sandstone unit of this formation. Ground water within this formation ranges in depth from 35 to 300 ft (11 to 90 m) beneath the site. Ground water flows southwest at an average velocity of approximately 40 ft

(12 m) per year. Recharge to the uppermost aquifer is principally from infiltration of precipitation and snowmelt. Ground water from this aquifer discharges into the alluvial aquifer of the Yampa River.

Background ground water quality is affected by natural mineralization related to the uranium ore body; selenium and uranium levels exceed the maximum concentration limits. Contaminants from the processing site have entered the aquifer beneath the site but because of advantageous geochemical conditions, the contamination has not passed the site boundary. Contaminants that have exceeded the maximum concentration limits in the tailings pore fluid and the ground water beneath the site at least twice since 1990 are arsenic, cadmium, molybdenum, nitrate, net gross alpha, radium-226 and -228, selenium, and uranium. The estimated amount of contaminated ground water at the Maybell site is 230 million gal (0.87 million m^3).

The domestic well nearest the site is 3.0 mi (5.0 km) to the southwest in the alluvial aquifer of the Yampa River. Contaminants from the processing site likely will not affect this aquifer because favorable geochemical conditions limit downgradient contaminants migration. In addition, the ground water in the uppermost aquifer is unsuitable for drinking due to widespread ambient contamination that is related to naturally occurring uranium mineralization and to mining activities not related to the uranium milling operations.

3.2.7 Naturita, Colorado

The Naturita processing site is in Montrose County, Colorado, approximately 2.0 mi (3.0 km) northwest of the town of Naturita along the San Miguel River. Much of the site is in the floodplain of the river. Between 1977 and 1979, the tailings were moved to a facility 3.0 mi (5.0 km) south of the processing site for reprocessing. There are 547,000 yd^3 (418,000 m^3) of contaminated material on 247 ac (100 ha) at the site. This total includes 194 ac (79 ha) that were contaminated with windblown and waterborne tailings. Tailings washed down the San Miguel River and contaminated approximately 56 ac (23 ha) of the mostly wooded riparian zone along the river. The contaminated material will be moved out of the floodplain to an off-site disposal cell. Surface remedial action began in April 1995 and is scheduled for completion in September 1997.

The Naturita processing site is in a sparsely populated area on the south side of the San Miguel River. The population of the town of Naturita is 430 (DOC, 1990). The San Miguel River is the only surface water body in the site area. Surface water samples have shown that site-related contaminated ground water is not adversely affecting the water in the river. Cottonwoods and willows dominate a riparian wetland zone along the river. Junipers and piñon pines dominate the surrounding hillsides. The San Miguel River contains no endangered fish species. The endangered southwestern willow flycatcher may occur at the site (DOE, 1994d). Wintering bald eagles also occur along the river in the processing site area.

The site is on private land. The nearest residence is approximately 2000 ft (600 m) north-northwest of the site. The Naturita site is arid, with an estimated average annual precipitation of 9.0 inches (23 cm). The average annual snowfall is approximately 30 inches (80 cm). Three prehistoric sites near the site are eligible for inclusion on the National Register of Historic Places (DOE, 1994d).

Ground water beneath the Naturita site occurs in the alluvial deposits of the San Miguel River floodplain. This aquifer is recharged by the river southeast of the site and discharges into the river northwest of the site. The alluvial aquifer flows approximately parallel to the river at an estimated linear velocity of 22 ft (7.0 m) per year. Background ground water quality in the alluvium near the processing site did not exceed the EPA maximum concentration limits. Uranium concentrations indicate a contaminant plume in the alluvial ground water extending approximately 1500 ft (460 m) downgradient from the processing site. Other site-related contaminants that have exceeded maximum concentration limits in this aquifer at least twice since 1990 are arsenic, molybdenum, selenium, radium-226 and -228, and net gross alpha. The estimated amount of contaminated ground water at the Naturita site is 100 million gal (0.38 million m^3).

Ground water in the Salt Wash aquifer, which is below the alluvial aquifer, is not contaminated by the processing site. Contaminated ground water is likely entering the San Miguel River, but surface water and sediment samples indicate this ground water has not affected the river. There are no known uses of the contaminated ground water beneath or downgradient of the processing site.

3.2.8 Rifle, Colorado (two sites)

The Old and New Rifle UMTRA Project sites are near the city of Rifle, Colorado, in Garfield County. The Old Rifle site is 0.3 mi (0.5 km) southeast of the center of Rifle. The New Rifle site is 2.0 mi (3.0 km) southwest of the center of Rifle. Approximately 661,000 yd^3 (505,000 m^3) of contaminated material were on 88 ac (36 ha) at the Old Rifle site, and approximately 3,474,000 yd^3 (2,656,000 m^3) of contaminated material were on 238 ac (96 ha) at the New Rifle site (DOE, 1990). The contaminated materials from both sites are being transported to the Estes Gulch disposal site, approximately 6.0 mi (10 km) north of the Rifle sites. Remedial action began during the spring of 1992 and is scheduled for completion in October 1996.

The Old and New Rifle sites are in the floodplain of the Colorado River. The base of the Old Rifle site is slightly above the Colorado River during average flow and is separated from the river by the tracks of the Denver & Rio Grande Western Railroad. The Colorado River flows 1000 ft (300 m) east and 600 ft (180 m) south of the New Rifle tailings pile. The mill and ore storage areas were located between the tailings pile and the river to the east.

Before surface remedial action, the Old Rifle site contained a small wetland (0.7 ac [0.3 ha]). In addition, 20 ac (8.0 ha) of wetlands occurred at the New Rifle site, including wetlands in the southeast portion of the site and in the contaminated area west of the site. These wetlands were destroyed during surface remediation and a 44-ac (18-ha) mitigation wetland was constructed near the former New Rifle tailings pile. In addition, sediments and fish in a fishing pond downgradient of the Old Rifle site had elevated uranium levels. Several surface water bodies west of the New Rifle site, including a drainage ditch and a gravel pit pond, also have elevated uranium levels. Sampling in the Colorado River indicated no elevated contaminant levels (DOE, 1992b).

The population of the city of Rifle is approximately 4600, the population in Garfield County is 30,000 (DOC, 1990). The region is semiarid, with an annual average precipitation of 11 inches (28 cm) and an average annual snowfall of 41 inches (104 cm) (DOE, 1990). Threatened or endangered species in the site area include the endangered fish in the Colorado River and the bald eagle (DOE, 1990). Cultural resources were not identified at or near the Old and New Rifle sites.

Both Rifle sites are underlain by Colorado River alluvium. Beneath the alluvium, semiconfined ground water occurs in interlayered sandstone, siltstone, and claystone beds in the Wasatch Formation. In general, ground water in the alluvium and in the Wasatch Formation flows southwest. Seasonal water level fluctuations in the river influence flow in the aquifers. During periods of high flow, the river recharges the alluvium. During periods of low river flow, the alluvial aquifer tends to discharge into the river. The alluvium at the Old Rifle site is approximately 20 ft (6.0 m) thick, with depth to ground water generally ranging from 2.0 to 12 ft (1.0 to 4.0 m). At the New Rifle site, the alluvium is 25 to 30 ft (8.0 to 9.0 m) thick, with depth to ground water generally ranging from 5.0 to 10 ft (2.0 to 3.0 m). The average linear ground water velocity in the alluvial aquifer is 800 ft (250 m) per year at the Old Rifle site and 300 ft (90 m) per year at the New Rifle site. The average linear ground water velocity in the Wasatch Formation is 0.3 ft (0.09 m) per year at the Old Rifle site and 3.0 ft (0.9 m) per year at the New Rifle site (DOE, 1992b).

Background ground water in the alluvial aquifer has exceeded the maximum concentration limits for chromium, molybdenum, selenium, uranium, and net gross alpha at various times since sampling began. The maximum concentration limits have been exceeded for molybdenum, selenium, uranium, and net gross alpha in the Wasatch Formation background ground water. In addition, background ground water for the Wasatch Formation exceeds the maximum concentration limits for barium and activities of radium-226 and -228.

Both the alluvial and Wasatch aquifers are contaminated by seepage from the tailings piles at both sites. Contaminants introduced into the ground water from the tailings at the Old Rifle site that have exceeded the maximum concentration limits at least twice since 1990 are arsenic, molybdenum, selenium, and uranium, and activities of net gross alpha and radium-226 and -228. In

addition, levels of fluoride, vanadium, and zinc are elevated above background levels.

Tailings seepage has also contaminated the Wasatch Formation below the Old Rifle site; cadmium and chromium concentrations and activities of net gross alpha and radium-226 and -228 have exceeded the maximum concentration limits at least once since 1990 in monitor wells 623 and 624. Antimony, strontium, vanadium, and zinc are above background levels. The estimated amount of contaminated ground water at the Old Rifle site is 70 million gal (0.26 million m^3). Most of the contaminated ground water at the Old Rifle site discharges into the Colorado River, several hundred feet downriver from the tailings pile (DOE, 1991d).

At the New Rifle site, ground water contamination in the alluvial aquifer extends at least 5000 ft (1500 m) downgradient from the pile. Downgradient contaminant concentrations in the alluvium generally are higher at the New Rifle site than the Old Rifle site. Concentrations of arsenic, cadmium, molybdenum, nitrate, selenium, and uranium, net gross alpha, and radium-226 and -228 activity have exceeded the maximum concentration limits at least twice since 1990. In addition, levels of antimony, fluoride, strontium, vanadium, and zinc exceed background levels in the alluvial aquifer.

The horizontal extent of contamination in the Wasatch Formation at New Rifle extends 3500 ft (1100 m) downgradient from the tailings pile. The estimated amount of contaminated ground water at the New Rifle site is 600 million gal (2.3 million m^3). Concentrations of molybdenum, nitrate, selenium, uranium, and activities of net gross alpha and radium-226 and -228 have exceeded the maximum concentration limits at least once since 1990; levels of antimony, fluoride, strontium, sulfide, vanadium, and zinc are elevated above background levels in the Wasatch Formation (DOE, 1990).

The Colorado River is the primary source of municipal water in the Rifle area. The Colorado River intake is approximately 0.5 mi (0.8 km) upriver from the Old Rifle site. The city obtains about 10 percent of its water from Beaver Creek, southwest of the New Rifle site and south of the Colorado River. The DOE has sampled 16 private wells and springs in the Rifle vicinity. An UMTRA Project position paper discusses potential impact to local private wells and springs near the Rifle sites (DOE, 1995b).

3.2.9 Slick Rock, Colorado (two sites)

Two processing sites are near Slick Rock, Colorado, along the Dolores River in San Miguel County. The population of San Miguel County is approximately 3700 (DOC, 1990). The Union Carbide processing site is approximately 1.0 mi (1.6 km) downriver from the North Continent processing site. Both sites are partially in the floodplain of the Dolores River in a sparsely populated area. There are 488,000 yd^3 (373,000 m^3) of contaminated material on 92 ac (37 ha) at the Union Carbide site and 85,000 yd^3 (65,000 m^3) of contaminated material

on 47 ac (19 ha) at the North Continent site. The proposed surface remedial action is to move the contaminated material out of the floodplain to the Burro Canyon disposal cell, 2.0 mi (3.0 km) north of the sites. The current schedule calls for completion of surface remedial action at the two sites in December 1996.

The Union Carbide and North Continent sites are in a steep canyon of the Dolores River, in the floodplain of the river. The Dolores River is the only permanent water body in the area of the sites, although there are dry washes. Surface water and sediment samples indicate contaminated ground water at the site has not adversely affected the water or sediment quality of the river. Willows and other shrubs dominate the riparian wetland zone along the river. A total of 96 ac (39 ha) of the riparian plant communities occurs in the contaminated zone at the Union Carbide and North Continent sites. The riparian zone supports many productive plant communities, which in turn support diverse wildlife. The surrounding canyon contains steep cliff faces or steep slopes dominated by desert shrubs. No endangered fish species are in the river in the area of the sites; endangered species are wintering bald eagles along the river and nesting peregrine falcons within 8.0 mi (13 km) of the sites. The river otter, a federal candidate species, occasionally occurs in the river near the sites.

Cultural resources near the processing and disposal sites have been identified and are being addressed during remedial planning (DOE, 1994e).

Both processing sites are on private land. The major land use in the area is grazing. A gas sweetener plant is adjacent to the Union Carbide site.

The Slick Rock site area is arid. The mean annual precipitation is 7.0 inches (18 cm). The average annual snowfall is approximately 30 inches (76 cm).

Ground water beneath the Slick Rock sites occurs in the alluvial aquifer of the Dolores River and in the underlying Entrada Sandstone and Navajo Sandstone Formations. These three hydrostratigraphic units are believed to be hydraulically interconnected. Ground water in the alluvium generally flows northwest, parallel to the flow of the river. Depth to ground water ranges from 10 to 20 ft (3.0 to 6.0 m) beneath the sites. The average linear ground water velocity in the alluvium ranges from 100 ft (30 m) per year at the North Continent site to 150 ft (50 m) per year at the Union Carbide site. The alluvial aquifer is recharged by seepage from the Dolores River upstream and by precipitation. Ground water discharges from the alluvium into the Dolores River downgradient.

Concentrations of molybdenum and uranium have exceeded the maximum concentration limits in one or more background alluvial monitor wells. These elevated constituent levels may be influenced by nearby mines upriver from the processing sites. Tailings seepage has affected the ground water quality in the alluvium beneath the Union Carbide site. Contaminant plume migration has been limited to within or slightly downgradient of this site. Concentrations of molybdenum, nitrate, selenium, and uranium and activities of net gross alpha

and radium-226 and -228 have exceeded the maximum concentration limits at least twice since 1990. The estimated amount of contaminated ground water at the Union Carbide site is 26 million gal (100,000 m^3).

Tailings seepage also has contaminated the alluvial ground water beneath the North Continent site, although the concentrations generally are lower than at the Union Carbide site. Hazardous constituents that have exceeded maximum concentration limits at least twice since 1990 are net gross alpha, radium-226 and -228, and uranium. Contaminant migration appears to be limited to within the site boundary. The estimated amount of contaminated ground water at the North Continent site is 12 million gal (50,000 m^3).

The contaminated ground water in the alluvium at both sites discharges into the Dolores River. Surface water sampling of the river detected none of the contaminants found in the alluvium. Ground water quality of the Entrada Sandstone underlying the alluvium also has been affected by uranium milling activities based on concentrations of selenium and total dissolved solids that are elevated above background levels. Ground water in the underlying Navajo Sandstone aquifer is not contaminated by tailings seepage from either the Union Carbide or North Continent site. Three water supply wells are upgradient or crossgradient from the processing sites. One of these wells is completed in the alluvium and lower formations. The other two are completed in the Navajo Sandstone. There are no known human uses of the contaminated ground water in the alluvium beneath or downgradient of either the Union Carbide or North Continent site.

3.2.10 Lowman, Idaho

The Lowman processing site is in Boise County, Idaho (population 3509), 0.5 mi (0.8 km) northeast of the unincorporated town of Lowman and 70 mi (112 km) north of Boise (DOC, 1990). The site is in the northern Rocky Mountains in heavily wooded terrain within the Boise National Forest. It is surrounded by ponderosa pine forest on the north, south, and east sides. Clear Creek, a perennial trout stream, forms the site's western boundary. Contaminated material from the processing site was deposited in a small portion of the Clear Creek floodplain and associated wetland. The principal land uses in the surrounding forest are logging, recreation, wildlife management, and livestock grazing. The site is characterized by a continental climate with dry, hot summers and cold winters. The average annual precipitation is 27 inches (69 cm); the average annual snowfall is 95 inches (241 cm) (DOE, 1991e). There are no known threatened or endangered species or historic or cultural resources at the site (DOE, 1991e).

A total of 128,000 yd^3 (98,000 m^3) on 30 ac (12 ha) was stabilized on the site in a 8.2-ac (3.3-ha) disposal cell. Surface remedial action was completed in June 1992.

The uppermost aquifer beneath the site consists of ground water in alluvium and weathered granodiorite. Depth to ground water varies from 27 to 78 ft (8.0 to 24 m) at the processing site. Ground water flows west-to-southwest along the alluvium/weathered granodiorite bedrock contact and discharges into Clear Creek. The estimated linear ground water velocity is approximately 55 ft (18 m) per year. Water quality analyses indicate none of the EPA maximum concentration limits are exceeded in the upgradient or downgradient monitor wells or in the tailings pore fluid. Therefore, the ground water beneath the site and the water discharging into Clear Creek does not contain contaminants that are the result of milling operations at the Lowman processing site. Residents in the village of Lowman obtain their water from wells in the deep granodiorite bedrock aquifer or from the South Fork Payette River, which flows through town (DOE, 1991e; 1991f).

3.2.11 Ambrosia Lake, New Mexico

The Ambrosia Lake UMTRA Project site is in McKinley County, New Mexico, approximately 20 mi (32 km) north of Grants. The population of the city of Grants is 8626; the population of McKinley County is 60,686 (DOC, 1990). The site is in the Ambrosia Lake Valley, a broad, elongated valley dominated by desert grassland plant communities with basalt-capped mesas to the north. An estimated 3,759,000 yd^3 (2,874,000 m^3) of contaminated material at the processing site and windblown area covered 612 ac (248 ha). Surface remediation consisted of stabilizing all contaminated material on the site in an 88-ac (36-ha) disposal cell. Remedial action was completed in June 1995.

The Ambrosia Lake site is in a sparsely populated area. Cultural resources have been identified near the site. The site lies within the drainage basin of Arroyo del Puerto, an intermittent stream 1.0 mi (1.6 km) southwest of the site. No permanent surface water bodies, including wetlands, are at or near the site. No threatened or endangered species are known to occur at or near the site. The Ambrosia Lake site is arid, with an average annual precipitation of 9.0 inches (23 cm) (DOE, 1987a).

The uppermost water-bearing unit beneath the Ambrosia Lake site consists of alluvium that grades into weathered Mancos Shale in the eastern portion of the site and into the Tres Hermanos-C Sandstone in the western portion of the site. Ground water in the alluvium and upper weathered bedrock is the result of uranium milling and mining activities in the area. This ground water occurs at depths ranging from 15 to 45 ft (5.0 to 14 m) and flows southwest at an estimated 15 ft (4.0 m) per year. It is unlikely that ground water from the alluvium would be used for drinking water due to its low yield, limited saturated extent, and poor quality.

Background water quality data are not available because the alluvium and upper bedrock did not contain water before the advent of uranium mining and milling in the area. Concentrations of molybdenum, nitrate, selenium, and uranium and activities of radium-226 and -228 have exceeded the maximum concentration

limits in the alluvium and upper Mancos Shale ground water beneath the site at least twice since 1990. Ground water in the Tres Hermanos-C Sandstone unit has exceeded the maximum concentration limits of molybdenum, nitrate, selenium, uranium, and the activities of net gross alpha at least twice since 1990. The estimated amount of contaminated ground water at the Ambrosia Lake site is 320 million gal (1.2 million m^3). Ground water in aquifers below the Tres Hermanos-C unit does not appear to have been contaminated by seepage from the contaminated ground water units beneath the Ambrosia Lake site.

No domestic, stock watering, or irrigation wells are completed within the alluvium and upper weathered bedrock in the Ambrosia Lake Valley. This is not expected to change due to the low yield of water from these units.

3.2.12 Shiprock, New Mexico

The Shiprock UMTRA Project site is on Navajo Nation land in San Juan County, New Mexico, on the southeast edge of Shiprock (population, 7687). The county per capita income is $8911 and the population in the site vicinity is predominantly Native American (DOC, 1990). The residents of Shiprock use the public water system, which is supplied by the San Juan River.

Approximately 1,600,000 yd^3 (1,200,000 m^3) of contaminated materials on 130 ac (53 ha) were stabilized in a 72-ac (29-ha) disposal cell in the same location as the former milling operations. Remedial action was completed in September 1986. The site is arid, averaging 6.0 inches (15 cm) of precipitation and 4.1 inches (10.4 cm) of snowfall annually. Threatened and endangered species occur near the site, including wintering bald eagles along the river and the Mesa Verde cactus in the upland desert/shrub plant community. No historic resources occur at or near the site (DOE, 1984a).

The site is along the south side of the San Juan River on an elevated terrace about 50 ft (21 m) above the river. Bob Lee Wash traverses the west side of the site and flows into the floodplain of the San Juan River. This wash is ephemeral, except for the lower 600 ft (200 m) that receives a constant discharge of about 60 gal (200 L) per minute from a potable water artesian well west of the wash. This water has created wetlands within Bob Lee Wash and at the mouth of the wash where it discharges into the floodplain of the river. In addition, two seeps flow from the base of the escarpment below the disposal cell into the floodplain of the river. These seeps flow at an estimated rate of 0.3 to 1.0 gal (1.0 to 4.0 L) per minute. A canal and ditches in the floodplain contain water year-round. Other surface water and small wetland areas are in the San Juan River floodplain below the disposal cell.

Surface water and sediment samples from the San Juan River downgradient of the site and from Bob Lee Wash indicate site-related contaminants have not affected these waters. Water quality data from the two seeps show elevated concentrations of nitrate, sulfate, and uranium (DOE, 1993e).

The Shiprock disposal cell is on unconsolidated alluvial terrace deposits underlain by Mancos Shale. Ground water occurs at the contact between the terrace alluvium and the upper portion of the Mancos Shale, where it has been weathered. There are an insufficient number of water level measuring points to prepare a reliable ground water contour map, but perched ground water on the terrace is believed to follow paleochannels to the southwest and west. The ground water layer in the alluvium above the bedrock is thin (generally less than 3.0 ft [1.0 m]), and the rate of recharge to the monitor wells is slow. Ground water levels in the monitor wells continue to decrease. Ground water also moves through fractures in the Mancos Shale and seeps from the escarpment.

Background ground water quality has not been defined for the terrace alluvium and upper Mancos Shale because all monitor wells installed have intercepted contaminated ground water. Background ground water quality for the floodplain alluvium was defined by ground water quality north of the river. Uranium milling and processing activities have resulted in ground water contamination in the alluvium and upper Mancos Shale on the terrace and in the floodplain alluvium. The contaminated ground water in the river terrace alluvium and upper Mancos Shale beneath the site and in the floodplain alluvium along the river have exceeded the maximum concentration limits for cadmium, net gross alpha, nitrate, radium-226 and -228, selenium, and uranium (DOE, 1993e). In addition, the maximum concentration limits for radium-226 and -228 exceed the maximum concentration limits in the contaminated ground water beneath the site. The volume of contaminated ground water is estimated to be 160 million gal (610,000 m^3).

3.2.13 Belfield, North Dakota

The Belfield, North Dakota, processing site is in Stark County. The Belfield site is 1.0 mi (1.6 km) south of the city of Belfield (population, 881) (DOC, 1990). The estimated amount of contaminated material is 58,000 yd^3 (44,000 m^3) on 31 ac (13 ha) of land. The once proposed remedial action alternative was to transport the contaminated material from the Belfield site 65 mi (104 km) to the Bowman site and stabilize all the material in a 12-ac (5.0-ha) disposal cell at Bowman. However, surface or ground water remedial action at these sites will not be completed at the request of the state.

The Belfield site is in the Northern Great Plains; the climate is semiarid. Annual temperature extremes are common; the recorded maximum and minimum temperatures are 105 degrees Fahrenheit (°F) (35 degrees Celsius [°C]) to -35°F (-19°C). The average annual precipitation is almost 16 inches (41 cm), with an average annual snowfall of 30 inches (80 cm) (DOE, 1993f).

The Belfield site is in a light industrial use area just outside Belfield along the North Branch of the Heart River. Part of the contaminated land is in the floodplain of this river. The Heart River is a wooded draw with steep sides. It is 5.0 to 10 ft (2.0 to 3.0 m) wide with intermittent flow. Contaminated ground water from the site does not discharge into the Heart River in the site

area. Cultural resources near the site have been identified and will undergo further study. No federally listed or candidate plant or animal species are known to occur in the site area. U.S. Army Corps of Engineers-designated wetlands occur along the Heart River near the site (DOE, 1993f).

Ground water occurs beneath the Belfield processing site in the fine-grained sediments and lignite layers. Depth to ground water ranges from 15 to 38 ft (5.0 to 12 m). Ground water flow is generally east. The average linear ground water velocity is 26 ft (7.0 m) per year. There is no evidence that contaminated ground water from the Belfield processing site is entering the Heart River, nor has ground water discharged to the land surface at this site. The volume of contaminated ground water at the Belfield site is an estimated 4.7 million gal (18,000 m^3).

Background ground water quality at the Belfield site exceeds the EPA drinking water standards for sulfate and total dissolved solids and the EPA maximum concentration limit for selenium. Contaminants have entered the shallow ground water, and concentrations of chromium, radium-226 and -228, molybdenum, selenium, and uranium exceed the maximum concentration limits. Because of the diffuse nature of the contaminant source, which originated from airborne ash, the development of a contaminant plume in ground water is insignificant. No evidence suggests site-related contaminants have entered deeper aquifers.

Ground water from the shallow aquifer system is used for limited stock watering and some domestic purposes but it is not a drinking water source. Water for most domestic uses is obtained from deep aquifers in the Belfield site area. The water supply for the city of Belfield is obtained from a 1000-ft (300-m) deep aquifer 1000 ft (300 m) upgradient from the Belfield UMTRA Project site (DOE, 1993f).

3.2.14 Bowman, North Dakota

The Bowman, North Dakota, site is in Bowman County, 7 mi (11 km) northwest of the city of Bowman (population, 1713) (DOC, 1990). A total of 128,000 yd^3 (98,000 m^3) of contaminated material on 71 ac (29 ha) will be cleaned up at the Bowman site. This contaminated material, along with contaminated ground water, will not be remediated at the request of the state.

The site is in a rural area surrounded by short-grass prairie and other grasslands used for grazing and dryland farming. One small ephemeral wetland occurs within the zone of contamination. The nearest permanent water bodies are a pond and stream 1200 ft (360 m) west of the site; these water bodies are not affected by the site. Historical structures from early 1900s settlements have been identified at the site and need further study. Two federal candidate species (ferruginous hawk and loggerheaded shrike) have been observed within 1.0 mi (1.6 km) of the site. U.S. Army Corps of Engineers-designated wetlands

occur near the site (DOE, 1993f). The annual precipitation is the same as the Belfield site.

Ground water beneath the Bowman processing site occurs in fine-grained sediments and in lignite layers. Depth to ground water ranges from 6.0 to 20 ft (2.0 to 6.0 m), and flow is generally to the east. The average ground water velocity is 2.0 ft (0.7 m) per year at the Bowman site. There is no evidence of ground water discharge to the land surface.

Background ground water quality at the Bowman site exceeds the EPA drinking water standards for sulfate and total dissolved solids, as well as the EPA maximum concentration limits for chromium, selenium, and uranium. Contaminants from the Bowman site have entered the shallow ground water, and concentrations of chromium, radium-226 and -228, molybdenum, selenium, and uranium exceed the maximum concentration limits. The estimated amount of contaminated ground water at the Bowman site is 58 million gal (0.22 million m^3). There is no evidence that site-related contaminants have migrated into deeper aquifers.

Ground water from the uppermost aquifer is not used as a drinking water source but is used for limited stock watering and some domestic purposes. Public water for most uses is obtained from deep aquifers in the Bowman site area.

3.2.15 Lakeview, Oregon

The Lakeview processing site is in Lake County, Oregon, about 1.0 mi (1.6 km) north of the city of Lakeview. About 926,000 yd^3 (708,000 m^3) of contaminated material on 116 ac (47 ha) at the Lakeview processing site were stabilized off the site at the Collins Ranch disposal cell, 7.0 mi (11 km) northwest of Lakeview. Surface remedial action was completed in October 1989.

The Lakeview processing site is nearly surrounded by ranch lands. Two lumber mills to the southeast constitute most of the industrial facilities in the immediate area. The population is approximately 7200 in Lake County and 2500 in the city of Lakeview (DOC, 1990). No historic or prehistoric sites were reported in the vicinity of the processing site (DOE, 1985b).

Surface water bodies at the site include Hunters Creek and associated wetlands along the northern boundary of the site, Warner Creek just west of the site, the East Branch of Thomas Creek along the east and south boundaries, Hammersley Creek on the east side, and a pond near the site of the former mill buildings. Surface water and sediment samples from these water bodies indicate site-related contaminated ground water has not adversely affected the water or sediment quality. The Lakeview site is in a semiarid, high desert climate, with cool temperatures and an average annual precipitation of about 17 inches (43 cm). No threatened or endangered species are known to exist at or near the

site; however, migrant species may find suitable habitat near the site (DOE, 1985b).

Ground water beneath the site occurs in an alluvial/lacustrine aquifer. The water table beneath the site generally occurs at a depth of 5.0 to 15 ft (1.5 to 4.6 m). Ground water moves south and southwest at approximately 50 to 160 ft (15 to 49 m) per year. Recharge to the alluvial/lacustrine aquifer is from precipitation and from surface water infiltration from nearby cold water and geothermal water streams. Ground water is withdrawn from agricultural, industrial, municipal, and domestic wells in the site vicinity and discharges into surface water channels that drain into Goose Lake, about 8.0 mi (13 km) south of the site.

Background ground water consists of low-temperature water and hot water from geothermal sources. The background ground water has exceeded maximum concentration limits for molybdenum, and radium-226 and -228 at least once. Arsenic, molybdenum, and net gross alpha have exceeded the maximum concentration limits in the alluvial/lacustrine aquifer beneath the processing site at least twice since 1990. Current information indicates a contaminant plume extends approximately 1500 ft (460 m) southwest from the processing site, as determined from sulfate and total dissolved solids concentrations (DOE, 1992c). The estimated amount of contaminated ground water at the Lakeview site is 1.2 billion gal (4.5 million m^3). Alluvial/lacustrine ground water is used for domestic, livestock watering, and industrial purposes in the processing site area.

3.2.16 Canonsburg, Pennsylvania

The Canonsburg site is in Washington County in western Pennsylvania. This site consists of the former processing site in the borough of Canonsburg, approximately 20 mi (32 km) southwest of downtown Pittsburgh. The Canonsburg disposal cell is surrounded on the north, south, and west by a buffer zone that separates it from nearby residential and commercial properties. The population of the borough of Canonsburg is 9200 (DOC, 1990). Approximately 172,000 yd^3 (132,000 m^3) of contaminated material on 30 ac (12 ha) were stabilized in an on-site disposal cell. Surface remedial action was completed in December 1985.

The Canonsburg site is in the humid continental climate region. The average annual precipitation is 37 inches (94 cm); the average annual snowfall is 45 inches (114 cm).

Chartiers Creek bounds the site on the north, east, and west sides. This creek is bordered by wooded riparian vegetation. The water quality of this creek is poor near the site as a result of sewage and industrial waste. Water samples and limited sediment samples indicate that site-related ground water has not adversely affected the water and sediment quality at Chartiers Creek. There are no known threatened or endangered species at the site. Within a 1.0-mi

(1.6-km) radius of the Canonsburg site are two places that are listed on the National Register of Historic Places (DOE, 1983).

Ground water occurs in unconsolidated fill at a depth of 3.0 to 14 ft (1.0 to 4.0 m) and in the bedrock beneath the Canonsburg site. Ground water in both aquifers flows toward Chartiers Creek. Ground water recharge occurs from precipitation and underflow from upgradient areas. Uranium and net gross alpha have exceeded the maximum concentration limits at least twice since 1990. The estimated amount of contaminated ground water at the Canonsburg site is 5.3 million gal (20,000 m^3). In general, contaminant concentrations in ground water have decreased since post-closure monitoring started. Public water supplies are obtained from protected surface water sources upstream of the site (DOE, 1983).

The Burrell site is a vicinity property disposal cell associated with the Canonsburg site. It is in Indiana County, Pennsylvania, approximately 40 mi (64 km) east of downtown Pittsburgh and 50 mi (80 km) east-northeast of the Canonsburg site. At the Burrell site, 54,000 yd^3 (41,000 m^3) of contaminated material covering 49 ac (20 ha) were stabilized in place in a 6.0-ac (2.4-ha) disposal cell. Surface remedial action was completed in July 1987. Some radioactively contaminated materials were transferred to Burrell from the Canonsburg site from 1956 to 1957. The Burrell site is in a rural setting. Blairsville, the nearest borough, is approximately 0.75 mi (1.2 km) west of the site. The population is 3595 in the borough of Blairsville (DOC, 1990).

The average annual precipitation is 44 inches (112 cm), while the average annual snowfall is 45 inches (114 cm). The Burrell site is within the floodplain of the Conemaugh River. It is surrounded by abandoned fields on the north and east sides and the floodplain of the Conemaugh River on the west and south sides. A spring has created wetlands at the base of the south-facing slope of the disposal cell. This spring drains into the nearby Conemaugh River, which is contaminated by mine drainage, industrial pollution, and municipal wastewater discharge. A small wetland (less than 1.0 ac [0.4 ha]) has developed along the northern boundary of the disposal cell. There are no known threatened or endangered species at the site. Several historical resources are located within a 1.0-mi (1.6-km) radius of the site (DOE, 1983).

Ground water occurs in unconsolidated fill at depths greater than 30 ft (9.0 m) and in the bedrock beneath the site. It flows south toward the Conemaugh River. Surface water samples indicate that constituents associated with the Burrell disposal cell have not entered the Conemaugh River or the wetlands on the south side of the cell. Water samples have not been collected from the wetlands along the north side of the cell. Sediment samples have not been collected from any water bodies near the site. Domestic water supplies for the surrounding population are from protected surface water sources (DOE, 1983).

3.2.17 Falls City, Texas

The Falls City, Texas, site is in Karnes County, 46 mi (74 km) south of San Antonio and 8.0 mi (13 km) southwest of Falls City. During surface remedial action, 593 ac (240 ha) of land and 5,764,000 yd^3 (4,407,000 m^3) of contaminated material are being cleaned up at this site. Contaminated material covered 593 ac (240 ha) of land at this site. The contaminated material was stabilized on the site in a 127-ac (51-ha) disposal cell. Surface remedial action began in 1992 and the disposal cell was completed in June 1994.

The Falls City site is in a rural setting. Grazing is the principal land use for the mesquite-dominated woodlands around the site. The area around the Falls City site is sparsely populated. Falls City, the nearest town, had an estimated population of 497 in 1990 (DOC, 1990). Cultural resource surveys identified prehistoric sites within a 5.0-mi (8.0-km) radius of the site. However, cultural resource surveys were not required at the processing or borrow sites because of previous major disruption to the area (DOE, 1991g).

Surface water bodies that occur on-site or at the site boundary are Tordilla and Scared Dog Creeks, which are intermittent streams, and a pond along the south end of what had been tailings pile number three. Small wetlands occur at these water bodies. Four additional ponds are within 3000 ft (900 m) of the site. Water samples from the surface water bodies indicate site-related contaminated ground water has not adversely impacted water quality. Limited sediment, vegetation, and fish samples from the on-site surface water bodies indicate site-related contaminated ground water likely has not contaminated these media. However, further sampling, including the collection of background samples, is needed to verify this.

The climate at the site is considered subtropical, with hot summers and mild winters. High humidity is typical, and the average annual precipitation is 30 inches (76 cm). No federally listed threatened and/or endangered species occur in the site area. Extensive field surveys determined that none of the state-designated threatened and/or endangered species that may occur in Karnes County occur at the site (DOE, 1991g). However, subsequent observations during remedial action show the Texas horned lizard occurs at the site. In addition, the Texas tortoise and indigo snake may occur in the site area.

Two low-yield aquifers have been identified in the upper 200 ft (60 m) of the clastic sedimentary strata underlying the site. These aquifers are separated by 30 to 50 ft (27 to 46 m) of clay. However, because improperly abandoned exploratory boreholes form a potential hydraulic interconnection between these two aquifers, they are considered together, as the uppermost aquifer. Shallow ground water in the uppermost aquifer occurs at depths of 5.0 to 30 ft (1.5 to 9.0 m) below land surface. The maximum average linear ground water velocity is approximately 130 ft (40 m) per year, and the aquifers yield small amounts of water (1.0 to 2.0 gal per minute) (0.06 to 0.12 L per second). The site is bisected by a drainage divide; the shallow ground water flows primarily

northeastward and southwestward, paralleling intermittent drainages. Shallow ground water may discharge into these intermittent drainages from ephemeral seeps. The uppermost aquifer is underlain by a 300-ft (100-m) thick formation of clay and lignite seams that prevents the downward migration of contaminants.

Background water quality is highly variable with depth and location because it occurs within the uranium ore body. The background ground water is classified as limited use, based on high average uranium concentrations and activities of net gross alpha and radium that render the water untreatable by methods reasonably employed by public water systems in the region (DOE, 1992d).

Tailings fluids have migrated into the uppermost aquifer; as a result, concentrations of arsenic, cadmium, chromium, lead, mercury, molybdenum, net gross alpha, nitrate, radium-226 and -228, selenium, and uranium have exceeded the maximum concentration limits at least twice since 1990. However, because the background ground water is of poor quality, this water is of limited use for stock watering and is of no use for any other purpose. The estimated amount of contaminated ground water at the Falls City site is 1.2 billion gal (4.5 million m^3). Because area residents currently do not use the Deweesville/Conquista ground water, human health is not at risk from direct ground water use (DOE, 1994f). Potable water is obtained from one domestic well more than 800 ft (240 m) deep and a water cooperative's well 2000 ft (600 m) deep (DOE, 1991g; 1991h, 1994f).

3.2.18 Green River, Utah

The Green River processing site is in Grand County, Utah, 1.0 mi (1.6 km) southeast of the city of Green River. The site is partially in the floodplain of Brown's Wash, an intermittent tributary of the Green River. The tailings pile covered 8.0 ac (3.0 ha); an additional 40 ac (16 ha) were contaminated with tailings. An estimated 382,000 yd^3 (292,000 m^3) of contaminated material were placed in a 6.0-ac (2.0-ha) disposal cell on the site. Surface remediation was completed in October 1989.

The Green River disposal cell is on a terrace above Brown's Wash. This wash is approximately 800 ft (240 m) north of the cell. The original tailings pile was in the floodplain of Brown's Wash, along the southern border of the wash. The wash flows only during periods of heavy precipitation and is dry for most of the year. However, pools of water that may be created by the discharge of contaminated ground water into Brown's Wash are often present downstream of the site. Sampling over the years has shown that these pools contain elevated concentrations of nitrates, selenium, uranium, and other constituents that have the potential to be harmful to aquatic and terrestrial organisms. The Green River is about 2000 ft (610 m) west of the site and surface water samples from the river indicate that site-related contaminated ground water is not adversely affecting surface water quality.

The site is in a sparsely populated area. The population of the city of Green River is 881; the population in Grand County is 6620 (DOC, 1990). Two cultural resource sites near the processing site are eligible for inclusion on the National Register of Historic Places. The Green River site is arid; the average annual precipitation is 6.0 inches (15 cm), with an average annual snowfall of 10 inches (25 cm). No threatened or endangered species occur at or near the site (DOE, 1988).

Four distinct water-bearing units occur at the Green River site: the alluvium of Brown's Wash and the upper, middle, and lower Cedar Mountain Formation aquifers. The Brown's Wash alluvial aquifer is limited to 300 to 400 ft (90 to 120 m) on each side of the wash and is up to 35 ft (11 m) thick. Depth to ground water ranges from 9.0 to 17 ft (3.0 to 5.0 m) below ground surface. Ground water in this unit flows west, parallel with the wash toward the Green River, at a velocity ranging from 0.6 to 2.0 ft (0.2 to 0.7 m) per day. The alluvial aquifer is recharged from underflow and by infiltration of surface runoff in the channel of Brown's Wash.

Ground water in the upper Cedar Mountain aquifer flows west toward the Green River at a velocity ranging from 4.0 to 260 ft (1.0 to 70 m) per year. Ground water is about 26 ft (8.0 m) deep at the old tailings pile area. Ground water in this unit is recharged by the overlying alluvial aquifer and the underlying middle Cedar Mountain aquifer.

The middle Cedar Mountain aquifer flows west toward the Green River. This aquifer is an estimated 60 ft (20 m) deep beneath the old tailings pile area; however, there is a strong upward gradient between this unit and the overlying aquifers. Due to fracturing, this aquifer likely is connected to the upper Cedar Mountain aquifer. Because of an overlying confining layer and a strong upward hydraulic gradient, the lower Cedar Mountain aquifer is not recharged by the aquifers above it.

In background ground water of the alluvial aquifer, chromium, molybdenum, net gross alpha, nitrate, and selenium have exceeded maximum concentration limits. Concentrations of net gross alpha, nitrate, and selenium in the background ground water in the upper Cedar Mountain aquifer have exceeded the maximum concentration limits. Concentrations of molybdenum, nitrate, selenium, uranium, and net gross alpha have exceeded the maximum concentration limits in background ground water of the middle Cedar Mountain aquifer. Analysis of background ground water in the lower Cedar Mountain aquifer indicates levels of chromium, molybdenum, and selenium exceed the maximum concentration limits. The estimated amount of contaminated ground water at the Green River site is 180 million gal (0.68 million m^3).

Seepage of hazardous constituents from the former tailings pile area has contaminated the alluvial and upper Cedar Mountain aquifers. Net gross alpha and radium-226 and -228 activity and concentrations of molybdenum, nitrate, selenium, and uranium have exceeded the maximum concentration limits

beneath and downgradient of the former tailings pile at least twice since 1990. The extent of contamination is confined to these two aquifers by strong upward hydraulic gradients between the upper Cedar Mountain aquifer and the underlying aquifers.

There are no known uses of the ground water at or near the Green River processing site. The city of Green River uses water from the Green River, upriver of the tailings site, for its water supply (DOE, 1988).

3.2.19 Mexican Hat, Utah

The Mexican Hat processing site is in the Navajo Nation in San Juan County, Utah. The village of Halchita is approximately 0.5 mi (0.8 km) from the site, and the estimated population is approximately 500. The per capita income in the county is $5907 and the population is 54 percent Native American (DOC, 1990). The village of Mexican Hat, Utah, is 2.0 mi (2.2 km) from the site, and the estimated population is 43 (DOE, 1987b). This site consisted of two tailings piles totaling 69 ac (28 ha). An estimated 2,810,000 yd^3 (2,150,000 m^3) of contaminated material are contained in these two tailings piles and on an additional 250 ac (101 ha) of adjacent land. The contaminated material at this site and contaminated material from the Monument Valley, Arizona, processing site are being stabilized in a 72-ac (29-ha) disposal cell at the Mexican Hat site. Surface remediation was completed by January 1995.

The climate is arid with an average annual precipitation of 6.0 inches (15 cm). The Mexican Hat site is in a rural setting surrounded by desert shrub habitat. The site is adjacent to an unnamed intermittent arroyo (called the North Arroyo) that is a tributary to Gypsum Creek, a larger ephemeral arroyo that, when flowing, empties into the San Juan River. The site is approximately 1.0 mi (1.6 km) from the San Juan River. There are no known threatened or endangered species or historic resources at or near the processing site (DOE, 1987b). The population of San Juan County is 12,621 (DOC, 1990).

During construction of the Mexican Hat disposal cell, seeps were discovered in the North Arroyo. In Gypsum Creek northeast of the site, naturally occurring seeps are present. The North Arroyo and Gypsum Creek seeps discharge site-related contaminated ground water with concentrations or activities of nitrate, molybdenum, selenium, uranium, net gross alpha, and radium-226 and -228 that have exceeded EPA maximum concentration limits at various times in the past (DOE, 1993d). Surface water samples from the San Juan River indicate that if the site-related contaminated ground water is discharging into the river, it is not adversely affecting water quality.

The tailings site is on top of the Halgaito Shale outcrop. Ground water beneath the Mexican Hat site occurs in the Halgaito Shale and the underlying Honaker Trail Formation. Perched water in the Halgaito Shale occurs only as a result of uranium milling operations. It is only in a localized area of saturation beneath the site at a depth ranging from 35 to 60 ft (11 to 18 m). Perched water in the

Halgaito Shale generally flows northeast, and is controlled by the structural dip and fractures in the Halgaito Shale. The water discharges with very low flow rates (less than 1.0 gal [4.0 L] per minute) into isolated seeps in the North Arroyo. Gypsum Creek seeps flow intermittently.

The Honaker Trail Formation is considered the uppermost aquifer at the site. The Honaker Trail Formation occurs at a depth of 100 to 150 ft (30 to 50 m) beneath the site; ground water in this formation flows at an average velocity of 4.0 ft (1.0 m) per year. This ground water flows generally northeast. Recharge of this unit occurs at higher elevations, and it discharges to seeps in Gypsum Creek or as underflow to the northeast. The occurrence of a thick low-permeability unit and an upward hydraulic gradient has prevented contaminated water from the Halgaito Shale from entering the Honaker Trail Formation aquifer.

Because the ground water in the Halgaito Shale occurs as a result of milling operations, background ground water quality could only be defined from seeps isolated from site-related contamination. Background ground water in the Honaker Trail Formation shows maximum observed concentrations of arsenic, chromium, net gross alpha, radium-226 and -228, selenium, and uranium that have exceeded maximum concentration limits (DOE, 1993d). Ground water in the Halgaito Shale has concentrations of arsenic, chromium, and nitrate that have exceeded the maximum concentration limits at least twice since 1990. The estimated amount of contaminated ground water at the Mexican Hat site is 110 million gal (0.42 million m^3).

There are no records of past or current users of the ground water from these two formations in the Mexican Hat site area. Domestic water for Halchita is supplied by a treatment facility that obtains water from the San Juan River. The Mexican Hat water supply is from a converted oil exploration well and the San Juan River (DOE, 1987b; 1993d).

3.2.20 Salt Lake City, Utah

The Salt Lake City processing site is in Salt Lake County, Utah, 4.0 mi (6.0 km) south-southwest of the center of Salt Lake City. A total of 2,710,000 yd^3 (2,070,000 m^3) of tailings was removed from 128 ac (52 ha) on this site and transported to the South Clive disposal site, 85 mi (136 km) west of Salt Lake City. Surface remedial action was completed in June 1989.

The Salt Lake City processing site is in an urban area, bounded by a sewage treatment plant on the north, a railroad on the east, and city streets on the south and west. The population of Salt Lake County is 725,956; the population of Salt Lake City is 159,936 (DOC, 1990). The site is close to the Jordan River (1500 ft [460 m] west of the site) and Mill Creek, a perennial stream that flows along the site's northern boundary. In addition, an irrigation ditch (South Vitro Ditch) traverses the site and a small wetland is just east of the site. Surface water samples indicate that the site-related contaminated ground water has not

adversely affected water quality. Limited sediment sampling indicates that the South Vitro Ditch may have high levels of molybdenum while the remaining samples showed no adverse effects from site-related contamination. The Salt Lake City site has a semiarid climate, receiving an average annual precipitation of 15 inches (38 cm); the average annual snowfall is 59 inches (150 cm) (DOE, 1984b). There are no threatened or endangered species or cultural resources at or near the processing site (DOE, 1984b).

An unconfined aquifer approximately 45 ft (14 m) thick and composed of sand, silt, and clay is the uppermost aquifer under the processing site. The major sources of recharge for this aquifer are infiltration of precipitation and upward leakage from the lower confined aquifer. Water levels of the unconfined aquifer beneath the site range from 5.0 to 15 ft (1.5 to 5.0 m). This aquifer flows primarily toward the northwest and discharges into surface water bodies such as Mill Creek and the Jordan River. The estimated ground water velocity is 170 ft (50 m) per year.

Background water has a total dissolved solids content ranging from 300 to 550 mg/L, and sulfate levels ranging from 2.0 to 6.0 mg/L. Arsenic has exceeded the maximum concentration limit in most background ground water samples. A contaminant plume exists beneath the site, and molybdenum, net gross alpha, and uranium have exceeded the maximum concentration limits in some on-site and downgradient monitor wells at least twice since 1990. The estimated amount of contaminated ground water at the Salt Lake City site is 350 million gal (1.3 million m^3).

There is no evidence that contaminants derived from uranium processing have entered the lower confined aquifer beneath the site, undoubtedly due to the upward gradient between the lower confined and unconfined aquifers. Because of its poor quality and minimal well yield the upper aquifer has very limited potential use for domestic or agricultural purposes (DOE, 1993g). Residents of Salt Lake City obtain water from a municipal supply system that is upgradient of the processing site. However, the city of South Salt Lake is planning to install a water supply well within the site boundary. This well will draw water from an uncontaminated aquifer below the site.

3.2.21 Riverton, Wyoming

The Riverton, Wyoming, site is in a rural setting 2.0 mi (3.0 km) southwest of the city of Riverton in Fremont County. The per capita income in the county is $9806 and the population in the site vicinity is predominantly Native American (DOC, 1990). The site is on private land within the boundary of the Wind River Indian Reservation (Northern Arapaho and Shoshone Indian Tribes). Contaminated material totaling 1,793,000 yd^3 (1,371,000 m^3) was on 140 ac (57 ha) of land at the processing site and at off-site vicinity properties. All the contaminated material was transported 45 mi (72 km) to the Gas Hills uranium district, consolidated into an active uranium tailings pile, and stabilized. Surface remedial action at the Riverton site was completed in November 1989.

The Riverton site is on alluvial deposits between the Wind River, 1.0 mi (1.6 km) to the north, and the Little Wind River, 0.5 mi (0.8 km) southeast of the site. The confluence of these two rivers is 2.5 mi (4.0 km) east of the site. The site is bordered by drainage ditches and irrigation canals on the north, east, and southwest sides. Wetlands are nearby to the east and southwest. Surface water and sediment samples from the drainage ditches and wetlands indicate that the site-related contaminated ground water has not adversely affected these bodies of water. Elevated levels of uranium were detected in a side channel of the Little Wind River, which may represent the discharge of site-related contaminated ground water. The predominant land use in the site vicinity is agricultural; the primary crop is hay grown on irrigated fields. Cultural resources identified at the site are extensive and are considered eligible for listing on the National Register of Historic Places. No known threatened and/or endangered species exist at the site (DOE, 1987c).

A sulfuric acid plant that was used during the former uranium milling is still in operation near the site boundary. Residences exist along the north, south, southeast, and east boundaries of the site. The population of the city of Riverton is 9202, and Fremont County has a population of 33,662 (DOC, 1990). The climate is arid, with an average annual precipitation of almost 8.0 inches (20 cm); the average annual snowfall is almost 36 inches (91 cm) (DOE, 1987c).

Two ground water systems occur in the vicinity of the Riverton processing site. The uppermost aquifer consists of unconfined ground water in the shallow alluvial deposits and the hydrologically connected semiconfined sandstone unit of the Wind River Formation. The second system contains confined ground water in the deeper sandstone layers of the Wind River Formation. Depth to water in the uppermost aquifer is approximately 6.0 ft (2.0 m) below the site; the aquifer has an average saturated thickness of 50 ft (15 m). Ground water flow in the uppermost aquifer is predominantly to the south-southeast toward the Little Wind River. Water from this aquifer discharges into this river approximately 2800 ft (850 m) downgradient of the site and probably to the wetlands east and southwest of the site. The estimated ground water velocity is 160 ft (50 m) per year. Recharge to the uppermost aquifer is from precipitation, snowmelt, and ephemeral and perennial creeks.

Background water quality data from the uppermost aquifer system show that chromium exceeded the maximum concentration limit in one well once. Molybdenum, net gross alpha, selenium, radium-226 and -228, and uranium have exceeded the maximum concentration limits at various times in on-site and downgradient monitor wells in the uppermost aquifer. Molybdenum, net gross alpha, radium-226 and -228, and uranium have exceeded maximum concentration limits in on-site and downgradient ground water at least twice since 1990. Plume movement is in the direction of ground water flow, which is to the south-southeast. The estimated amount of contaminated ground water at the Riverton site is 500 million gal (1.9 million m^3). Surface water samples from the Little Wind River downgradient of the processing site contained

detectable concentrations of net gross alpha, radium-226 and -228, and uranium, but these all were below the maximum concentration limits.

The uppermost aquifer is of low quality. Only two wells in the area of the processing site are known to be completed in this unit. One is located about 200 ft (60 m) upgradient of the site and the other is 2000 ft (600 m) downgradient along the boundary of the contaminant plume. Both wells are used for livestock watering. There are no known domestic water supply wells in this aquifer system in the site area. The confined aquifer is of good quality and is used for domestic water supplies in the area (DOE, 1987d).

3.2.22 Spook, Wyoming

The Spook UMTRA Project site is on private ranch land in central Wyoming in Converse County. The site is approximately 48 mi (77 m) northeast of Casper, Wyoming. A total of 315,000 yd^3 (241,000 m^3) of contaminated material was on 21 ac (8.0 ha) at the site. In addition, 1,600,000 yd^3 (1,200,000 m^3) of overburden material from open pit uranium mines on 115 ac (47 ha) were on the site. All the contaminated and overburden material was stabilized in an on-site open pit mine. Surface remedial action was completed in November 1989 (DOE, 1989c).

The Spook site is in rolling sagebrush and grassland terrain and is surrounded by cattle and sheep ranches. Approximately 1.0 mi (1.6 km) south of the Spook site is the Dry Fork of the Cheyenne River, an ephemeral tributary that supports a large stand of mature cottonwood trees and other stream-side vegetation. The nearest residence is a ranch house 1.4 mi (2.3 km) southwest of the site. The population is 11,128 in Converse County (DOC, 1990). The climate is arid, with an average annual precipitation of 11 inches (28 cm). The average annual snowfall is 74 inches (190 cm) (DOE, 1989c).

The Spook site has suitable habitat for three migratory birds of federal interest, and the endangered bald eagle roosts in wooded areas throughout northern Wyoming. The State Historic Preservation Officer does not consider the few cultural resources within a 270 ac (109 ha) radius of the site eligible for the National Register of Historic Places (DOE, 1989c).

Ground water in the uppermost aquifer beneath the Spook site occurs within the Wasatch Formation in a sandstone unit that ranges from 40 to 120 ft (12 to 40 m) deep. There is no evidence of ground water discharge to the surface in the site vicinity. Ground water flows predominantly northeast. The average ground water velocity in the upper aquifer is 150 ft (37 m) per year.

Background ground water quality in this aquifer is affected by naturally occurring mineralization related to the uranium ore body. Concentrations of uranium and selenium in the background ground water exceed the regulatory limits. Contaminants in the ground water beneath the processing site and downgradient that exceed the maximum concentration limits are cadmium,

chromium, molybdenum, net gross alpha, nitrate, radium-226 and -228, selenium, silver, and uranium at least twice since 1990. The contaminant plume extends 2500 ft (1200 m) downgradient from the tailings pile. The estimated amount of contaminated ground water at the Spook site is 1.0 billion gal (3.8 million m^3). Ground water in the underlying lower sandstone aquifer is not contaminated from the milling operations.

The ground water in the uppermost aquifer is considered limited use ground water because it is not a current or potential source of drinking water, and it contains widespread ambient uranium and selenium contamination from natural sources.

The lower sandstone aquifer is used as a drinking water source beyond the site area. This aquifer has not been contaminated by tailings seepage or by naturally occurring contaminants (DOE, 1989c).

4.0 ENVIRONMENTAL IMPACTS

This section analyzes the potential impacts associated with the alternatives for implementing the Ground Water Project. These alternatives, except the no action alternative, implement one or more of three strategies for complying with the EPA ground water standards (Table 4.1).

Table 4.1 Ground water compliance strategies that apply under each alternative

Strategy	Alternative			
	Proposed action	No action[a]	Active remediation to background levels	Passive remediation
Active ground water remediation methods	✓		✓[b]	
Natural flushing [c]	✓			✓
No ground water remediation				
- Sites that qualify for supplemental standards [d] or alternate concentration limits[e].	✓			✓
- Sites that meet maximum concentration limits or background levels (no impacts).[f]	✓			✓

[a]The analysis of the no action alternative is required by the CEQ and DOE.
[b]Active remediation methods would not be used at sites where contamination does not exceed background and likely would not be used at sites that qualify for supplemental standards based on the existence of limited use ground water.
[c]Natural flushing means allowing the natural ground water movement and geochemical processes to decrease contaminant concentrations.
[d]Supplemental standards applicable for certain site conditions, as identified in the EPA standards, that are protective of human health and the environment, and may be applied in lieu of prescriptive levels.
[e]Concentrations of contaminants that may exceed the maximum concentration limits; or, limits for those constituents without maximum concentration limits. If DOE demonstrates, and NRC concurs, that human health and the environment would not be adversely affected, DOE may meet an alternate concentration limit.
[f]"No remediation" at sites that do not exceed maximum concentration limits or background levels is not the same as "no action" because these sites would require activities such as site characterization to show that no remediation is warranted.

These strategies are described below:

- Active ground water remediation—This includes methods such as gradient manipulation, ground water extraction, and *in situ* ground water treatment. Section 2.8 summarizes active ground water remediation methods. This strategy would be

used with both the proposed action and active remediation to background levels alternative.

- Passive ground water remediation by natural flushing—Natural flushing is described in Sections 1.4.1 and 2.8.2. This strategy would be used under the proposed action as well as the passive remediation alternative.

- No ground water remediation—In this PEIS, this strategy is considered in two parts: first, "no remediation" sites that do not have ground water contamination above maximum concentration limits and/or background levels, and second, "no remediation" sites that have ground water contamination above maximum concentration limits and/or background levels but qualify for supplemental standards or alternate concentration limits. In the first part of this strategy, site characterization may cause minor environmental impacts, with no impacts expected from implementation. Therefore, this part of the "no remediation" strategy is not considered further in this PEIS. Some minor environmental impacts may result from implementing the second part of this strategy; therefore, these environmental impacts are analyzed in Section 4.2.3 of this PEIS. This strategy would be used for all the alternatives except the no action alternative.

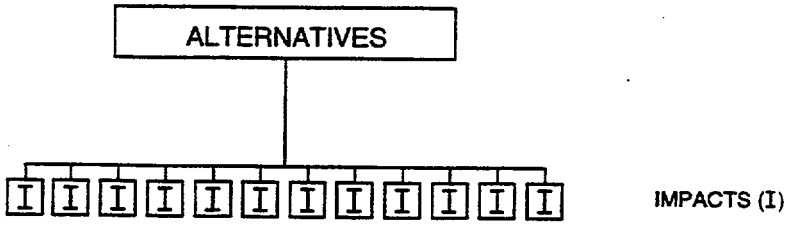
This PEIS differs substantially from a site-specific environmental impact statement because multiple ground water compliance strategies, each with its own set of potential impacts, could be used to implement all the alternatives except the no action alternative. In a traditional environmental impact statement, an impacts analysis leads directly to the defined alternatives. The impacts analysis for implementing alternatives in this PEIS first involves evaluating a ground water compliance strategy or strategies (Figure 4.1), the use of which would result in site-specific impacts. This PEIS impacts analysis assesses only the potential impacts of the various ground water compliance strategies, then relates them to the alternatives to provide a comparison of impacts.

The potential impacts of site characterization are analyzed in Section 4.1. Site characterization is used to help determine the site-specific ground water compliance strategies for the alternatives being evaluated. Impacts analyses for the ground water compliance strategies are presented in Section 4.2, followed by the potential impacts of the no action alternative in Section 4.3. The comparison of alternatives (Section 4.4) and the cumulative impacts analysis (Section 4.5) follow the analysis of the no action alternative.

The following categories were analyzed for potential impacts:

- Human health
- Air quality
- Surface water
- Ground water
- Ecological resources
- Land use
- Cultural/traditional resources
- Background noise

PROJECT-SPECIFIC
ENVIRONMENTAL IMPACT STATEMENT



GROUND WATER PROJECT
PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

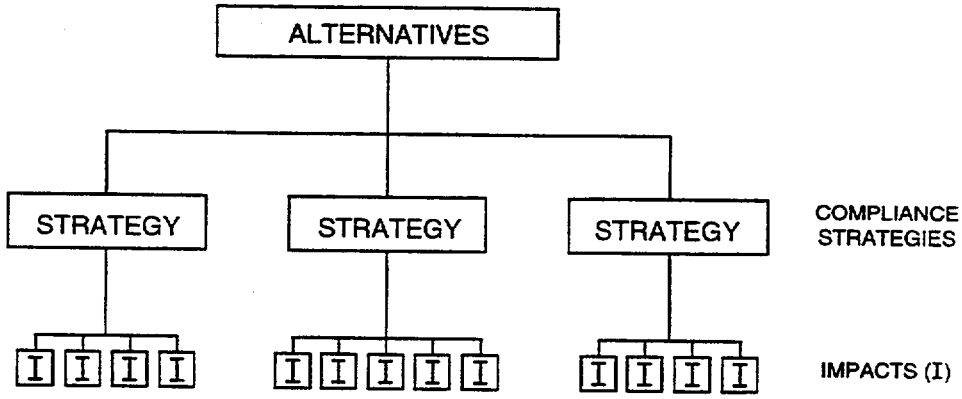


FIGURE 4.1
RELATIONSHIP BETWEEN ALTERNATIVES AND IMPACTS FOR PROJECT-SPECIFIC ENVIRONMENTAL IMPACT STATEMENTS AND THE GROUND WATER PROJECT PEIS

- Visual resources
- Transportation
- Social and economic resources
- Environmental justice
- Utilities and energy resources
- Waste management
- Estimated costs.

Mitigation of the potential impacts analyzed in this section are discussed under each appropriate resource category subheading. Descriptions of the mitigation measures are general. For example, contaminated wastewater produced during ground water remediation would be treated to meet the requirements of a National Pollutant Discharge Elimination System (NPDES) Permit before the water is released into the environment. Other examples are mitigation plans for impacts that may occur to archeological resources or threatened and endangered species. Under all the alternatives except no action, when a site-specific ground water compliance strategy is proposed, its environmental impacts would be assessed in the site-specific environmental documents and specific mitigation measures would be recommended.

4.1 SITE CHARACTERIZATION AND MONITORING IMPACTS ANALYSES

Ground water characterization would be performed to describe the ground water characteristics at the UMTRA Project sites. This characterization would take place under all the alternatives except the no action alternative. Site characterization data would also be used to prepare and/or update the site-specific risk assessments. These risk assessments, ground water characterization, and input from affected tribes, states, and public would be used to determine the appropriate ground water compliance strategy. Monitoring would take place to determine the effectiveness of the ground water compliance strategy and to protect human health.

Field site characterization activities would consist primarily of drilling boreholes and installing monitor wells; sampling ground water, surface water, soil, and other media; and conducting geophysical surveys and aquifer tests. Some of these activities, such as drilling boreholes, would require clearing small amounts of land (e.g., less than 1.0 ac [0.4 ha]) and developing or improving access roads to site areas (if necessary), while other activities such as collecting surface water samples would not result in any environmental disturbance. The potential environmental impacts associated with these types of field activities discussed below are based on the descriptions of site characterization activities in Section 2.8. Table 4.2 summarizes field activities that could affect the environment.

No disproportionally high or adverse human health or environmental effects would occur to minority or low-income populations due to site characterization or monitoring because the impacts of site characterization are minor or nonexistent.

Table 4.2 Hydrogeologic data collection activities and potential environmental effects

Field activity	Objective	Potential environmental effect
Drilling/monitor well installation, core sampling	Ground water sampling, hydraulic parameter data collection, geologic data collection.	Small amount of surface clearing for each location (less than 1.0 ac [0.4 ha]); access road construction; contaminated cuttings and ground water generation requiring proper disposal.
Ground water sampling	Water quality determination.	Contaminated ground water generation requiring proper disposal.
Soil sampling—test pits or soil borings	Unsaturated and saturated zone contamination determination; attenuation determination.	Small amount of surface clearing (less than 1.0 ac [0.4 ha]); contaminated soil requiring proper disposal.
Geophysics	Depth to bedrock, depth to ground water, other hydrogeologic information. Zones of ground water contamination.	Small amount of surface clearing for survey grid; access road construction.
Aquifer testing	Determination of aquifer parameters.	Contaminated ground water generation requiring proper disposal.

Table 4.3 summarizes the potential impacts of site characterization and monitoring activities. Impacts associated with these activities are minor and generally short-term. The construction and use of access roads may generate dust, which may require the use of dust suppressants. Site characterization aquifer tests may pull contaminated ground water into uncontaminated areas; these tests would be conducted in areas where the possibility of such an impact is remote. Potential impacts on ecological or cultural/traditional resources would also be unlikely because site characterization facilities would be located away from sensitive areas such as wetlands or archaeological sites. Potential visual impacts may arise from the long-term use of monitor wells. However, these potential impacts could be reduced by using flush-mounted monitor wells or landscaping. There is the potential for the active remediation to background levels alternative to have a greater chance of affecting resources in the floodplain of rivers due to its reliance on the active ground water remediation strategy. However, these potential impacts could be mitigated by conducting activities outside the floodplain or implementing erosion control measures. The potential for site characterization activities to impact the remaining resources listed in Table 4.3 is also unlikely.

Table 4.3 Potential environmental impacts associated with ground water site characterization and monitoring activities

Resource category	Potential impact
Human health	The potential for unauthorized personnel to enter the site characterization work area would be controlled and workers would be trained in appropriate health and safety procedures. Consequently, human health impacts are not expected.
Air quality	Dust emission would be minor and temporary. In situations when such emissions would be excessive, dust suppressants could be applied.
Surface water	Ground disturbance activities could result in erosion into a surface water body. Facilities would be placed well away from surface water bodies. If this were not possible, erosion control measures such as silt fences or hay bales would be used to control erosion.
Ground water	Aquifer tests could pull contaminated ground water into uncontaminated ground water. This would be avoided by conducting aquifer tests where this situation could not occur.
Ecological resources	Only small amounts of land would be disturbed. Facilities would be situated well away from sensitive ecological areas such as wetlands.
Land use	Installation of monitor wells and temporary land disturbances from soil borings and test pits would have a minor, short-term impact on land and land use.
Cultural/ traditional resources	Cultural resource surveys and contacts with appropriate tribal groups would be conducted before land disturbance activities begin. Cultural/traditional resources would be avoided where possible. If significant resources could not be avoided, a mitigation plan would be prepared in consultation with the State Historic Preservation Officer, tribal officer, or applicable agency.
Background noise	Site characterization may result in a slight and temporary increase in noise.
Visual resources	Site characterization and monitoring may impact visual resources. Flush-mounted monitor wells and landscaping will be used, as necessary, to reduce visual impacts.
Transportation	Site characterization would result in an occasional slight increase in local traffic at the sites. This increase is not expected to affect local traffic use patterns in the site area.
Social and economic	A few temporary jobs associated with drilling wells or digging test pits could be created during site characterization. This may result in a minor temporary benefit to the local economy. No other social or economic impacts would be expected.
Environmental justice	No disproportionally high or adverse effects would be expected because impacts are minor or nonexistent.
Utilities and energy resources	Electricity and fuel would be needed for some site characterization activities. Use of these resources would not be expected to affect local energy resources due to the small scale of activities and short duration of work.
Waste management	Liquid and solid waste could be generated from contaminated well purge water and cuttings. Any contaminated material generated would be managed in accordance with appropriate regulatory requirements.

4.2 GROUND WATER COMPLIANCE STRATEGY IMPACTS

This section addresses the potential impacts associated with the ground water compliance strategies. Some or all of these strategies would be used in three alternatives: the proposed action, the active remediation to background levels alternative, and the passive remediation alternative (Section 2.0). Information collected during the Surface Project pertains to some of the resources analyzed below (e.g., wetlands and cultural/traditional resources). This information is used, where appropriate, to indicate the potential impacts of the Ground Water Project. The actual site-specific impacts of applying these strategies would be addressed in the site-specific NEPA documents.

4.2.1 Active ground water remediation methods impacts

As summarized in Section 2.8.2 and provided in detail in Appendix C, active ground water remediation methods include ground water extraction, gradient manipulation, and *in situ* treatment. Currently, there is insufficient information to predict how many sites would require active ground water remediation under the proposed action, although it is expected that a few sites would. Under the alternative of active remediation to background levels, active ground water remediation would be the major ground water compliance strategy. Active ground water remediation would not be used under the passive remediation alternative.

Active methods would involve ground disturbance activities such as constructing wells and access roads or installing utilities and water treatment facilities. The following sections identify the potential impacts of active ground water remediation methods.

4.2.1.1 Human health

Certain active ground water remediation methods could generate contaminated water or sludge. If the contaminated water were discharged to a surface water body, an NPDES permit or other types of permits may be required to protect human health and the environment. Contaminated sludge would be handled so as to reduce risk of worker exposure and would be disposed of in accordance with applicable regulations. The management of potential waste streams is discussed in more detail in Section 2.9.

A risk assessment would be performed to assess the potential effects to human health of applying nitrogen-rich ground water to agricultural crops. This method involves adding high-nitrate ground water directly on the land or to irrigation water. This water could be treated prior to land application if it contained high levels of undesirable constituents, such as heavy metals or salts. Furthermore, if the risk assessment indicated that land application was not protective of human health, this method would not be used.

The use of active ground water remediation methods could result in injury to workers. This risk would be greatest when workers would be using heavy equipment. The potential for worker injury is minimal because of the short construction period (up to a few months) and the small number of worker-years of labor required (5.0 to 10 worker-years). Following construction, the potential for these types of impacts would exist but be reduced during operation of the active ground water remediation facilities because workers would be trained in health and safety procedures and only a small staff would be needed to operate remediation facilities and equipment.

Active ground water remediation could take many years and a potential exists for the use of contaminated ground water. This potential risk would be minimized because monitoring would likely identify potential risks before they occur and institutional controls could be used to limit access to contaminated ground water.

4.2.1.2 Air quality

Dust could be generated from heavy equipment and earth-moving activities as remediation facilities and access roads are constructed. An air quality permit may be required for some construction activities. An air quality permit would provide information on the potential for generating dust and on mitigation measures to keep dust emissions below air quality standards (such as applying water or other dust suppressants). The potential for dust emissions to exceed the standards is unlikely because the construction activities would be temporary and mitigation measures would be used, if necessary, to reduce fugitive dust.

This impact would be short-term, occurring during construction activities. Dust would be minimal during facility operations because there would be no dirt-moving activities. Some fugitive dust could be generated by workers driving on unimproved access roads. Water or some other dust suppressant would be applied, if necessary, to control dust.

The EPA's priority air pollutants, including sulfur oxides and nitrogen oxides, would be emitted from construction equipment during construction of ground water remediation facilities. Studies for the UMTRA Surface Project show that these emissions form a small portion of the total emissions inventory and that the air quality standards are not exceeded (DOE, 1987b). Therefore, the operation of active ground water remediation facilities is not expected to result in exceedance of the EPA standards for these air pollutants. The potential for extracted contaminants to become airborne from the treatment processes is minimal because the contaminants at the UMTRA Project sites are not volatile, and any solid waste would be disposed of in an approved disposal facility.

4.2.1.3 Surface water

During ground water remediation, potential impacts to surface water could occur but would be reduced or eliminated by implementing best management practices.

Ground water remediation facilities would produce water that may be discharged into a nearby stream or river after the water is treated to remove contaminants. If plans called for this type of discharge, an NPDES permit would be obtained that would stipulate appropriate treatment, monitoring, and reporting requirements. This permit would ensure that the water discharged into a surface water body would have minimal impacts. In addition, a storm water permit may be required.

4.2.1.4 Ground water

Active remediation methods that extract contaminated ground water may cause lateral ground water flow. Lateral flow could mix contaminated ground water with uncontaminated ground water, reducing contaminant concentrations (thus expediting the achievement of remedial goals) but increasing the total volume of contaminated water. Ground water extraction could have a negative impact by depleting an aquifer that is or has the potential to be a ground water resource.

Ground water extracted from contaminated aquifers may be treated, then reinjected into deeper aquifers or in the same aquifer upgradient of the contaminant plume. The quality of the treated ground water would be monitored prior to injection to reduce or eliminate potential adverse affects on the quality of the ground water into which it is injected. At some sites, an NPDES permit would be required to discharge this treated water into an aquifer.

4.2.1.5 Ecological resources

Site-related contaminants in ground water are known to be entering the surface water at some sites. During active ground water remediation, contaminants from this ground water would continue to enter the aquatic and terrestrial ecosystems, negatively impacting the resources. In the long term, active ground water remediation would reduce or eliminate this source of contaminated ground water entering the environment.

Under some active methods, treated ground water could be discharged to the land (e.g., water with high nitrate concentrations). The potential risks of discharging this water into the environment would be determined to ensure there is no unacceptable ecological risk.

Construction of ground water remediation facilities would have a short-term adverse impact, resulting in the clearing of plant communities and wildlife habitat. The amount of habitat that would be cleared at a site typically would be small (up to 20 ac [8.0 ha]), and active cleanup would last from a few

months to 10 years or more. Once ground water cleanup activities were complete, most of the facilities and access roads would be revegetated with native species and returned to their approximate pre-remedial action conditions. Revegetation back to a grassland or grassland-shrub plant community would take approximately 2.0 to 5.0 years, depending on the plant community type and climate conditions. As can be seen by the annual precipitation statistics shown in Table 3.2, most UMTRA Project sites are in arid and semiarid climates. Revegetation at sites with these types of climates would likely need mulch and irrigation to be successful.

Construction and operation of ground water remediation facilities could create dust, noise, and human activity, which could indirectly affect habitat adjacent to the direct impact area. However, these impacts would be minor due to the low level of human activity (only a few personnel would be at the site) and the low intensity of operational activities.

Active ground water remediation could negatively impact sensitive habitats such as wetlands, riparian areas, and aquatic habitat. These types of habitats are common at and near the UMTRA Project sites, as documented in Section 3.2; 22 of the sites are near aquatic habitat, while wetlands occur at 18 of the sites (Table 3.2). Placement and construction of facilities could affect these sensitive areas, and pumping ground water may dry up wetlands and lower water levels in other aquatic habitat. Usually, remediation facilities could be placed away from sensitive habitats to reduce potential adverse effects. If sensitive areas such as floodplains or wetlands would be affected, the disturbed area would likely be small and the duration of the impact would be short-term (during construction and remediation). These areas would be returned to preconstruction conditions after ground water remediation is complete. A floodplain/wetlands assessment would be prepared consistent with 10 CFR Part 1022, *Compliance With Floodplains/Wetlands Environmental Review Requirements*, and a U.S. Army Corps of Engineers Section 404 Permit application would be prepared if wetlands under the jurisdiction of the Corps of Engineers were affected. Ground water characterization and data analysis would be used to determine whether ground water extraction would lower the water levels in aquatic habitats. If such an impact were predicted, the active ground water remediation would be altered to avoid this impact. In addition, monitoring during remediation would ensure that drawdowns in sensitive habitats would be detected and corrective action taken.

Threatened and endangered species or other species of concern occur at or near 14 of the UMTRA Project sites (Table 3.2). Active ground water remediation methods could adversely affect these species directly through habitat destruction or indirectly through human activity adjacent to the direct impact zone. In addition, pumping water from aquifers that are hydrologically connected to rivers could adversely affect threatened or endangered fish and/or their critical habitat. The DOE would consult with the Fish and Wildlife Service during the preparation of the site-specific NEPA documents. If impacts to threatened and endangered species were unavoidable, formal consultation with

the Fish and Wildlife Service would be initiated and a biological assessment would be prepared.

Construction of ground water restoration facilities, possibly resulting in sediment runoff into surface waters, could adversely affect aquatic resources. Increased sedimentation in surface waters would degrade water clarity, thereby affecting the aquatic food chain. The potential for this type of impact would be slight because erosion protection measures would be implemented, where required, to prevent sediment runoff.

4.2.1.6 Land use

Active ground water remediation methods would require that land be used to construct facilities such as water treatment plants and retention ponds. This would preclude use of the land for other purposes during remediation. This potential negative impact could be short-term (a few months to a year) or long-term (up to 10 years), depending on the ground water remediation objectives and the method used.

In certain cases, the contaminant plume may extend outside the active ground water remediation work zone, and it would be necessary to restrict human access to contaminated ground water during active remediation. These controls could limit the uses of the land to such activities as grazing and prevent other uses such as home construction. In some cases, restriction could preclude any use of the land until compliance with EPA standards is achieved. This impact could be short- or long-term, depending on the goals, methods, and duration of ground water remediation. The potential adverse impacts of institutional controls are discussed in greater detail in Section 4.2.2.6. There is the potential for long-term positive impacts because once the ground water meets the EPA standards, there may be opportunities for more land uses.

4.2.1.7 Cultural/traditional resources

Construction of active ground water remediation facilities could affect cultural resources (for example, archaeological, historic, or Native American traditional areas). The potential for such resources in the area of the UMTRA Project sites is high; during the Surface Project it was determined that there are cultural resources at 11 sites (Table 3.2). The DOE would conduct additional surveys for cultural resources before site-disturbing activities took place in areas that have not been surveyed. Appropriate tribal groups would be contacted regarding the existence of traditional-use areas. Efforts would be made to avoid placing facilities at or near identified cultural/traditional resources. If a site were considered significant (that is, eligible for inclusion on the National Register of Historic Places) and disturbance could not be avoided, the DOE would consult with the State Historic Preservation Officer or tribal officials and other applicable agencies to identify appropriate mitigation.

Water resources, ground water, and seeps have religious significance to many Native Americans. These resources often have ceremonial significance or may be associated with traditional, symbolic plants. The contamination of these resources at the UMTRA Project sites is a negative impact. The remediation of contaminated ground water quality would be a positive benefit.

4.2.1.8 Background noise

Noise from heavy equipment would occur during construction of facilities. If warranted, noise prediction models would be used to determine any increase above background noise. If noise levels were determined to be unacceptable (that is, above EPA hearing protection levels), mitigation measures would be implemented (EPA, 1974). However, potential impacts associated with higher noise levels likely would be minor, given the small scale of the construction operations, and would last only during construction of remediation facilities. Facilities such as ground water extraction wells and water treatment plants would emit noise.

4.2.1.9 Visual resources

Water treatment facilities and retention ponds could be visible from a few months to decades. Impacts on visual resources depend on the extent to which the landscape would be changed by new structures, the scenic value of the landscape, and the potential number of viewers. Facilities constructed in urban areas would be seen by more people; however, urban facilities would be less likely to contrast with the surrounding area. In rural areas, new facilities would be more obtrusive but, in general, fewer people would see the landscape change.

Significant visual resource impacts from remediation facilities are not expected because most facilities would be located on or near a processing site that was already disturbed. Once ground water remediation activities were complete, remediation facilities would likely be removed and the land would be recontoured and revegetated to approximate preoperational conditions.

Monitor wells used during site characterization, ground water remediation, and monitoring may have a visual impact, particularly on residents near the sites. The DOE would work with local landowners, residents, tribes, and states as necessary to reduce potential visual impact, using such measures as flush-mounted monitor wells or landscaping.

4.2.1.10 Transportation

Construction of ground water remediation facilities would involve movement of heavy equipment and increases in traffic from commuting workers. Most of the heavy equipment movement would be on the site and would not increase traffic on local roads. The occasional off-site trip and worker commuting trips would increase traffic levels on local roads. The level of impact would depend on

current traffic volumes in the area, load capacity, and the number of additional trips that would result from facility construction. Significant impacts on local traffic patterns are not expected because the construction work force would be small and construction activities would be temporary. Traffic control measures could be implemented if necessary to reduce transportation impacts (for example, traffic lights or turn lanes). During facility operation, the work force would be smaller and potential transportation impacts would be less than during construction.

4.2.1.11 Social and economic resources

Social and economic impacts typically derive from increased employment and circulation of additional monies into local and regional economies as a result of UMTRA Project development. The extent of these impacts depends on the type and level of employment generated by a project. Often these impacts are beneficial, particularly in rural areas with lower employment levels and less diverse economies because Project development offers opportunities for local hiring and an expansion of the local economy. Negative impacts occur when there is a demand for a large work force but few workers are available locally, causing a large, abrupt influx of workers and their families into a community. Social and economic impacts generally occur in four interrelated categories: demographics, employment, economy, and community facilities and services.

Construction and operation of the ground water remediation facilities would minimally increase employment and opportunities for local hiring, particularly during construction. Data from UMTRA Surface Project sites show about 80 percent of the remedial action work force commutes from within 60 mi (100 km). This increased employment would last only during the construction phase. It is expected that fewer, more technically skilled people would be required during facility operation. Workers who relocated during facility operation would be more likely to bring families than construction workers whose employment duration is shorter. The level and extent of impacts on housing, community services, and facilities would depend on the number of workers who relocated with their families and the ability of communities to absorb them. Because operation work force requirements would be small (less than five workers), local communities probably could accommodate their needs for housing, community services, and facilities (for example, schools, fire, and police protection).

Facility construction and operation would temporarily benefit the local and regional economies. This would result from UMTRA Project purchases of goods and services (for example, construction supplies, gasoline, and automotive service contracts); wages paid to employees that are recirculated; and income from employment created by direct and indirect Project-generated monies (that is, as more project money was spent on goods and services, additional employment would be generated to provide these goods and services).

The extent of these economic benefits depends on the number of workers required and the extent to which Project-related materials, supplies, and services are available locally. These beneficial impacts would likely be small given the small work force required for construction and operation of active gound water remediation facilities.

The use of land for active ground water remediation facilities and land use restrictions from institutional controls may reduce the property values of the affected land or limit the types of activities that can take place on the land. These impacts would last for the duration of the active remediation. However, when the ground water is cleaned up, property values that had been devalued due to contamination or construction could be restored and higher or more intense land uses may be possible.

Extracting ground water from aquifers that are a ground water resource has the potential to impinge on the water rights of the users of the aquifer. This could affect uses for agricultural, industrial, and other purposes. During the preparation of the site-specific environmental assessment, the DOE would consult with the tribal water authority or state engineer to determine if such an impact exists.

4.2.1.12 Environmental justice

No disproportionately high or adverse human health or environmental effects to minority or low-income populations would be expected under the active ground water compliance strategy because ground water would likely meet regulatory standards.

4.2.1.13 Utilities and energy resources

It is expected that local utilities would supply electricity, gas, and telephone services during the construction and operation of ground water remediation facilities. In urban areas, water needed during construction likely would come from existing water supply systems; in rural areas, water likely would come from wells or rivers. Because ground water remediation methods are relatively small-scale operations, local utilities probably could meet these short-term Project needs.

Construction equipment would use petroleum products during construction and fuel-powered generators may be used during facility operations. The greatest amount of energy would be used during construction because heavy equipment would be needed to build the facility. Impacts would be minimal, due to the short construction period and the operation's small scale. Energy use during operation would also be minimal due to the low level of activity that would take place.

4.2.1.14 Waste management

The following contaminated materials could be generated during site characterization, operations, and monitoring under the active remediation strategy: well development water, drill cuttings and drilling muds, purge water, sludge and brine, and contaminated ground water and soils. These materials would be analyzed. Based on this analysis, solid material such as mud or soil would be applied to the land or disposed of in a disposal facility such as an existing open UMTRA Project cell capable of accepting these materials. Contaminated water would be treated, if necessary, and applied to the land, reinjected to the ground water, or discharged to surface water, after permits are received. Section 2.9 provides more details on the management of contaminated materials.

Potential adverse impacts on human health or the environment from the generation, treatment, storage, or disposal of contaminated materials are not expected because all such activities would be performed in compliance with applicable regulations and guidelines that were developed to be protective of human health and the environment. However, human error could result in environmental impacts.

4.2.1.15 Estimated costs

As indicated in Section 2.10, activities such as the preparation of baseline risk assessments, site observational work plans, and NEPA documents would be prepared for most UMTRA Project sites, regardless of the proposed ground water compliance strategies. The active remediation compliance strategy also would include site characterization, monitoring, and revisions to site observational work plans; field management, capital equipment, and operations costs associated with implementing an active remediation method; and program support throughout the remediation period.

Estimated costs for active remediation to background levels range from $86 million to $162 million per site (escalated dollars) and include all generic cost elements plus costs associated with field management and operation (Foskey, 1995). These cost elements include utility installation, number of wells required, collection systems, installation of water treatment plants, plant operations, testing, land application of water, closure, demobilization, and site restoration. The plant size and length of operations are generated on a site-specific basis using current assumptions of the technical parameters of the plume, soil, and contaminants.

4.2.2 Natural flushing impacts

Natural flushing in conjunction with institutional controls is a potential strategy for meeting the EPA ground water standards. Sections 1.4.1 and 2.8 summarize the natural flushing process and institutional controls.

Natural flushing would likely be the principal ground water compliance strategy used under the passive remediation alternative. Natural flushing would also be used under the proposed action, either alone or in conjunction with active ground water remediation. This strategy would not be available under the active remediation to background levels alternative because this alternative would rely principally on active ground water remediation.

This impact analysis assumes that the criteria required to implement natural flushing are met. However, under the passive remediation alternative, the use of natural flushing at certain sites may not be protective of human health or the environment; compliance may not be accomplished within 100 years as required by the EPA ground water standards; or required institutional controls may not be viable. In these cases, the standards would not be met and the potential for human health or environmental harm exists. At sites that would not comply with the standards within 100 years, institutional controls and monitoring would be required for more than 100 years; this would not meet the EPA ground water standards and would increase the uncertainty in protecting human health and the environment. In addition, natural flushing may not be protective of beneficial uses of the ground water, such as irrigation or livestock watering. The potential impacts on resources of applying natural flushing under these circumstances are discussed in Section 4.4.

4.2.2.1 Human health

Ground water remediation using natural flushing may result in human exposure to contaminated ground and/or surface water. However, the probability of such an exposure is remote because the following conditions must be met before natural flushing can be used:

- The contaminated aquifer must not be a source for a public drinking water system.
- The concentrations of hazardous constituents must meet the EPA standards within 100 years.
- Any institutional controls relied on to control exposure must be effective and enforceable throughout the natural flushing period.

To ensure continued protection, ground and surface water monitoring, as needed, would take place during the natural flushing period.

4.2.2.2 Air quality

The installation of monitor wells or construction of institutional control structures such as perimeter fences could generate small amounts of dust. This impact would be minor and short-term, lasting only during construction or installation. The potential for air quality impacts from other priority pollutants

would be remote, given the limited use of construction equipment needed for establishing and maintaining institutional controls.

4.2.2.3 Surface water

During the natural flushing period, contaminated ground water could discharge into surface water bodies such as springs and wetlands. Before implementing natural flushing, the DOE would evaluate the potential for such a discharge. If it were determined that such a discharge may take place and threaten human health and the environment, natural flushing probably would not be a viable ground water compliance strategy. If it were determined that the potential for such a discharge would be remote, this strategy may be viable. However, because the natural flushing period could last up to 100 years, there would be an increased potential for surface water bodies to be affected within this time period. Monitoring would take place during natural flushing, and if monitoring indicated that surface water bodies were being contaminated, an additional risk assessment may be performed. If the contamination levels were not protective of human health or the environment, active remedial action may be undertaken. Institutional controls would be required to control access to areas where surface waters were contaminated.

4.2.2.4 Ground water

Ground water remediation from natural flushing would most likely be slower than active remediation methods. Hazardous constituent concentrations in the plume that exceed the standards would be reduced to meet background levels, maximum concentration limits, or alternate concentration limits during the natural flushing period. The potential for contaminated ground water to affect uncontaminated areas is site specific. There are three general cases: 1) geochemical attenuation limits plume migration and additional ground water contamination is unlikely or would be minimal, 2) the plume has already reached a discharge point and thus the maximum extent of ground water contamination has already occurred, and 3) the plume is migrating and dispersing through the aquifer system with potential for additional ground water contamination. Ground water monitoring would identify any expansion of the ground water plume. Corrective measures, such as expanding the institutional controls area, may be required.

4.2.2.5 Ecological resources

Natural flushing would have minimal impact on wildlife and aquatic and sensitive habitats. The major activity associated with this strategy is the application of institutional controls. Fencing to supplement other controls could positively impact wildlife and aquatic habitat because activities such as grazing, which can degrade these habitats, may be prevented. However, fencing could negatively impact certain species of wildlife by blocking migration corridors and improperly constructed fences could cause wildlife mortality. These impacts could be minimized by installing fences designed to accommodate wildlife needs.

The low levels of human activity are not likely to result in a negative impact on threatened and endangered species. However, the DOE would consult with the Fish and Wildlife Service during preparation of the site-specific NEPA documents to determine whether threatened and endangered species are known to occur in the area.

The potential for contaminated ground water to be released into the environment during the natural flushing period would be evaluated in an ecological risk assessment to determine whether natural flushing would be protective of the environment. This assessment would consider existing and potential future releases of contaminated ground water into the environment. If there were no risk or there were acceptable risks, natural flushing could be implemented if all other requirements were also met. However, as the length of a natural flushing period increases, so does the potential for contaminated ground water to enter the environment. A ground water and surface water monitoring program would be conducted during the natural flushing period, and any releases of contaminated ground water into the environment would be detected. If contaminated ground water were released into the environment, an ecological risk assessment may be performed. If the risks from such a release were unacceptable, active remedial action may be initiated.

4.2.2.6 Land use

The EPA ground water standards require that institutional controls be implemented to limit access to a contaminated aquifer during natural flushing. These institutional controls would be used to restrict the use of the land above the contaminated aquifer. The types of institutional controls used depend in part on the extent of the ground water contamination and the potential for ground water use. These controls could involve posting information warnings on private land, purchasing an interest in the land, preventing access to the land through fencing, or imposing land or water use restrictions. The potential impacts of institutional controls on land use would be restricted use of land and decreased property values. These impacts would be minimal at the UMTRA Project processing sites, because use of these sites is currently restricted in most cases. Impacts could occur outside processing site boundaries, but as the ground water contamination is reduced over time, the restrictiveness of the institutional controls may be reduced.

4.2.2.7 Cultural/traditional resources

Potential impacts to surface cultural resources would be minor because little if any site-disturbing activity would take place. Installation of fencing or monuments (institutional controls) would likely be the most intensive activity. Cultural resource surveys would be performed prior to site-disturbing activities and appropriate tribal officials would be contacted to identify and evaluate cultural or traditional resources that may be affected. In most cases, fencing and monuments could be located to avoid cultural resource sites.

Water is a traditional resource of significance to many Native Americans. These resources often have ceremonial significance, and surficial expressions such as seeps may be associated with traditional, symbolic plants. Remediation of contaminated ground water by natural flushing would have a positive impact on this resource. Impacts to this Native American traditional resource would be reduced as natural flushing progressed.

4.2.2.8 Background noise

Natural flushing would not affect background noise levels in the site area because no noise-generating activities would occur except for brief periods during the construction of some types of institutional control features.

4.2.2.9 Visual resources

Natural flushing could result in the use of signs, monuments, or fences to control human land use above the contaminated aquifer. These measures typically would be unobtrusive (small and low to the ground), resulting in minor (if any) impact on visual resources. In areas of scenic beauty, structures used to implement institutional controls (such as fences) could negatively impact visual resources.

Monitor wells used during site characterization, ground water remediation, and monitoring may have a visual impact, particularly on residents near the sites. The DOE would work with local landowners, residents, tribes, and states where necessary to reduce this potential visual impact through the use of such measures as flush-mounted monitor wells or landscaping.

4.2.2.10 Transportation

During the operational phase, the only traffic would be for water quality monitoring and monitoring to verify that institutional controls were working as planned. There would be no transportation impacts from these activities.

4.2.2.11 Social and economic resources

No impacts on demography, employment, community services, or facilities would be expected if natural flushing were implemented, because essentially no activities associated with this strategy would require a work force. Institutional controls may require occasional maintenance and monitoring. There could, however, be a slight, short-term beneficial impact to the local economy from local workers or subcontractors who may install land access controls (for example, fencing).

Institutional controls that restrict land use could represent an economic loss to a property owner by precluding a higher use of the land. For example, grazing might be allowed within an area of institutional control, but a more intense (and potentially profitable) use of the land, such as crop production or residential use,

may not be allowed. In some cases, the land could be restricted from any use during the period of natural flushing. The extent of the potential adverse economic impact would depend on the type and duration of the land use restrictions and the reasonable alternative uses of the land that could be precluded because of the institutional controls.

4.2.2.12 Environmental justice

Minority or low-income populations would not experience disproportionately high or adverse environmental impacts if criteria for natural flushing are met. However, under the passive remediation alternative, it is possible that the criteria would not be met and that natural flushing would not be protective of human health and the environment at some sites (see Section 4.2.2). For sites that have minority or low-income populations, there would be a potential for disproportionately higher impacts to human health and the environment.

4.2.2.13 Utilities and energy resources

Natural flushing would not affect utilities or energy resources because no activities would occur that would require the use of these resources.

4.2.2.14 Waste management

Contaminated materials that could be generated during site characterization and monitoring under the natural flushing strategy include well development water, drill cuttings and drilling muds, purge water, sludge and brine, and contaminated ground water and soils. These materials would be analyzed. Based on this analysis, solid material such as mud or soil would be applied to the land or disposed of in a disposal facility such as an existing open UMTRA Project cell capable of receiving these materials. Contaminated water would be treated, if necessary, and applied to the land, reinjected to the ground water, or discharged to surface water, after permits are received. Section 2.9 provides more details on the management of contaminated materials.

Potential adverse impacts on human health or the environment are not expected from the generation, treatment, storage, or disposal of contaminated materials because all such activities would be performed in full compliance with applicable regulations and guidelines that were developed to be protective of human health and the environment. However, human error could result in environmental impacts.

4.2.2.15 Estimated costs

Activities associated with natural flushing include all the generic activities, additional site characterization, new wells, and revisions to site observational work plans. Natural flushing would likely require the use of institutional controls. This strategy would likely result in a longer monitoring period than the other two strategies. Estimated costs for the natural flushing compliance

strategy range from $14 million to $24 million per site (escalated dollars) and include all generic costs associated with this strategy.

4.2.3 Impacts from applying supplemental standards or alternate concentration limits at no remediation sites

Ground water at some UMTRA Project sites may exceed maximum concentration limits or background levels and yet require no remediation because the sites would qualify for supplemental standards or alternate concentration limits. Supplemental standards or alternate concentration limits could be used in combination with active ground water remediation methods and/or natural flushing to achieve compliance with the EPA ground water standards. For example, active remediation methods may be used to protect beneficial uses at a site that would otherwise qualify for supplemental standards. However, the analysis in this section considers only potential impacts from applying these standards at the no remediation sites; refer to Sections 4.2.1 and 4.2.2 for discussions of potential impacts of active ground water remediation methods and natural flushing.

Supplemental standards and alternate concentration limits are described in Section 1.4.1. Eight criteria are available for applying supplemental standards. The occurrence of limited use ground water is the criterion that likely would be used most frequently to justify the application of supplemental standards for the UMTRA Ground Water Project. However, site-specific uses of ground water from limited use wells, if any, would be carefully evaluated when a supplemental standards application is prepared. Limited use ground water refers to water from units that have poor background quality or low yield (less than 150 gal [570 L] per day). Supplemental standards based on limited use ground water would not involve ground-disturbing activities. Other criteria for applying supplemental standards that may be used on the UMTRA Ground Water Project include 1) protection of the environment from excessive harm, 2) there is no known remedial action, and 3) inability to perform remedial action because it is technically impracticable. The use of supplemental standards may require monitoring or the use of some form of institutional controls to prevent access to contaminated ground water. The DOE UMTRA Ground Water Project would likely not use the remaining criteria listed in Section 1.4.1.

A risk evaluation would be performed to determine whether the use of supplemental standards would be protective of human health and the environment. In all cases, a supplemental standards application would require NRC concurrence, state participation, and consultation with Indian tribes to become effective.

The use of alternate concentration limits would also require an application that would need NRC concurrence, state participation, and consultation with Indian tribes. A risk evaluation would have been performed to demonstrate that an alternate concentration limit would be protective of human health and the

environment. This analysis also assumes that potential environmental impacts may be associated with using alternate concentration limits.

The no remediation ground water compliance strategy would likely be used under all the alternatives except the no action alternative. There are two categories of no remediation sites. One category refers to sites where there is no ground water contamination above maximum concentration limits and/or background levels. Under the proposed action and the passive remediation alternative, this no remediation strategy would be appropriate at such sites. Under the active remediation to background levels alternative, this strategy may be appropriate if all the constituents are at background levels; it would not be appropriate for constituents below the maximum concentration limits but above background levels.

The second category under the no remediation ground water compliance strategy refers to sites that have contamination above background levels and/or maximum concentration limits but are eligible for supplemental standards or alternate concentration limits. The sites that would be eligible for this no remediation strategy under the proposed action would also be eligible under the passive remediation alternative. In addition, some of these sites would be eligible for the no remediation strategy under the active remediation to background levels alternative. At some sites, no remediation in the form of supplemental standards based on the existence of limited use ground water could be part of the active remediation to background levels alternative.

The following analysis includes the potential impacts of applying supplemental standards and of applying alternate concentration limits.

4.2.3.1 Human health

For successful application of supplemental standards or alternate concentration limits, a risk evaluation must show that these standards would be protective of human health and the environment. Monitoring or institutional controls may be required if alternate concentration limits or supplemental standards are used. Monitoring may be required to assess the degree and extent of ground water contamination to ensure that supplemental standards and alternate concentration limits remained protective of human health and the environment. Institutional controls may be used if, for example, it were technically impracticable to clean contaminated ground water, but controls were required to prevent its inadvertent use. Consequently, the likelihood of human exposure to contaminated ground water and the surface expression of this water at sites that met supplemental standards or alternate concentration limits would be remote.

4.2.3.2 Air quality

Dust and priority pollutant emissions would not result from the application of supplemental standards or alternate concentration limits because few or no ground-disturbing activities would occur.

4.2.3.3 Surface water

The potential for discharge of contaminated ground water into surface water bodies would be unlikely. As indicated in Section 4.2.3.1, a monitoring program may be required for the use of some supplemental standards and for alternate concentration limits, that may include sampling surface water bodies. If contamination were discovered, further evaluation would be undertaken and remedial action performed if required.

4.2.3.4 Ground water

The application of supplemental standards would have little or no impact on ground water at sites that qualify for supplemental standards based on the presence of limited use ground water. Contaminated ground water at sites that qualify for supplemental standards based on other criteria or alternate concentration limits could contaminate less contaminated or noncontaminated ground water. Ground water monitoring may be required to assess this possibility under these supplemental standard criteria or alternate concentration limits.

4.2.3.5 Ecological resources

If supplemental standards or alternate concentration limits were applied, terrestrial and aquatic ecological habitat disturbance would be minimal because few or no ground-disturbing activities would occur.

As part of the supplemental standards and alternate concentration limits application processes, an ecological risk evaluation may be prepared or updated to determine the potential for contaminated ground water to result in ecological risk. If unacceptable ecological risks could occur, supplemental standards or alternate concentration limits likely would not be proposed. If there were no ecological risks or the risks were acceptable, these standards could be applied if no other factors precluded their use. As indicated in Section 4.2.3.1, a monitoring program may be implemented as part of the supplemental standards and alternate concentration limits applications. If monitoring indicated contaminated ground water from the UMTRA Project site had been released into aquatic habitats such as wetlands and springs, another ecological risk evaluation may be performed. If the results of this evaluation indicated unacceptable risk, remedial action might be required.

4.2.3.6 Land use

Little or no ground-disturbing activity would occur if supplemental standards or alternate concentration limits were applied. The only activity that would potentially affect land use would be the use of institutional controls.

Institutional controls may be implemented if the limited use criterion were used to apply for supplemental standards. These types of controls also may be required if another criterion (such as excessive environmental harm or the technical impracticability of ground water remediation) were used, or if alternate concentration limits were applied. The potential impacts on land use associated with the use of institutional controls are discussed in Section 4.2.2.6.

4.2.3.7 Cultural/traditional resources

There would be no impacts to surface cultural resources because no surface disturbance would take place. Minor surface disturbance would occur if institutional controls were used in conjunction with supplemental standards. The potential impacts of institutional controls on cultural resources are discussed in Section 4.2.2.7.

With the application of supplemental standards or alternate concentration limits, contaminants associated with the UMTRA Project would most likely not be removed. Therefore, traditional resource impacts associated with ground water would not be mitigated. However, at sites where supplemental standards were applied using the limited use criterion, the surrounding background ground water quality is poor; therefore, the impact of leaving the contaminated ground water would be minor.

4.2.3.8 Background noise

The application of supplemental standards or alternate concentration limits would not affect ambient noise because no noise-generating activities would take place.

4.2.3.9 Visual resources

Impacts on visual resources would be limited to those associated with site characterization activities (refer to Section 4.1) or the implementation of institutional controls. These potential impacts would be minor and temporary.

Monitor wells used during site characterization, ground water remediation, and monitoring may have a visual impact, particularly on residents near the sites. The DOE would work with local landowners, residents, tribes, and states where necessary to reduce this potential visual impact through the use of such measures as flush-mounted monitor wells or landscaping.

4.2.3.10 Transportation

There would be no transportation impacts if supplemental standards or alternate concentration limits were instituted.

4.2.3.11 Social and economic resources

Supplemental standards or alternate concentration limits would have little impact on social and economic resources because no ground water remediation activities would take place. Potential minor negative economic impacts could result from the implementation of institutional controls (refer to Section 4.2.2.11).

4.2.3.12 Environmental justice

Disproportionately high or adverse effects to minority or low-income populations would not occur if application of supplemental standards or alternative concentration limits were protective of human health and the environment.

4.2.3.13 Utilities and energy resources

Supplemental standards would not affect utilities or energy resources because no activities would occur that require these resources.

4.2.3.14 Waste management

The following contaminated materials may be generated during site characterization and monitoring under the no remediation strategy: well development water, drill cuttings and drilling muds, purge water, sludge and brine, and contaminated ground water and soils. These materials would be analyzed. Based on this analysis, solid material such as mud or soil would be applied to the land or disposed of in a disposal facility such as an existing open UMTRA Project cell capable of receiving these materials. Contaminated water would be treated, if necessary, and applied to the land, reinjected to the ground water, or discharged to surface water, after permits are received. Section 2.9 describes the management of contaminated materials.

Potential negative impacts are not expected to human health and the environment from the generation, treatment, storage, or disposal of contaminated materials because all such activities would be performed in full compliance with applicable regulations and guidelines that were developed to be protective of human health and the environment. However, human error may result in environmental impacts.

4.2.3.15 Estimated costs

Activities associated with the no remediation compliance strategy include the general activities required for the other two strategies, including site

characterization and possible revision of the site observational work plans. This strategy would also require the preparation of supplemental standards and/or alternate concentration limits applications and the concurrence of these applications by the NRC. The estimated cost of the no remediation compliance strategy is $1.0 million to $10.4 million per site, based on 1995 escalated dollars.

4.2.4 Impacts comparison and summary

This summary compares the potential negative impacts of the ground water compliance strategies. The relationship of these potential impacts to the alternatives is presented in Section 4.4. The impacts analysis does not relate to the no action alternative because none of the strategies would be used under this alternative. The potential impacts of the no action alternative are assessed in Section 4.3.

It is anticipated that the impacts that could occur for each strategy (see Table 4.4) would be the impacts analyzed in the site-specific NEPA documents. Based on this analysis, the number of potential negative impacts is highest for the active ground water remediation methods, next highest for natural flushing, and lowest for no remediation sites that meet the standards with supplemental standards or alternate concentration limits (Table 4.4).

4.3 NO ACTION

Under the no action alternative, the UMTRA Project would end with the completion of surface remediation. The DOE would perform no ground water compliance or remediation activities. Evaluation of the no action alternative is required under the NEPA, as it provides a baseline against which impacts of other alternatives can be compared.

4.3.1 Human health

The no action alternative could expose humans to contaminated ground water. Under this alternative, there would be no federally sponsored ground water compliance, remediation, monitoring, or controls over the contaminated aquifers. Although unlikely, exposure could occur in the following ways:

- Using contaminated ground water from water supply wells
- Drilling new water supply wells into contaminant plumes
- Using contaminated surface water for drinking water
- Using contaminated ground water and/or surface water for agricultural purposes, such as irrigation or livestock watering

Table 4.4 Summary of potential impacts of the ground water compliance strategies

Impact	Ground water compliance strategy		
	Active ground water remediation	Natural flushing	No remediation[a]
Human health			
Exposure to contaminated water resources	✓	✓	✓
Risks to workers handling contaminated materials	✓		
Accidents not involving hazardous constituents	✓		
Air quality - Dust emissions	✓	✓	
Surface water			
Surface water contamination from contaminated ground water	✓	✓	✓
Surface water contamination from wastewater	✓		
Ground water			
Expansion of ground water plume into uncontaminated areas	✓	✓	✓
Contaminated wastewater affecting ground water	✓		
Ecological resources			
Habitat disturbance	✓	✓	
Sensitive habitats	✓	✓	
Threatened and endangered species effects	✓	✓	✓
Contamination of biological systems (ecological risk)	✓	✓	✓
Land use - restrictions	✓	✓	✓
Cultural/traditional resources	✓	✓	✓
Background noise	✓		
Visual resources	✓	✓	✓
Transportation	✓		
Social and economic			
Economic benefits (employment, goods, services)	✓	✓	✓
Reduction in property values due to remediation activities or implementation of institutional controls	✓	✓	
Reduction in property values due to contaminated ground water	✓	✓	✓
Water rights	✓	✓	
Environmental justice[b]		✓	✓
Utilities and energy resources	✓		
Waste management	✓	✓	✓

[a]Refers to no remediation sites where ground water contamination exceeds maximum concentration limits or background levels and that qualify for supplemental standards or alternate concentration limits.
[b]Potential negative impacts may occur only if EPA ground water standards are not met.

✓ - an impact could occur.

- Using contaminated surface water for recreational purposes, such as swimming or fishing

- Consuming fish and wildlife exposed to contaminated water.

4.3.2 Air quality

There would be no air quality impacts because no ground-disturbing activities would occur.

4.3.3 Surface water

Under the no action alternative, the discharge of contaminated ground water to surface water bodies (streams, rivers, ponds, wetlands, springs, or arroyos) would continue. In addition, there is the potential for currently uncontaminated surface water bodies to become contaminated. The potential impacts to surface water bodies would be greater in areas of standing water because the hazardous constituents would concentrate in the sediments of ponds or wetlands. The accumulation of contaminants in these aquatic habitats could result in human health and ecological impacts, as discussed in Sections 4.3.1 and 4.3.5.

4.3.4 Ground water

Under the no action alternative, uncontaminated ground water in the same aquifer and other aquifers could become contaminated. This could result in adverse human health and environmental impacts. Under the no action alternative, the continued spread of contaminated ground water and surface water may reduce the beneficial uses of the water, such as drinking, irrigating, or stock watering. These impacts likely would be long-term because there would be no federal program to clean up the ground water; remediation would be accomplished by natural processes that could take decades or longer. The spread of ground water contamination also could result in negative impacts on land use (refer to Section 4.3.6) and to social and economic resources (Section 4.3.11).

4.3.5 Ecological resources

Implementation of the no action alternative would not result in the destruction of wildlife or aquatic habitats because site-disturbing activities would not occur.

Habitats and protected species could be adversely affected if contaminated ground water were discharged to the surface or by plant root uptake of contaminated ground water. Contaminant plumes could surface in sensitive areas such as ponds, lakes, and wetlands that may be hydrologically connected to a contaminated aquifer. Contaminants may accumulate in the sediments and be transported through the food chain and into the terrestrial ecosystems. These contaminants could be taken up by aquatic and/or terrestrial threatened and/or endangered species. Contaminants could also be ingested directly by

humans drinking contaminated water or indirectly by consuming fish, wildlife, or livestock that have ingested contaminated material from the affected habitat. Since there would be no Ground Water Project under this alternative, DOE would not monitor the fate and transport of the contaminated ground water and would take no measures to mitigate potential contamination of sensitive habitats, threatened and endangered species, other biological resources, or livestock.

4.3.6 Land use

The no action alternative could affect land uses because of the potential for access to and use of contaminated ground water. Contamination could spread to wells currently used for agricultural purposes, causing farmers or ranchers to seek alternative water supplies. The no action alternative also could affect agricultural land use (e.g., crops and livestock grazing) due to the potential for plant uptake of contaminated water or if ground water discharged to the surface. More intense uses such as industrial, commercial, or residential development also would be affected. This impact would be long-term and could extend over larger land areas if the contaminated ground water plume expands over time.

4.3.7 Cultural/traditional resources

The no action alternative could affect cultural and historic resources because contaminants associated with UMTRA Project sites would not be removed. Therefore, traditional Native American water resources would be adversely affected by the contaminated ground water. Some Native Americans already consider ground water a cultural/traditional resource that is adversely impacted.

4.3.8 Background noise

The no action alternative would not affect background noise levels near the sites because there would be no remediation activities.

4.3.9 Visual resources

There would be no impact on visual resources from the no action alternative because there would be no remediation activities.

4.3.10 Transportation

The no action alternative would not affect traffic or transportation patterns because no traffic-generating activities would occur.

4.3.11 Social and economic resources

The no action alternative could result in the contamination of ground water currently used for domestic purposes (refer to Section 4.3.1). Replacing

domestic water sources that become contaminated could require drilling new wells, purchasing bottled water, or funding a domestic water supply line.

The potential contamination of domestic and/or agricultural water supplies could adversely affect property values and sales of agricultural products grown in the area.

4.3.12 Environmental justice

Under no action, there is a potential for significant negative effects on human health and the environment as indicated above. Therefore, a potential exists for high or adverse disproportionate impacts at UMTRA Project sites on minority or low-income populations. For example, low-income or minority populations may not have the financial means to provide an alternate source of drinking water if ground water at the site does not meet compliance.

4.3.13 Utilities and energy resources

The no action alternative would have no effect on utilities and energy resources because there would be no remediation activities.

4.3.14 Waste management

No contaminated materials associated with site characterization, monitoring, or remedial action would be generated under the no action alternative; therefore, there would be no impact.

4.3.15 Estimated costs

Fiscal impacts associated with the no action alternative represent the costs expended on the Ground Water Project to date (such as preparation of this PEIS) and estimated costs to close down current ongoing activities associated with preliminary Ground Water Project activities. Estimated total cost of the no action alternative is $20.1 million.

4.4 COMPARISON OF ALTERNATIVES

The qualitative analysis of potential impacts of the ground water compliance strategies and the no action alternative as presented in Sections 4.2 and 4.3 are used below to compare the alternatives.

This analysis compares one alternative to another alternative. For example, if the no action alternative is said to have a high potential for ecological risk, it is high only in relation to the other alternatives' potential for such an impact. These comparisons do not assess the type and degree of impacts at a given site; this type of assessment would be provided in the site-specific NEPA documents that would tier off the PEIS. Assumptions regarding the severity of

potential impacts among alternatives for each impact category are based on the impact analyses in Sections 4.2 and 4.3.

In comparing the potential impacts of the alternatives, technical specialists in each field were consulted. These comparisons are subjective because they are based on estimates of potential impacts, not measurements of actual impacts resulting from on-site remediation. Further, the comparisons treat all impacts equally so that, for example, potential impacts to human health are considered equal to potential impacts on cultural resources. To give more weight to potentially more severe impacts, long-term and short-term impacts were compared separately (Section 4.4.16). Long-term impacts would have the potential to be more severe because they would result from leaving contaminated ground water in place or using institutional controls for a long time. In general, short-term impacts would be potentially less severe because most relate to the effects of construction (such as habitat destruction, noise, and dust emissions) that are relatively minor and/or can be mitigated. While these effects are important, there is greater concern about the potential long-term health and environmental effects of leaving contaminated ground water in place.

4.4.1 Human health

The potential short- and long-term health effects from contaminated ground water would be low for the proposed action and the active remediation to background levels alternative because they would result in compliance with EPA ground water standards at all UMTRA Project sites. In addition, institutional controls may be in place for sites under all alternatives except no action where contaminated ground water has migrated off the site.

The passive remediation alternative would have some potential for adverse health effects because passive strategies and the duration of institutional controls may not protect human health at some sites. However, it would have less impact than the no action alternative because the viability of using the no remediation compliance strategy would be justified at some sites and the public would be protected from contaminated ground water at most of the remaining sites. The no action alternative would have the highest potential to result in adverse health effects from contaminated ground water because no federally sponsored ground water remediation, controls, or monitoring of the contaminated ground water would take place; this impact could be long-term.

4.4.2 Air quality

The potential for the Ground Water Project to affect air quality would be minimal, especially for the no action and passive remediation alternatives. Potential air quality impacts would be low for the proposed action alternative, which relies, at least partially, on passive ground water remediation strategies and methods. The active remediation to background levels alternative would have a short-term potential for minor air quality impacts because of its reliance

on active ground water remediation methods; however, mitigation measures could be taken to ensure that no significant impact occurs. There would be no long-term air quality impacts.

4.4.3 Surface water

The proposed action and the active remediation to background levels alternative would have a low potential to result in the contamination of surface water bodies because ground water (the potential source for surface water contamination) would meet EPA ground water standards under these alternatives. Surface water monitoring would take place during ground water remediation activities at the sites and, if necessary, remedial action would be initiated. The passive remediation alternative would have more potential to result in the contamination of surface water bodies because, while passive measures could be adequate at some sites, active methods could be needed at other sites to control plume migration. Under this alternative, there would be no way to clean up contaminated surface water. However, the use of this water could be restricted, thereby reducing the potential impact of using contaminated surface water. The no action alternative would have the greatest potential to result in the contamination of surface water bodies because there would be no federally sponsored remediation. In addition, the use of the contaminated water would not be controlled.

4.4.4 Ground water

The proposed action and the active remediation to background levels alternative would have the least potential to result in contamination of uncontaminated ground water because these alternatives are expected to clean up the quality of contaminated ground water to at least the EPA ground water standards. Ground water monitoring would detect any expansion of the contamination so that appropriate controls could be implemented. Under the passive remediation and no action alternatives, the potential spread of ground water contamination could not be prevented or slowed because active remediation would not be possible. However, the passive remediation alternative would attempt to meet the standards, resulting in less of an impact than no action. The spread of this contaminated ground water would have a greater potential for negative impacts under the no action alternative because access to this water could not be controlled.

4.4.5 Ecological resources

In general, the impacts of surface disturbance activities associated with site characterization and active ground water remediation would be short-term. However, if active remediation took several years, these impacts could become long-term and significant. The potential ecological impacts of leaving contaminated ground water would likely be long-term.

In terms of potential destruction of wildlife and aquatic habitat due to site characterization and the construction of remediation facilities, the no action and passive remediation alternatives would have the least likelihood for adverse impacts because there would be little or no ground-disturbing activities. The proposed action would result in some habitat disturbance because of the site-disturbing activities associated with active remediation. The active remediation to background levels alternative would result in habitat disturbance at most sites because of its reliance on active ground water remediation methods. Every effort would be made to avoid sensitive habitats or species; in most cases, it is likely that ground-disturbing activities would take place in areas away from these resources. If sensitive resources were affected, those effects would be mitigated to minimize environmental impacts.

In terms of contaminated ground water entering the ecosystem and creating a potential ecological risk, the proposed action and the active remediation to background levels alternative would have the lowest potential impact. If a ground water compliance strategy were not protective of the environment, it likely would not be implemented. Under the active remediation to background levels alternative, active ground water remediation methods would be used to remove the potential source of contamination at most UMTRA Project sites regardless of the risks. Under the passive remediation and no action alternatives, there is a greater potential for the release of contaminated ground water into the environment because the use of active remediation methods would not be available with these alternatives. In addition, their implementation would not result in the cleanup of already existing surface water contamination with its potential for an ecological risk. The no action alternative would have the highest potential for ecological risk to occur because no action would be taken to reduce or limit the use of the contaminated water. Under the passive remediation alternative, certain controls such as fencing would be available to limit wildlife use of contaminated water.

4.4.6 Land use

Land uses could be affected if land were acquired to conduct remediation or to impose controls restricting access to or use of land. The no action alternative would not require land acquisition; the proposed action and the passive remediation alternative could result in land acquisition. The active remediation to background levels alternative would likely result in the temporary use of the most land because more land would be needed to conduct active ground water remediation. In most cases, active remediation methods would require the acquisition or total control of land on which these facilities are placed. Land would likely revert to former uses after ground water remediation was completed.

The no action alternative would not limit or restrict land use because no remediation activities would occur. However, where ground water is contaminated and use could be affected. The proposed action and, to a lesser extent, the active remediation to background levels alternative would likely

require land use restrictions because these alternatives would require institutional controls at some sites. The passive remediation alternative would likely result in restricted land use at most sites because institutional controls would be the most frequent restriction to access under this alternative. This impact has the potential to be long-term as well as short-term because institutional controls could be in effect for up to 100 years.

Site-related contamination could affect land use by contaminating ground water and surface water used for domestic, agricultural, or industrial purposes. The potential for such an impact is highest under no action because there would be no Ground Water Project. This potential impact would be less under the passive remediation alternative because monitoring and institutional controls, where necessary, would be available to limit use of contaminated ground water. However, this alternative may not be protective of human health and the environment at all sites and the active ground water compliance strategy could not be used. The potential for this impact is lowest under the proposed action and active remediation to background levels alternatives because compliance with the EPA standards would be achieved at all sites. In addition, the active ground water remediation strategy is available for use with these two alternatives. This strategy could be used to clean up areas of contaminated ground water or surface water that may affect beneficial domestic, agricultural, and industrial uses.

4.4.7 Cultural/traditional resources

During construction, the potential effects on cultural resources would be low for both the no action and the passive remediation alternatives because little or no construction would take place. Potential impacts would be possible under the proposed action because it would use both passive and active ground water remediation methods. The potential impacts to cultural/traditional resources would be highest for the active remediation to background levels alternative because of its reliance on active remediation methods. In most cases, it would likely be possible to avoid cultural resources during ground-disturbing activities. If sensitive cultural resources, including tribal traditional areas, were affected, these impacts would be mitigated.

Impacts to Native American traditional resources associated with water would be highest for the no action and passive remediation alternatives because ground water might not meet standards at sites on tribal lands. Under the proposed action and active remediation to background levels alternatives, ground water would meet standards and would provide a beneficial impact to these traditional resources. The active remediation to background levels alternative would have less impact than the proposed action. This is because of its reliance on active ground water remediation methods which presumably would result in compliance with the standards.

4.4.8 Background noise

The potential for adverse noise impacts under any of the alternatives would be minimal, and any impacts would be temporary.

4.4.9 Visual resources

The potential for the Ground Water Project to negatively impact visual resources would be minimal. None of the UMTRA Project sites is located in areas of sensitive scenic resources (e.g., national parks or wilderness areas), and most visual impacts would be temporary (e.g., construction-related only). Potential long-term visual impacts from monitor wells would be possible under all alternatives except no action. As indicated in Section 4.2, these impacts could be mitigated.

4.4.10 Transportation

No significant transportation impacts would be expected under any of the alternatives. Any impacts would be minor and temporary.

4.4.11 Social and economic resources

In comparing the alternatives for potential socioeconomic impacts, the following factors are considered:

- The potential beneficial impacts associated with increased employment and economic expansion
- The potential adverse effects on property values from restrictive land uses or contaminated ground water.

Active remediation to background levels has the highest potential for socioeconomic benefits of increased employment and economic expansion. The proposed action would result in some increased employment, particularly at sites where active remedial actions would be implemented to meet EPA standards.

In terms of impacts on property values due to imposed restrictions on land use, the passive remediation alternative would have the highest potential adverse impact because it would likely result in the use of institutional controls at many sites. The proposed action and active remediation to background levels alternative would have less potential for such an impact. Under the proposed action, land use restrictions would be required as a result of the use of institutional controls at some sites and active remediation methods at other sites. The active remediation to background levels alternative would restrict land use at many sites during the active remediation period. The no action alternative would not entail land use restrictions. Under the no action alternative, contaminated ground water could adversely affect property values.

Property value impacts associated with active ground water remediation are generally short-term, although the impacts of institutional controls are potentially long-term.

In terms of potential impacts on property values due to the existence of contaminated ground water and/or surface water, the proposed action and the active remediation to background levels alternative would have the least impact because implementation of either of these alternatives would result in compliance with the EPA ground water standards. The passive remediation alternative could have an impact because this alternative may not be protective of human health and the environment at some sites. The no action alternative would have the highest potential for long-term property value impacts because the existence of contaminated water resources could preclude the use of land for agricultural purposes or development, require development and use of alternative water supplies, or affect the sale of land or agricultural products.

4.4.12 Environmental justice

The no action alternative would have the potential to result in a high disproportionate impact to minority or low-income groups relative to the other alternatives. This is because the ground water will not comply with EPA standards.

The passive compliance alternative would have a medium potential to have a disproportionately high effect on minorities and low-income populations because it may not result in compliance with the EPA ground water standards at all sites. The natural flushing ground water compliance strategy may result in compliance with the standard.

The proposed action and active remediation to background levels alternatives would have a low potential to have a disproportionately high effect on minority or low-income populations because both of these alternatives would result in compliance with EPA ground water standards.

DOE has attempted in this PEIS, and will continue in subsequent tiered NEPA documents, to identify and to mitigate when so identified, any disproportionately high and adverse human health or environmental effects on minority and low-income populations resulting from decisions based on this PEIS. The activities required to complete the ground water project are highly localized and would not result in cumulative impacts to air quality, noise levels, visual resources, transportation systems, utilities and energy supplies, waste generation, and cultural resources. Further, the proposed action would result in human health, socioeconomic, and environmental impacts that would be beneficial to any surrounding population. Therefore, the DOE does not anticipate any disproportionately high and adverse human health and environmental effects on minority and low-income populations as a result of the implementation of the proposed action. The DOE will reassess potential

environmental justice issues in site-specific NEPA documents that will be tiered from this PEIS.

4.4.13 Utilities and energy resources

The potential for the Ground Water Project to have a negative impact on utilities and energy resources would be none to minimal under any of the four alternatives.

4.4.14 Waste management

No liquid or solid waste management issues would arise under the no action alternative. The passive remediation alternative would produce only a small amount of waste during site characterization and monitoring. Therefore, these two alternatives would have little or no impact in terms of the potential for generating liquid and solid waste. The proposed action would have a medium probability of impacts from the production of wastes because it would rely on a combination of ground water strategies ranging from passive methods (generating little or no waste) to active methods (generating more waste). The active remediation to background levels alternative would have the highest potential to produce waste because of its reliance on active methods. All wastes would be managed in accordance with existing regulations (refer to Section 2.9).

4.4.15 Estimated costs

Highest estimated costs are associated with the active remediation to background levels alternative primarily because of the costs associated with equipment, operations, and field management. The no action and passive remediation alternatives are the least costly alternatives. The proposed action, because it combines passive and active strategies, would be less costly than the active remediation to background levels alternatives but more costly than the other two alternatives. The proposed action provides for compliance with ground water standards, and protects public health and safety by using the most appropriate compliance strategy for each UMTRA Project site.

For this PEIS, only qualitative analysis has been done. Quantitative analysis is not possible at the programmatic level because costs for the alternatives are highly variable and could be applied differently depending on site-specific conditions.

4.4.16 Summary of the comparison of alternatives

Table 4.5 compares potential adverse impacts of alternatives. Estimated cost is not included in the table because high and low expenditures are not necessarily negative or positive impacts. The potential impacts of the alternatives are divided into short-term and long-term impacts. Short-term impacts are associated with site characterization and the construction of ground water

Table 4.5 Comparison of potential adverse environmental impacts of the alternatives

Environmental factor	Alternative			
	Proposed action	No action	Active remediation to background levels	Passive remediation
Human health	Low	High	Low	Medium
Surface water	Low	High	Low	Medium
Ground water	Low	High	Low	Medium
Ecology				
Habitat destruction	Medium	Low	High	Low
Contaminated ground water	Low	High	Low	Medium
Land use				
Land acquisition	Medium	Low	High	Low
Institutional controls	Medium	Low	Medium	High
Contaminated ground water	Low	High	Low	Medium
Cultural/traditional resources				
Surface	Medium	Low	High	Low
Ground water	Medium	High	Low	High
Social and economic				
Institutional controls	Medium	Low	Medium	High
Contaminated ground water	Low	High	Low	Medium
Environmental justice	Low	High	Low	Low
Waste management	Medium	Low	High	Low

Notes:
1. High indicates high potential for negative impact relative to the other alternatives.
2. Medium indicates medium potential for negative impact relative to the other alternatives.
3. Low indicates little to no potential negative impact relative to the other alternatives.
4. The degree of actual negative impact, if any, would be addressed once the site-specific ground water compliance strategies are determined; thus analysis would appear in the site-specific NEPA documents.

remediation facilities. Long-term impacts could occur if no ground water remediation occurred or if ground water remediation took many years.

Short-term potential impacts

The no action alternative would have no short-term impacts associated with site characterization and ground water remediation because such activities would not take place under this alternative. None of the other alternatives are expected to have short-term impacts due to the short duration and small scale of the ground-disturbing activities. Potential negative impacts that could occur under the proposed action and active remediation to background levels alternative include the degradation of air quality (e.g., dust), noise levels, visual resources, transportation systems, and utilities and energy supplies. These resources are not included on Table 4.5 because they are minor and short-term. Site characterization, monitoring, and construction activities have the potential to disturb sensitive habitats, species, and cultural resources. The probability of these impacts occurring would be remote because site characterization and remediation activities can usually take place in areas away from these resources. In addition, if impacts to these resources occur, their effects could be mitigated to minimize impacts. Therefore, the potential for site characterization and construction activities to adversely affect these resources would be considered minor.

Implementation of all the alternatives except no action would have the potential to have a positive short-term effect on minority and low-income populations and other populations if measures such as supplying an alternative source of drinking water are put into effect.

Long-term potential impacts

Based on the analysis below, long-term impacts could arise under the following circumstances:

- If the contaminated ground water did not comply with the EPA standards and use of contaminated ground water was not controlled as under the no action alternative
- If the ground water compliance strategy were not protective of human health and the environment at all sites. This could occur under the passive remediation alternative.
- If institutional controls were in place for many years. This could occur under all the alternatives except the no action alternative.

Significant adverse impacts to human health and the environment could result under the no action alternative. Under this alternative, the public could be exposed to site-related hazardous contaminants by drinking contaminated ground water or surface water from a surface expression of contaminated

ground water. Disproportionately high or adverse human health effects to minority or low-income populations could occur because of the lack of means to provide for an alternate water supply.

Adverse impacts to the environment could also potentially occur if contamination enters the food chain (such as livestock or produce) or affects sensitive habitats (such as wetlands) or threatened and endangered species. These potentially significant adverse impacts would likely not occur under the proposed action or the active remediation to background alternative because these alternatives would comply with the EPA standards at all UMTRA Project sites. In addition, surface and ground water monitoring would take place before and during the implementation of the proposed action and the active remediation to background alternatives to ensure that the public is not exposed to existing and potential future surface and ground water contamination.

Implementation of the passive remediation alternative also could potentially result in the exposure of humans and the environment to UMTRA Project site-related contaminants. During the time required to implement the passive remediation alternative, contaminated ground water could reach potential receptors such as domestic wells or surface water features. Both the proposed action and active remediation to background alternatives would use hydrogeologic data and risk assessments to identify the need to implement active ground water remediation strategies quickly or to divert the flow of contamination.

Institutional controls would be required in conjunction with natural flushing. In some cases, institutional controls would be used at active ground water remediation and at no remediation sites. Institutional controls could result in potentially significant long-term land use and socioeconomic impacts. The passive remediation alternative could result in the need for institutional controls for more than 100 years if protection of the public and the environment were necessary. The proposed action and the active remediation to background alternatives would implement strategies to achieve ground water compliance within 100 years. The use of institutional controls could result in long-term land use and social and economic impacts, as discussed in Sections 4.4.6 and 4.4.11.

In summary, the proposed action and the active remediation to background alternative are most effective at protecting human health and the environment from the contaminated ground water at the UMTRA Project sites. When cost is factored in, the proposed action is likely to be the most cost-effective alternative because it would use passive remediation strategies such as natural flushing and no remediation at sites where these strategies are shown to be protective of human health and the environment. Implementation of the active remediation to background levels alternative would be the most costly because of its widespread use of active ground water remediation methods.

4.5 POTENTIAL CUMULATIVE IMPACTS OF THE ALTERNATIVES

Cumulative impacts, as defined in the CEQ regulations (40 CFR §1508.7), are the impacts which result from incremental impacts of the action when added to other past, present, or reasonably foreseeable future action regardless of what agency (federal or nonfederal) or person undertakes such other actions. For example, when the minor impacts of the Ground Water Project on a site-specific resource are combined with similar impacts of other nearby projects, the cumulative impact may become significant. Cumulative impacts in relation to past, present, and future projects at the UMTRA Project sites cannot be fully evaluated at this time because this analysis requires the use of site-specific data that are currently not available. However, the potential cumulative effects of the alternatives, combining the impacts of the Surface Project with potential impacts of the Ground Water Project, were evaluated and are presented below.

Based on the analysis of potential impacts of the ground water compliance strategies in Section 4.2 and the no action alternative in Section 4.3, the potential for the alternatives to result in cumulative impacts to air quality, noise levels, visual resources, transportation systems, utilities and energy supplies, and waste generation is minor. There is potential for cumulative impacts from other resources, as discussed below.

4.5.1 Human health

The UMTRA Surface Project has a positive impact on human health because it results in the cleanup of surface contamination at the designated processing sites. Under the Surface Project, the cleanup of the uranium mill tailings also prevents the misuse of the tailings that, in the past, resulted in the exposure of many people and the contamination of thousands of vicinity properties. Under the proposed action, the UMTRA Ground Water Project would result in a positive cumulative impact on human health by restoring contaminated ground water through active ground water remediation, preventing the use of contaminated ground water during natural flushing, or assuring the public that the contaminated ground water is not a threat to human health through the mechanism of supplemental standards or alternate concentration limits.

When considered with the Surface Project, the active remediation to background levels alternative would also result in a positive cumulative impact to human health because the EPA ground water protection standards would be met. The passive remediation alternative would also have a positive cumulative impact because it would protect the public from exposure to contaminated ground water at sites undergoing natural flushing. It would also demonstrate to the public that some sites are not a threat since they qualify for supplemental standards or alternate concentrations limits. However, the passive remediation alternative may not be protective of human health at some sites and, in comparison to the above alternatives, has the potential for a less positive cumulative impact on human health.

Implementation of the no action alternative under the Ground Water Project would likely have a negative impact because the federal government would not take any steps to monitor, characterize, or clean up contaminated ground water; protect the public from exposure to contaminated ground water; or provide assurances to the public that the contaminated ground water is not a threat. Under this alternative, only positive impacts on human health would result from the Surface Project.

4.5.2 Surface water

Twenty-two of the UMTRA Project sites are located next to or near surface water bodies. The Surface Project has a positive long-term impact on these surface water bodies by removing surface contamination from the floodplains of rivers or from upland areas where the potential for erosion of tailings into a surface water body existed. In addition, the Surface Project eliminates the source of ground water contamination (tailings), which would result in a decrease, over time, of the flow of contaminated ground water into surface water bodies. Also, the disposal cells are designed to greatly limit the infiltration of water through the cell. The Ground Water Project, under the proposed action, and the Surface Project together have a positive cumulative impact on surface water bodies due to the remediation of contaminated surface material and ground water and, in some cases, the cleanup of surface water contamination. In addition, the remediation of contaminated ground water would prevent future contamination of surface water bodies. The implementation of the active remediation to background levels alternative would have a similar positive cumulative impact on surface water.

Under the passive remediation and no action alternatives, no measures would be taken to prevent the spread of contamination into surface water bodies or to clean up those water bodies that currently are contaminated. However, under the passive remediation alternative, measures could be taken to limit or prevent human use of contaminated surface water and, if necessary, use by some wildlife species. Therefore, the passive remediation alternative, in conjunction with the Surface Project, would result in a positive cumulative impact. However, the no action alternative likely would have a negative impact on surface water, and would not result in a positive cumulative impact on surface water from the UMTRA Project as a whole.

The Surface Project resulted in the disturbance of river floodplains at some sites. These impacts have been addressed in site-specific floodplain assessments. When the Ground Water Project is considered in conjunction with Surface Project impacts on floodplains, no cumulative impacts to river floodplains are expected because ground water remediation activities likely would not take place in floodplains due to standard engineering site-selection requirements.

4.5.3 Ground water

Under the Surface Project, the stabilization of the uranium mill tailings and other contaminated material in disposal cells has a positive impact on ground water because the source of ground water contamination (the tailings) is removed from the system. Implementing the proposed action for the Ground Water Project would add to this positive impact by cleaning up contaminated water. The active remediation to background levels alternative would result in a similar positive cumulative impact.

Implementation of the passive remediation or no action alternatives would result in the spread of contaminated ground water. However, the potential impacts of using this contaminated water would be less under the passive remediation alternative because monitoring would identify the extent of contamination and institutional controls would restrict the use of contaminated ground water. In conjunction with the Surface Project, the passive remediation alternative would have a positive cumulative impact on ground water quality. Under the no action alternative, there would be no monitoring or controls to protect the public or the environment from this water. Consequently, this alternative would not result in a positive cumulative impact to ground water.

4.5.4 Ecological resources

The Surface Project has resulted in the disturbance of approximately 3900 ac (1500 ha) of land and associated plant communities and wildlife habitat. Much of the land consisted of upland plant communities or disturbed land associated with the abandoned processing sites. In some cases, riparian and wetland areas were cleared. Impacts to sensitive habitats such as these were mitigated through various processes, including the U.S. Army Corps of Engineers Section 404 Permit. Consultation with the Fish and Wildlife Service eliminated or reduced impacts to sensitive species such as threatened and endangered species. The implementation of the proposed action and the active remediation to background levels alternatives may cumulatively impact plant communities and habitats during the construction and operation of active ground water remediation facilities. This negative cumulative impact is expected to be relatively small because, as indicated in Section 4.2.1.5, the amount of land required for such facilities would likely be small (20 ac [8 ha] or less). The implementation of passive remediation or the no action alternatives would not result in a negative cumulative impact for this resource because little, if any, land would be disturbed.

The Surface Project has a positive impact on ecological resources because it results in stabilization of the surface contamination that at some sites had entered the biological systems via contaminated soil, surface water, or ground water. The cleanup of this material eliminated the soil pathway and the major source of contamination to the surface and ground water. The implementation of the proposed action and the active remediation to background levels alternatives would have a positive cumulative impact because they would

further reduce the potential for ecological risk from contaminated ground water. This is because active ground water remediation at some sites would reduce the amount of contaminated ground water available to enter the ecosystem. Active remediation of existing surface water contamination would also likely take place under these two alternatives.

As indicated in Sections 4.5.2 and 4.5.3, the passive remediation and no action alternatives would not result in the active cleanup of contaminated surface and ground water. However, the passive remediation alternative may result in a positive cumulative impact because the extent of contamination would be known and measures may be available to protect some sensitive ecological resources from contaminated surface and/or ground water. Under the no action alternative, no positive cumulative impact is anticipated because no measures would be taken to monitor the extent of contamination or protect resources from contaminated water.

4.5.5 Land use

The Surface Project results in some negative impacts on land use such as the clearing of land that had been used for grazing. Construction of active ground water remediation facilities under the proposed action or the active remediation to background levels alternatives is expected to result in only a minor negative cumulative impact in terms of land disturbance because these facilities use a relatively small amount of land, and it likely was disturbed during the Surface Project. The passive remediation and no action alternatives would not result in a cumulative impact because little or no construction would take place.

Considering both the Surface and Ground Water Projects together, the passive remediation alternative would result in a negative cumulative impact on land use because it would use the natural flushing compliance strategy more extensively than the other alternatives. With this strategy, institutional controls would be required and these controls could affect land use patterns. Under the proposed action, the negative cumulative impact on land use would be less because natural flushing would not be used as extensively. The active remediation to background levels and the no action alternatives would not result in a negative cumulative impact on land use because institutional controls associated with natural flushing would not be used.

The Surface Project has resulted in positive land use and land value impacts, particularly at processing sites where tailings were removed and disposed of off-site. There, land previously precluded from use because of contamination and federal control during cleanup would be available for public purposes such as parks (if ownership remains with a government agency) or for use by private owners following surface remediation. This positive impact would be balanced against the potentially negative land use and economic impacts that could result from institutional controls and from restricted use due to ground water contamination.

4.5.6 Cultural/traditional resources

Cultural resources are known to exist at 11 of the UMTRA Project sites. The Surface Project had very little negative impact on these resources because efforts were made to avoid or protect such resources, or measures were used to document resources. Implementing any of the alternatives for the Ground Water Project is expected to have little or no impact on cultural resources. Therefore, a cumulative impact on cultural resources is not expected.

4.5.7 Social and economic resources

Surface remedial activities employ between 80 and 300 workers per site during the construction season. The number and types of workers depend on the site and the status of remedial activities. For example, employment associated with surface remediation at Grand Junction totaled nearly 300 workers in 1993; in Naturita, employment is expected to average 54 workers and peak at 76 workers. Similarly, fewer workers are required during initial stages of remediation (e.g., building demolition). Research on the UMTRA Surface Project indicates about 80 percent of the work force is local, from within a 60-mi (96-km) commute distance. In addition to direct employment, secondary employment is generated when money spent on remedial action is respent and these expenditures create a demand for new jobs.

Surface remedial activities have a direct positive impact on local economies as well because of wages and salaries paid to workers and expenditures for equipment, materials, supplies, and services. Secondary benefits also result as monies from these wages and salaries are recirculated. Direct and secondary expenditures generate tax revenues that are available for county and state government use.

Similar but lesser impacts could occur with the Ground Water Project. Fewer workers would be required for active ground water remediation than for surface remediation. Consequently, the beneficial cumulative impact of ground water remediation added to the surface activities would be minimal. Higher cumulative beneficial economic impacts (increased employment and economic stimulation) would be expected under the active remediation compliance strategy due to its use of more labor-intensive active remediation methods. No beneficial cumulative impact would occur under the no action alternative.

4.5.8 Environmental justice

The activities required to complete the Ground Water Project under the proposed action and active remediation to background levels alternatives would not result in cumulative negative impacts to air quality, noise levels, visual resources, transportation systems, utilities and energy supplies, waste generation, or cultural/traditional resources. Further, when considered with the Surface Project, these alternatives would result in human health, social, economic, and environmental cumulative positive impacts that would also benefit any

surrounding population. Therefore, the DOE does not anticipate any disproportionately high adverse cumulative effects on minority or low-income populations from these alternatives.

Implementation of the passive remediation alternative likely will not be protective of human health and the environment (at some sites) as the proposed action and active remediation to background level alternatives. However, given that the passive compliance alternative would result in characterization and monitoring, and would protect the public from using contaminated ground water (through use of institutional controls), this alternative would have a positive cumulative impact. Therefore, implementation of this alternative is not expected to result in disproportionate negative and adverse cumulative effects to minority and low-income groups.

The no action alternative could result in negative impacts to human health and the environment and when considered with the Surface Project, likely would not have a positive cumulative impact. Further, if the negative impact of no action on human health and the environment is severe enough, there is a potential for the no action alternative to result in a disproportionate adverse cumulative impact on minority and low-income populations.

The DOE will assess potential environmental justice issues in greater detail in site-specific NEPA documents that will be tiered from this programmatic review.

5.0 UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS OF THE PROPOSED ACTION

This section discusses unavoidable adverse environmental impacts of the proposed action. The potential impacts identified in Section 4.0 may not occur every time a ground water compliance strategy is employed, but the potential does exist for the identified impacts to occur. Potential impacts would be analyzed in the site-specific NEPA documents. The following potential unavoidable adverse impacts would likely occur under the proposed action.

5.1 ECOLOGICAL RESOURCES

The proposed action would likely result in the clearing of small areas of terrestrial plant communities and wildlife habitat at sites where ground water remediation facilities would be constructed. Most of the land cleared for these facilities would be land that was previously disturbed during the Surface Project, so the plant communities are of marginal quality for wildlife. When ground water remediation is complete, the facilities would be dismantled, and the ground would be recontoured, if necessary, and revegetated.

5.2 LAND USE

Under the proposed action, active ground water remediation methods and natural flushing could affect land use by restricting land and water use during the remediation period. Active ground water remediation methods would require construction of facilities such as water treatment plants and wastewater evaporation ponds. This land for these facilities would not be available for other uses during the ground water remediation activities. Under the proposed action, institutional controls would be used in conjunction with natural flushing and possibly in conjunction with other ground water compliance strategies. Institutional controls could affect land use within the controlled area by restricting certain land uses or even eliminating all uses. This impact could be more significant to land use practices that require ground water withdrawal. These restrictions could last for an extended period because institutional controls for natural flushing could be in effect for up to 100 years.

6.0 SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

In accordance with NEPA, this section discusses the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity.

Under the no action alternative, there would be no remediation of the contaminated ground water at the UMTRA Project sites. Therefore, the impacts associated with ground water remediation, such as the disturbance of wildlife habitat and land use restrictions, would not occur. Long-term productivity at some sites would be adversely affected under the no action alternative because the contaminated ground water would not be cleaned up. This could result in the contamination of domestic wells, surface water bodies, and aquatic and wildlife habitat, resulting in potential human and environmental health effects. In addition, the long-term productivity of the sites could be affected because contaminated ground water and surface water bodies could not be used for practices such as agriculture and ranching.

Cleaning up the contaminated ground water at the UMTRA Project sites with active methods or natural flushing would preclude other short-term uses of the land during remediation. The remediation of contaminated ground water however, would enhance long-term productivity of the affected sites because aquifers that are currently contaminated would become available for use.

7.0 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The no action alternative would not use any resources because the Ground Water Project would not take place under this alternative. The proposed action and the other alternatives would require the use of resources during site characterization, monitoring, and ground water remediation. These resources would be fuel, electricity, construction materials, water, and land. In addition, the proposed action and the active remediation to background alternative would require the use of chemicals and other materials for water treatment. These are irretrievable commitments.

Site-specific NEPA documents would identify the needed amount of resources. The resources that would be irreversibly lost would be fuel; construction materials such as cement, wood, and metal; electricity; and chemicals and other materials used for water treatment. A net depletion of water would be associated with most treatment technologies.

The use of land would not be permanently committed because the land would be returned to its previous condition after the completion of ground water remediation. Land use restrictions due to institutional controls would be lifted once it had been verified that the affected ground water meets the EPA ground water standards. However, land used during the ground water remediation period would be irretrievably committed for that time period.

Baseline Risk Assessment of Ground Water Contamination at the Uranium Mill Tailings Site Near Lakeview, Oregon (BLRA) March 1996

The Baseline Risk Assessment (BLRA) addresses risks to human health and the environment from exposure to ground water contaminated by uranium-ore processing at the former millsite near Lakeview, Oregon. The assessment describes the source of contamination, the potential exposure pathways, the amount of contamination that could potentially reach people and the environment, and the health and ecological effects of exposure.

The study concluded that because ground water within the contaminant plume is not used for any purpose, there are no complete exposure pathways, and human health is not at risk. However, long-term use of contaminated ground water as a source of drinking water, especially water from the most contaminated portion of the plume, could present a risk to human health. Consequently, the BLRA recommends that site ground water not be used as drinking water in the future. The BLRA also indicates that because the source of contamination has been removed, contaminant concentrations in ground water should eventually decrease, and risk should become less with time.

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REV. 2

BASELINE RISK ASSESSMENT OF GROUND WATER CONTAMINATION AT THE URANIUM MILL TAILINGS SITE NEAR LAKEVIEW, OREGON

March 1996

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Prepared for
U.S. Department of Energy
Grand Junction Projects Office

Prepared by
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CITIZENS' SUMMARY

The U.S. Department of Energy (DOE) Uranium Mill Tailings Remedial Action (UMTRA) Project consists of the Surface Project (Phase I) and the Ground Water Project (Phase II). Under the UMTRA Surface Project, tailings, contaminated soil, equipment, and materials associated with the former uranium ore processing at UMTRA Project sites are placed into disposal cells. The cells are designed to reduce radon and other radiation emissions and to minimize further contamination of ground water. Surface cleanup at the UMTRA Project site near Lakeview, Oregon, was completed in 1989. The mill operated from February 1958 to November 1960. The Ground Water Project evaluates the nature and extent of ground water contamination that resulted from the uranium ore processing activities. The Ground Water Project is in its beginning stages.

Human health may be at risk from exposure to ground water contaminated by uranium ore processing. Exposure could occur by drinking water pumped out of a hypothetical well drilled in the contaminated areas. Ecological risks to plants or animals may result from exposure to surface water and sediment that have received contaminated ground water.

A risk assessment describes a source of contamination, how that contamination reaches people and the environment, the amount of contamination to which people or the ecological environment may be exposed, and the health or ecological effects that could result from that exposure. This risk assessment is a site-specific document that will be used to evaluate current and potential future impacts to the public and the environment from exposure to contaminated ground water. The results of this evaluation and further site characterization will determine whether any action is needed to protect human health or the ecological environment.

RISK SUMMARY

In the area around the Lakeview site, ground water is used for domestic purposes such as drinking, bathing, and cooking, and for agricultural purposes. However, no current users of the site-related contaminated ground water (for domestic or agricultural purposes) have been identified at the Lakeview site. Therefore, people are not exposed to contaminants and there is no risk to human health. This situation will continue if land and water use at the site does not change. Access to the site-related contaminated ground water is not restricted. Since different land use may or may not create future risks, when specific land and water uses are determined they should be evaluated to identify any potential human health risks that could occur because of exposure to contaminated ground water.

This risk assessment evaluates possible future health problems associated with exposure to site-related contaminated ground water; the results indicate some health problems could occur if contaminated ground water were used as drinking water. Consequently, it is recommended that the site-related contaminated ground water should not be used as drinking water.

Evaluation of the potential impacts of site-related contaminated ground water on the ecological environment indicates the ground water would not be suitable for continuous

irrigation of agricultural crops, as a long-term source of drinking water for livestock, or as a habitat for aquatic life (such as a ground water-fed pond).

Approximately 3000 feet (ft) (900 meters [m]) south of the site, several private wells contain some of the same constituents as the site-related contaminated ground water. Although it is unlikely the constituents in these wells are from the site, the source has not been identified. Evaluation of the ground water from the private wells indicates the manganese levels could cause adverse health effects.

GROUND WATER QUALITY AND USES

Background ground water quality

Background ground water quality is the natural quality of ground water if uranium milling activities had not taken place. Ground water was sampled in two ground water zones in the immediate vicinity of the Lakeview site: a shallow zone and a deeper zone. There are also two types of background ground water in the Lakeview site area. One type is geothermal ground water, which comes from hot springs in the area. The geothermal water is characterized by high levels of total dissolved solids (TDS), sodium, sulfate, and chloride, and proportionately low amounts of calcium and magnesium. The nongeothermal background ground water, however, is characterized by a higher proportion of calcium, magnesium, and bicarbonate, and low levels of sulfate, chloride, and TDS. The quality of both types of ground water is naturally poor because of iron and manganese in the nongeothermal ground water, and because of high TDS and arsenic in the geothermal ground water. Additionally, arsenic exceeds the U.S. Environmental Protection Agency (EPA) maximum concentration limit for ground water.

Site-related ground water quality

There are two types of contaminated ground water at the Lakeview site. One type is associated with constituents that seeped from the former tailings pile and has high levels of sodium, calcium, magnesium, and sulfate, and low levels of chloride. The other type of contaminated ground water is associated with constituents that seeped from the former evaporation ponds; it has high levels of sodium, sulfate, and chloride, and low levels of calcium and magnesium. The contaminated ground water associated with the tailings pile is chemically similar to the nongeothermal background ground water, and the contaminated ground water associated with the evaporation ponds is chemically similar to the geothermal background ground water. However, some chemicals are in both types of contaminated ground water. One explanation for this is that prior to construction of the tailings pile and evaporation ponds, the soil contained salts from background ground water. After the tailings pile and evaporation ponds were built, water passed through the tailings and ponds and through the soil, leaching the salts from the soil into the ground water. As a result, the contaminated ground water contains chemicals from the processing fluids as well as from natural salts. Therefore, although the composition of site-related contaminated ground water is similar to that of the background ground water, the concentrations of the constituents in the contaminated ground water are 10 to 20 times higher than background concentrations.

Elevated sulfate levels appear in both types of contaminated ground water, and sulfate distribution has been used to determine how far the site impact extends from the site. Based on the sulfate distribution, it appears that the shallow zone contains two impacted areas. One area is associated with the former tailings pile and the other is associated with the former evaporation ponds.

Private well ground water quality

Located approximately 3000 ft (900 m) south of the site are several private wells. Sulfate, manganese, chloride, sodium, calcium, and iron have been detected in some of these wells as well as some constituents that are detected in the site-related contaminated water at the site. Water quality analyses of ground water from these wells suggest that these constituents are not due to site-related contaminated ground water, primarily because their pattern of occurrence in the private wells is inconsistent with site-related constituents. That is, wells having the highest constituent levels are farthest from the site, whereas levels in wells closer to the site are similar to background. Thus, based on limited coverage of the on-site and private wells, there appears to be no connection between site-related constituents and elevated constituents in private wells. Based on a water use survey, none of the owners of the wells with high constituent levels use the ground water for drinking water, although they do use it for bathing, cooking, livestock watering, irrigation, and miscellaneous household activities.

Drinking water is supplied by the city of Lakeview for residents within the city limits; people living outside the city limits have private wells. The city obtains its water from springs in the mountains part of the year and from very deep wells located at least 1 mile (1.6 kilometers) south of the Lakeview site. These wells have not been impacted by contaminated ground water from the site. Although surface water is the primary source of irrigation water for crops in the site area, ground water is sometimes used for irrigation.

When contaminated ground water feeds a surface water body, it can contaminate the surface water and sediment. Limited analytical data are available for surface water and sediment. These data suggest surface water is not impacted by site-related constituents, and elevated concentrations of iron, manganese, and uranium detected in sediment may be due to natural variations in sediment composition. However, neither observation for surface water or sediment is conclusive because of the lack of data for these two media.

HUMAN HEALTH RISK ASSESSMENT

Methods

This risk assessment identifies constituents that are present in ground water because of past uranium ore processing activities. This is done by comparing water quality data from wells drilled on the site to water quality in wells from background areas. This ground water analysis probably will overestimate the potential risk because the comparison uses ground water from the most contaminated part of the shallow zone. Constituents detected in the ground water that could cause adverse human health effects if taken into the body are called constituents of potential concern. Arsenic, boron, chloride, iron, manganese,

molybdenum, nickel, polonium-210, sodium, sulfate, and uranium are the constituents of potential concern detected in the shallow zone at the Lakeview site.

This risk assessment also examines potential human health problems that could be caused by exposure to contaminated ground water. In a future scenario, a person in the Lakeview site area could be exposed to contaminated ground water by drinking or bathing in ground water, eating meat or drinking milk from livestock watered with contaminated ground water, or eating produce irrigated with contaminated ground water. All these potential exposure routes initially are screened for their potential contribution to high exposure levels. Of all of the exposure routes evaluated, drinking the contaminated ground water was determined to contribute the greatest exposure dose. Therefore, this document evaluates this exposure route in detail.

Health risks are evaluated for the age group most likely to experience health problems from drinking contaminated ground water. Children (aged 1 to 10 years) are most likely to be affected by drinking contaminated ground water because they are small and they tend to drink more water compared to their body weight than adults and consequently take in a higher contaminant dose than adults. Infants (aged 0 to 1 year) are especially sensitive to sulfate. Cancer risks are evaluated for adults (11 + years) assuming lifetime exposure.

The seriousness of health effects varies for several reasons. The levels of constituents in ground water can vary over time. Also, people vary in body weight, the amounts of water they drink each day, and their reactions to chemical exposures. This risk assessment considers these differences whenever possible.

The risk assessment provides graphs showing the various exposure levels that might occur and the most current scientific information on the health effects that could result from this hypothetical exposure.

Results

Some possible future health risks are associated with drinking the site-related contaminated ground water at the Lakeview site. Table CS.1 summarizes the nature of these health problems. Note that only people who drink all their water from a well placed in the most contaminated part of the ground water could experience the health problems listed in Table CS.1. Therefore, the table presents the upper limit of possible risks; real risks probably would be lower.

Severe health effects could develop due to the water's arsenic, iron, manganese, and sulfate content. Sulfate could affect infants in particular by causing severe diarrhea, quickly leading to dehydration. Manganese exposure could cause memory loss, irritability, and muscle rigidity. Long-term iron exposure could lead to cirrhosis of the liver. Arsenic exposure could cause adverse effects to the liver, arteries, and skin. Additionally, arsenic exposure could increase the risk of developing cancer.

Table CS.1 Constituents of potential concern to human health, Lakeview, Oregon, site

Constituent of potential concern	Results
Arsenic	Mild to severe toxicity including neurological effects, cirrhosis of the liver, thickening of the arteries, and skin discoloration. Individual excess lifetime cancer risk above the acceptable EPA risk range (skin cancer).
Boron	Adverse effects not expected to occur.
Iron	Mild to severe effects following long-term exposure, ranging from iron buildup in body organs and skin discoloration to cirrhosis of the liver.
Manganese	Mild to severe effects following long-term exposure. Neurological symptoms such as memory loss, irritability, and muscle rigidity.
Molybdenum	Mild to severe effects following long-term exposure; copper deficiency anemia.
Nickel	Allergic dermatitis in sensitized humans.
Sodium and chloride	Hypertension following long-term exposure.
Sulfate	Short-term mild to severe effects; diarrhea leading to dehydration in infants.
Uranium	Health problems not expected from chemical toxicity; individual excess lifetime cancer risk within the acceptable EPA risk range.
Polonium-210	Individual excess lifetime cancer risk within the acceptable EPA risk range.

EPA - U.S. Environmental Protection Agency.

Note: These effects could vary from person to person depending on the amount of water each person drinks and individual body weight, dietary habits, and sensitivities (for example, preexisting kidney or heart disease).

The exposure levels from the other routes of exposure (skin contact with ground water while bathing, eating meat and drinking milk from livestock watered with contaminated ground water, and eating produce irrigated with contaminated ground water) would not be expected to cause adverse health effects if they were the only source of exposure.

Furthermore, if the additional exposure levels would be added to the drinking water pathway, the exposure levels would not be expected to substantially increase the potential for adverse health effects.

Private well risk evaluation

Evaluation of the constituents in the private wells indicates that if the ground water is ingested over a long period of time, manganese could potentially cause adverse health effects in people. However, the assumptions used to evaluate the ground water in the private wells are very conservative and likely overestimate the potential risks.

ECOLOGICAL ASSESSMENT

Methods

The ecological risk assessment presented in this document is a qualitative screening level study that relies almost completely on existing site data. This assessment identifies habitats, aquatic life, terrestrial wildlife, livestock, and vegetation resources that could be affected by constituents from site activities, as well as potential exposure pathways.

The field of ecological risk assessment has many uncertainties and limitations including limited data from media of interest; limited information on how some constituents affect plants, animals, and aquatic life; and the inherent complexities of the ecosystem. In addition, methods of predicting nonchemical stresses (for example, drought), biologic interactions, behavior patterns, biological variability (differences in physical conditions, nutrient availability), and resiliency and recovery capacities are often unavailable. Therefore, it is often difficult to determine if constituents can affect the biological component of an ecosystem and to predict whether observed effects will adversely affect the ecosystem.

This risk assessment evaluates surface water and sediment from Hunters Hot Springs, Warner Creek, Thomas Creek, and Hammersley Creek. Concentrations of the constituents of potential concern identified in surface water, sediment, and ground water are compared to applicable guidelines from regulatory agencies and literature values to determine their possible effects on aquatic life, terrestrial wildlife, livestock, and vegetation.

RESULTS

Surface water does not appear to be impacted and no constituents of potential concern were identified. Three constituents (iron, manganese, and uranium) were detected above background concentrations in sediments and were retained as constituents of potential concern. However, because sediment guidelines are not available, it is not possible to evaluate the potential hazard to the ecological environment from these constituents.

Ground water at the Lakeview site would not be suitable as a long-term source of drinking water for livestock, due to elevated levels of boron and sulfate. If the ground water were used in a pond that could be stocked with fish, the ground water concentrations of arsenic, boron, chloride, and iron would exceed the water quality values considered protective of aquatic life. Therefore, the contaminated ground water would not be suitable as a habitat for aquatic life.

The concentrations of boron, manganese, and molybdenum observed in the contaminated ground water exceed guidelines that are toxic to plants. Additionally, the concentrations of arsenic, boron, iron, manganese, molybdenum, and nickel exceed levels considered protective of plants in water used for irrigation. However, preliminary results of a DOE-sponsored irrigation and plant growth study at the University of Arizona suggests that for manganese and molybdenum the guidance values may be considerably overprotective.

CONCLUSIONS

Currently, no users of the site-related contaminated ground water (for domestic or agricultural purposes) at the Lakeview site have been identified. Therefore, people are not exposed to site-related constituents of potential concern and human health is not at risk. This situation will continue if land and water use at the site does not change.

The source of the constituents detected in the private wells south of the site is not understood. It is unlikely that the constituents in these wells are site-related.

The results of this risk assessment indicate that if the site-related contaminated ground water is used for drinking water in the future, some health problems could occur. Consequently, it is recommended that the contaminated ground water should not be used as drinking water. However, this risk assessment is a conservative estimate of potential future risks at the Lakeview site because data from the most contaminated wells on the site were used in this evaluation. Furthermore, the uranium mill tailings (the source of the constituents) have been removed, and contaminated ground water at the site will tend to disperse and dilute (move away from the site and decrease in concentration), thereby reducing potential exposure concentrations over time. For these reasons, this risk assessment is a conservative estimate of risk to human health at the Lakeview site.

The environmental evaluation of the UMTRA Lakeview site is ongoing. This risk assessment and future investigations will be used to determine how to comply with the UMTRA ground water standards.

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LIST OF ACRONYMS

Acronym	Definition
BCF	bioconcentration factor
DHHS	U.S. Department of Health and Human Services
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FWS	Fish and Wildlife Service
HEAST	Health Effects Assessment Summary Tables
IRIS	Integrated Risk Information System
LOAEL	lowest observed adverse effect level
MCL	maximum concentration limit
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NOAEL	no observed adverse effect level
NRC	U.S. Nuclear Regulatory Commission
ODEQ	Oregon Department of Environmental Quality
PEIS	programmatic environmental impact statement
RDA	recommended dietary allowance
RfD	reference dose
RRM	residual radioactive material
SAR	sodium adsorption ratio
SF	slope factor
SQC	sediment quality criteria
TDS	total dissolved solids
UCL	upper confidence limit
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 if ground water contamination at the former uranium mill processing site near Lakeview, Oregon, could adversely affect public health or the environment. The Lakeview site is one of 24 abandoned uranium processing sites that are 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 1988 amendments to the UMTRCA authorize the DOE to conduct ground water restoration activities. Under the UMTRA Ground Water Project, site-related ground water contamination is being evaluated and an appropriate ground water compliance strategy will be selected. Results of this risk assessment will be one of the documents used to develop a ground water compliance strategy for the Lakeview site.

Under the UMTRA Surface Project, the source of ground water contamination, residual radioactive material (RRM), was stabilized in an off-site disposal cell at Collins Ranch, Oregon. The disposal cell is engineered to prevent radon and other radiation emissions, and to prevent ground water contamination. Surface remedial action at the Lakeview site was completed in October 1989. The processing site was determined to be "surface clean" by U.S. Nuclear Regulatory Commission (NRC) approval of the completion report.

The programmatic environmental impact statement (PEIS) for the UMTRA Ground Water Project (DOE, 1995a) proposes a framework for selecting a ground water compliance strategy to meet the U.S. Environmental Protection Agency (EPA) ground water standards for the UMTRA Project (40 CFR Part 192). This baseline risk assessment evaluates potential current and future human health and environmental risks from ground water contamination at the Lakeview site, and provides information to help determine an appropriate ground water compliance strategy. Remaining data gaps in ground water characterization will be addressed in the Lakeview site observational work plan. Based on the PEIS, the site observational work plan, and this risk assessment, site-specific National Environmental Policy Act (NEPA) documentation will be prepared to identify the impacts of the proposed ground water compliance strategy for the site.

This risk assessment is a baseline assessment in that it describes preremediation ground water conditions at the site, with ground water quality only partially characterized. This document evaluates potential risks that may need attention before a ground water compliance strategy is selected, and examines risk to human health and the ecological environment from the most contaminated wells at the site.

This risk assessment follows the human health risk assessment methodology for the UMTRA Ground Water Project (DOE, 1994a). The methodology is designed to evaluate human health risks associated with ground water contamination at inactive uranium processing sites. It allows the development of probabilistic distributions for exposure variables when data are sufficient and the simulation of exposure dose distributions, using Monte Carlo techniques rather than a single exposure dose calculation. Risk interpretation is based on a comparison between the predicted exposure dose distribution and observed toxicity ranges of constituents of potential concern. Graphic presentations (figures) are designed to increase

understanding of potential risks based on relative toxicity, likelihood of effect, and severity of effect.

The methodology used for the ecological portion of this risk assessment generally follows the EPA's *Risk Assessment Guidance for Superfund* (EPA, 1989a). Ecological risk assessment at the Lakeview site identifies potentially exposed habitats and receptors and qualitatively evaluates analytical data to describe how constituents could affect the ecological environment. Thus, this qualitative approach is a screening level assessment of the ecological risks associated with potential exposure to contaminated media at the site.

2.0 SITE DESCRIPTION

2.1 SITE BACKGROUND

The Lakeview site is approximately 1.5 mile (mi) (2.4 kilometer [km]) north-northwest of the town of Lakeview in Lake County, Oregon (Figure 2.1). Klamath Falls is about 96 mi (150 km) west of the site and the California-Oregon state line is approximately 16 mi (26 km) south of the site. The Lakeview mill was active from February 1958 until November 1960. It was constructed to produce uranium ore, and 171 tons (155 metric tons) of uranium oxide were sold to the Atomic Energy Commission (predecessor to the DOE). Ore was trucked to the mill from the White King and Lucky Lass mines of southern Lake County, Oregon. The ore was ground to a minus-65 mesh size and leached with sodium chlorate and sulfuric acid. After leaching, the uranium-rich solutions and waste solids were separated by a four-stage countercurrent classifier and thickener circuit. The uranium solutions then were treated by solvent extraction to concentrate and recover the uranium; the solids were dumped in what became the tailings pile. During its 3 years of operation, the mill processed about 130,000 dry tons (120,000 metric tons) of ore with an average grade of 0.15 percent uranium oxide.

The designated site covers 258 acres (ac) (104 hectares [ha]); approximately 30 ac (12 ha) were occupied by the almost square-shaped tailings pile and approximately 64 ac (26 ha) by the evaporation ponds; the remaining area included the former mill structures, ore storage area, and acres of windblown contamination from tailings. Figure 2.2 provides information on the site and land use in the vicinity of the site.

Surface remedial action at the Lakeview site consisted of cleanup of contaminated buildings, excavation of all contaminated soils, and transport to the disposal site. Approximately 926,000 cubic yards (yd^3) (708,000 cubic meters [m^3]) of contaminated materials from the tailings pile, evaporation ponds, windblown and waterborne deposit areas, and windblown-contaminated areas dispersed around the site were relocated to the Collins Ranch disposal site approximately 7 mi (11 km) north of Lakeview. Approximately 736,000 yd^3 (563,000 m^3) of these contaminated materials are classified as tailings (DOE, 1994b). The tailings were moved because seismic and geothermal activity in the area prevented on-site stabilization and disposal. The disposal site was selected based on public input, environmental considerations, and design opportunities acceptable to the state of Oregon and the NRC.

2.2 CLIMATE

The Lakeview area is characterized by low humidity, frequent sunny days, and moderate seasonal temperature ranges. The average annual temperature is 46 degrees Fahrenheit (°F) (7.8 degrees Celsius [°C]) and ranges from an

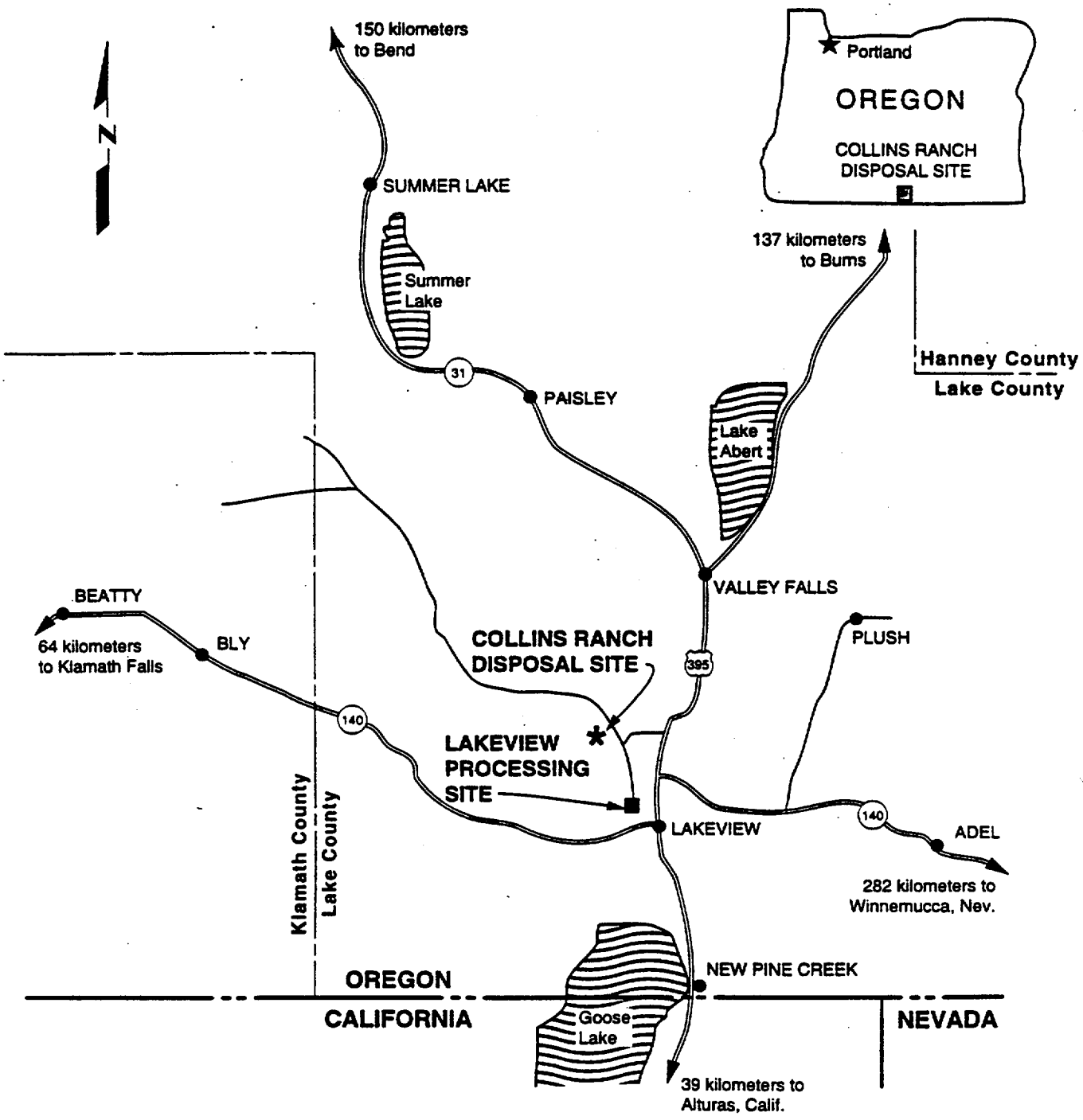


FIGURE 2.1
LOCATION MAP
LAKEVIEW, OREGON, SITE

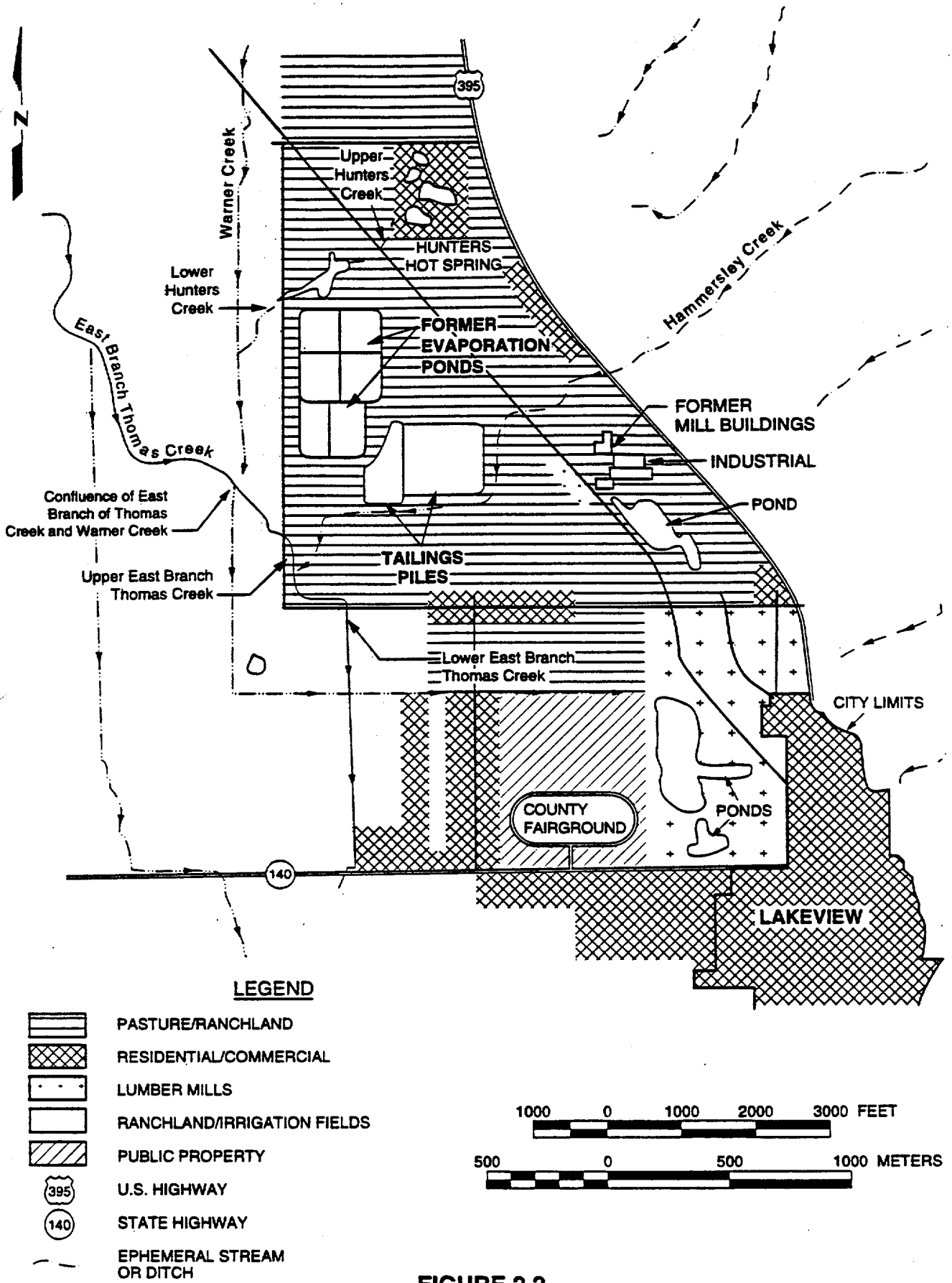


FIGURE 2.2
LAND USE
LAKEVIEW, OREGON, SITE VICINITY

average temperature of 27°F (-2.8°C) in January to 67°F (19°C) in July. The average annual precipitation is 14 inches (36 centimeters [cm]) (NOAA, 1974). Maximum rainfall occurs during January and February, while the least rainfall occurs from June through October. Thunderstorms are common during the summer. The average annual snowfall accumulation is 48 inches (122 cm), with the largest amount (15.6 inches [40 cm]) falling during January (NOAA, 1974).

2.3 HYDROGEOLOGY

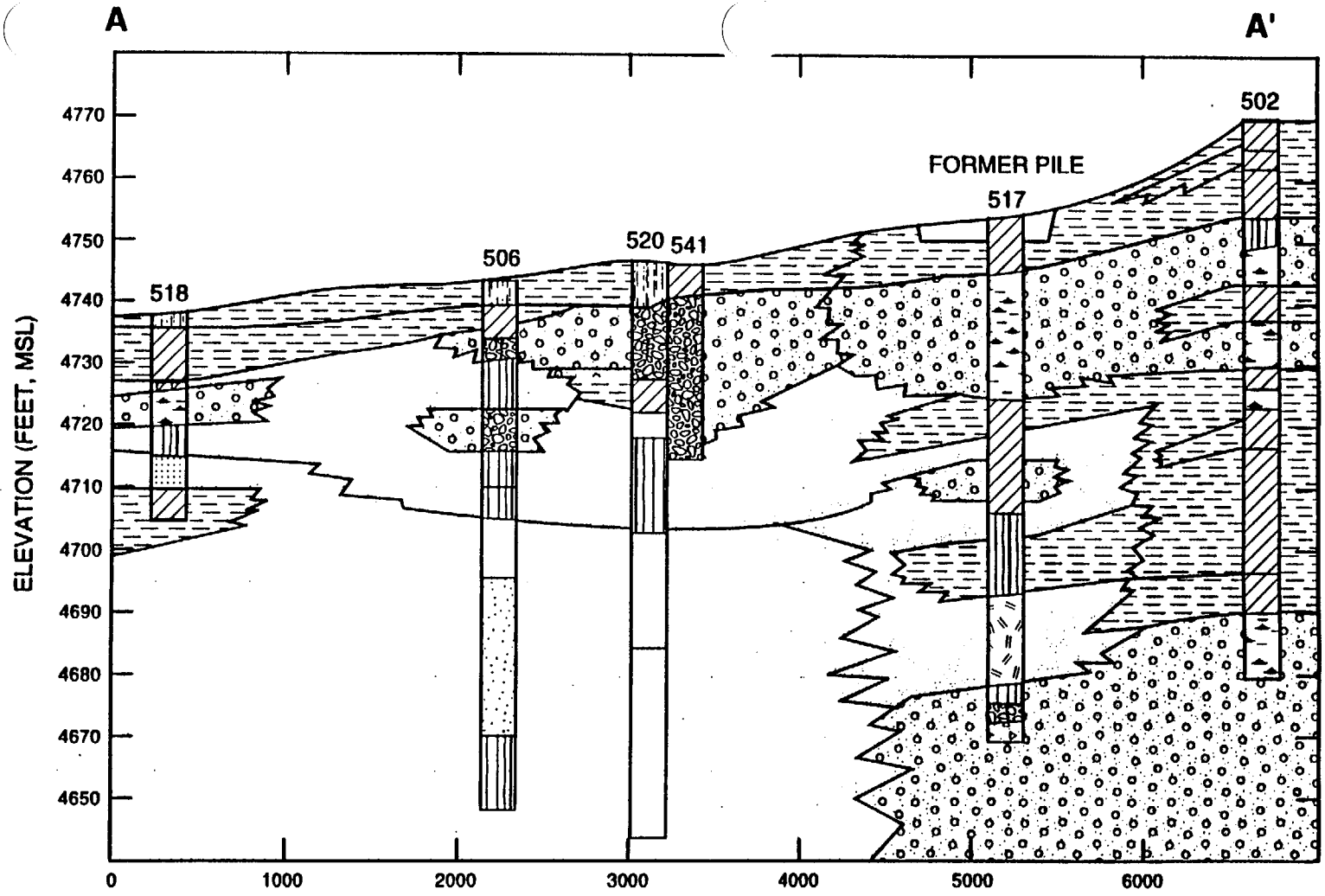
The Goose Lake Valley area, which includes the city of Lakeview and the processing site vicinity, is underlain by more than 2000 feet (ft) (600 meters [m]) of heterogeneous alluvial and lacustrine deposits (DOE, 1992). Unconsolidated alluvial deposits consisting of silt and sandy clay extend from the ground surface to an approximate depth of 20 ft (6 m). Underlying the alluvial deposits are discontinuous lenses of unconsolidated to consolidated water-bearing gravels, sands, and silts derived from recent fluvial and ancient lacustrine processes (Figure 2.3). A known geothermal resource area, Hunters Hot Springs, is approximately 2000 ft (600 m) upgradient of the former mill site. Hunters Hot Springs provide an upgradient source of thermal water northeast of the site that recharges surface water and ground water sources in the site vicinity.

Two alluvial/lacustrine ground water zones have been characterized at the former processing site (DOE, 1992). Monitor wells are screened and filter-packed in a shallow zone from about 16 to 30 ft (5 to 9 m) deep and a deeper zone between depths of 60 to 90 ft (18 to 27 m). DOE monitor well locations at the processing site are shown in Figure 2.4.

Regional ground water recharge occurs from mountains on the west (Fremont Mountains) and east (Warner Mountains) sides of Goose Lake valley, precipitation, snowmelt recharge from the unlined irrigation ditches, and upward movement from the underlying geothermal system. Ground water discharges to Goose Lake, surface drainages, springs, and wells.

A water table contour map of the shallow ground water zone at the processing site is shown in Figure 2.5. Shallow ground water beneath the site generally moves from northeast to southwest under a hydraulic gradient ranging from 0.003 to 0.010. The water table beneath the Lakeview site generally occurs at a depth of 5 to 15 ft (1.5 to 4.6 m).

Downward vertical gradients have been noted between the shallow and deep monitor well clusters (DOE, 1993). The background well cluster (501 and 502) shows head variations between the shallow (501) and deep (502) wells that range from 13 to 17 ft (4 to 5 m), indicating a downward vertical gradient. Water level elevations in geothermal monitor well cluster 523 and 524 are similar, indicating no clear vertical gradient. Static water level elevations in



NOTE: SEE FIGURE 2.4 FOR LOCATION OF CROSS SECTION

LEGEND

WELL LITHOLOGY

- 518 WELL ID NUMBER
- CLAYEY SAND
- SILTY SAND AND GRAVEL
- SILTY SAND
- SAND AND GRAVEL
- CLAYEY SILT
- ALLUVIUM
- SAND
- SANDY CLAY

INTERPRETIVE GEOLOGY

- CLAYS AND SILT
- GRAVELS
- SANDS

GEOLOGIC CROSS SECTION, FORMER LAKEVIEW, OREGON, PROCESSING SITE

MAC: SITE\LKV\WSAP\GEOCROSEC

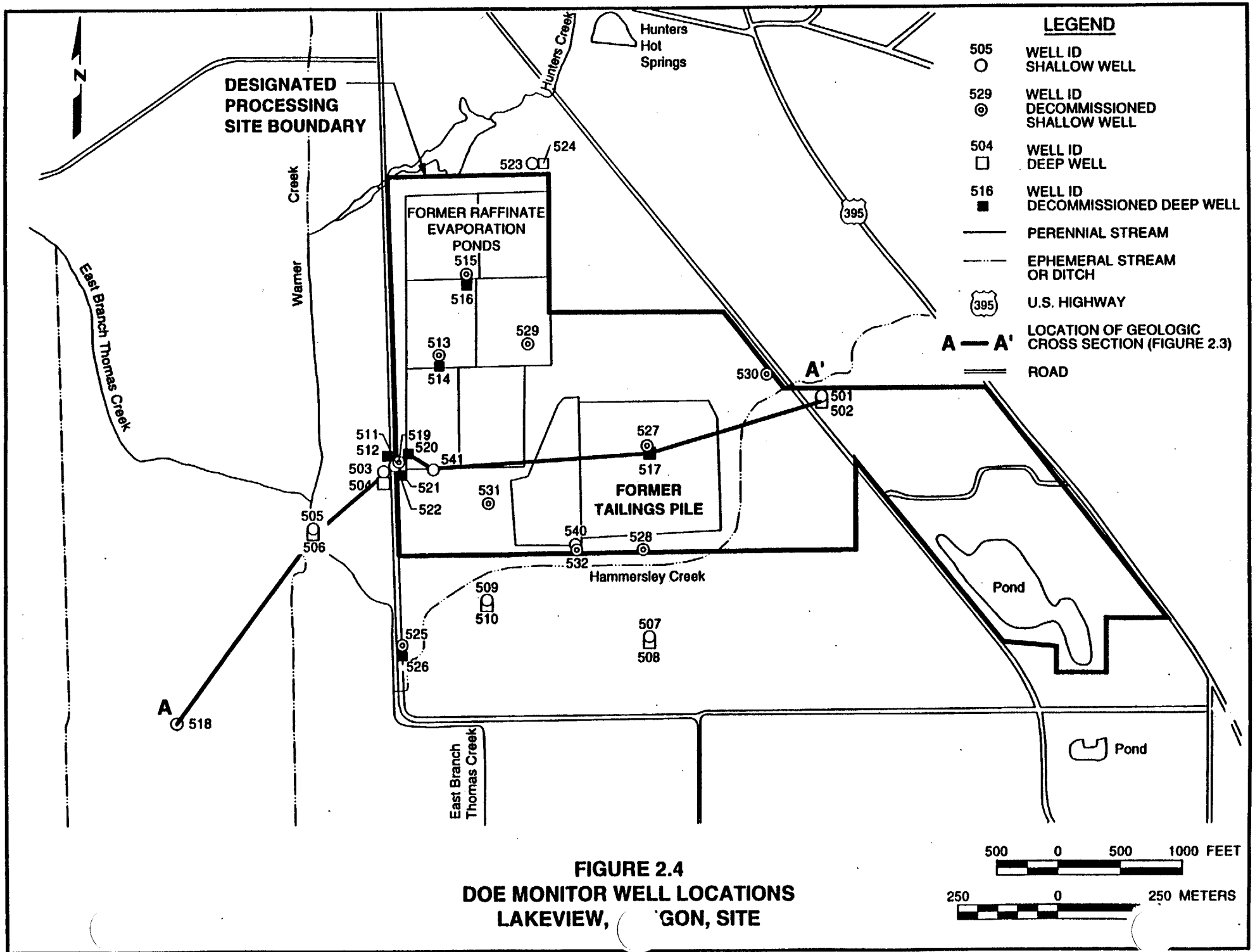


FIGURE 2.4
DOE MONITOR WELL LOCATIONS
LAKEVIEW, OREGON, SITE

MAC: SITE/LKV/BRA/BASE-DOEMONWELLOC

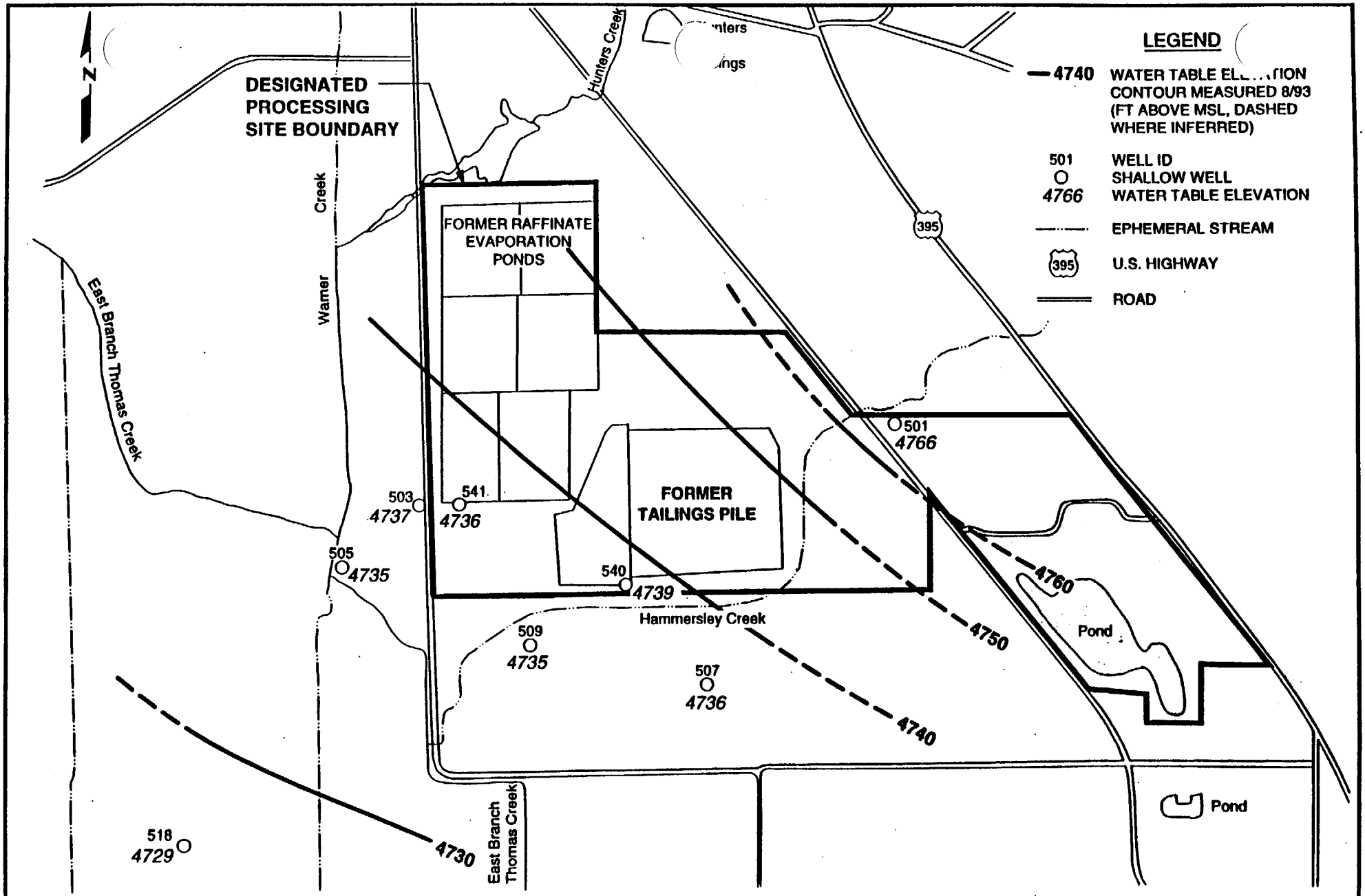


FIGURE 2.5
WATER TABLE ELEVATION MAP FOR SHALLOW WELLS
LAKEVIEW, OREGON, SITE

MAC: SITE/LKV/BRA/BASE-WATERTABLE

other downgradient monitor well clusters range from similar constant measurements (within ±1 ft [0.3 m]) to downward gradients with static head differences of 1 to 12 ft (0.3 to 4 m) (Table 2.1). Water levels are expected to fluctuate due to a combination of natural discharge, evapotranspiration, and localized pumpage in private wells.

Hydraulic properties at the Lakeview site were estimated; hydraulic parameter results are presented in the surface remedial action plan (DOE, 1992) and the Lakeview site characterization report (DOE, 1985a). These site characterization efforts included two 48-hour aquifer tests (with 24 hours of continuous pumping followed by 24 hours of recovery) to determine the hydraulic properties of the shallow and deep lacustrine zones. In one test, a shallow monitor well (519) was pumped at a rate of 0.60 gallons per minute (gpm) (38 cubic centimeters [cm^3] per second) and water levels were measured in three shallow observation wells (503, 511, and 521). Hydraulic conductivity values were calculated to range from approximately 0.92 to 11 ft per day (3.2×10^{-4} to 39×10^{-4} cm per second), using the Jacob-Cooper, Theis, and Boulton methods of analysis. In the other aquifer performance test, a deep monitor well (520) was pumped at a rate of approximately 12 gpm (760 cm^3 per second) and the water levels in one shallow (522) and three deep (504, 506, and 512) observation wells were measured. Hydraulic conductivities for the three deep monitor wells were estimated to range from approximately 0.78 to 8.9 ft per day (2.7×10^{-4} to 31×10^{-4} cm per second), using the Boulton, Hantush, and Jacob-Cooper methods of analysis. Hydraulic conductivity of the shallow monitor well ranged from 5.7 to 6.0 ft per day (20×10^{-4} to 21×10^{-4} cm per second), using the Jacob-Cooper and Boulton methods of analysis, respectively. These aquifer tests indicated that the two zones are hydraulically connected.

The calculated average linear ground water velocities range from 50 ft per year (8×10^{-5} cm per second) in the shallow zone to 160 ft per year (2.5×10^{-4} cm per second) in the deep zone. These values were determined using the average hydraulic conductivities for the shallow and deep zones, 1.4 and 4.4 ft (0.4 and 1.3 m) per day, respectively; an average hydraulic gradient of 0.01; and an assumed effective porosity of 0.10 (DOE, 1985a).

2.4 SURFACE WATER

The Lakeview site is in the drainage basin of Thomas Creek, a perennial tributary of Goose Lake. Goose Lake is a closed-basin lake with an overflow elevation of approximately 4720 ft (1440 m). This elevation is approximately 35 ft (11 m) below the base of the former tailings pile. The lake is approximately 8 mi (13 km) south of the site (DOE, 1985b).

Surface water features at and adjacent to the former processing site include three creeks, hot springs, ponds, and drainage ditches. An unnamed intermittent stream issuing from Hammersley Canyon, northeast of the site, flows across the site adjacent to the north side of the pile. This creek is referred to as Hammersley Creek. Thomas Creek flows approximately 1 mi

Table 2.1 Static ground water levels, Lakeview, Oregon, site

Location ID	North coordinate (ft)	East coordinate (ft)	Formation of completion	Flow relationship	Casing elevation (ft MSL)	Ground elevation (ft MSL)	Log date	Log time	Depth from top of casing (ft)	Depth from ground (ft)	Ground water elevation (ft MSL)
LKV-01-0501	8523.5	7525.3	SP	Upgradient	4771.05	4769.32	08/25/93	15:29	5.28	3.55	4765.77
LKV-01-0503	7931.9	3921.1	SP	Downgradient	4747.73	4745.89	08/25/93	15:54	10.99	9.15	4736.74
LKV-01-0505	7476.2	3342.9	SP	Downgradient	4744.64	4742.74	08/25/93	15:59	9.88	7.98	4734.76
LKV-01-0507	6599.3	6102.0	SP	Crossgradient	4742.77	4741.00	08/25/93	16:35	6.76	4.99	4736.01
LKV-01-0509	6897.1	4762.6	SP	Downgradient	4742.14	4740.06	08/25/93	16:47	7.36	5.28	4734.78
LKV-01-0518	5914.7	2231.0	SP	Downgradient	4739.79	4737.55	08/25/93	16:18	10.31	8.07	4729.48
LKV-01-0540	7340.20	5486.57	AL	Downgradient	4747.89	4745.93	08/25/93	15:20	9.09	7.13	4738.80
LKV-01-0541	7938.71	4223.85	AL	Downgradient	4747.56	4745.55	08/25/93	15:10	11.34	9.33	4736.22

Report date: 1 July 1994.

SP – sand or gravelly sand, poorly graded.
AL – alluvium.
MSL – mean sea level.

(2 km) west of the site; the East Branch of Thomas Creek flows 1000 to 2500 ft (300 m to 760 m) west of the site. An ephemeral stream, Warner Creek, flows approximately 1000 ft (300 m) west of the site where it joins the East Branch of Thomas Creek. The confluence of the East Branch of Thomas Creek with Hammersley Creek is approximately 1800 ft (550 m) southwest of the site. Surface water flows are also encountered approximately 0.5 mi (0.8 km) north of the tailings in the Hunters Hot Springs area. All drainage flows northeast to southwest across the site.

The drainage area for Hammersley Creek is about 3.3 square miles (mi^2) (8 square kilometers [km^2]) with an approximate slope of 0.06. Surface water in an area of approximately 30 mi^2 (80 km^2) drains into Thomas Creek above the Lakeview site. Most of this drainage basin is in the wooded area northwest of Lakeview. The drainage basin for Goose Lake is approximately 1140 mi^2 (2920 km^2), including the lake area.

2.5 LAND USE

Livestock grazing is the most extensive land use in Lake County, with approximately 69 percent of the county's total surface area used for this purpose (Figure 2.2) (DOE, 1985b). Timber production is another major land use, with about 23 percent of the county's total surface used for this purpose, primarily in the mountains. Approximately 4 percent of the county's land area, primarily in the intermountain basin area, is used to produce irrigated forage crops; this area includes the former processing site. The city of Lakeview is zoned mostly for single-family residential development. Demand for residential land in the site vicinity is very low (DOE, 1985b) and is expected to remain low because population over the last several years has not increased.

The former processing site, approximately 1 mi (2 km) north-northwest of the city of Lakeview, is zoned for heavy industry. However, current land use in the area immediately surrounding the site is primarily agricultural, i.e., grazing or growing forage crops such as alfalfa. The fields are marshy northeast, north, and west of the site because of surface discharge from the geothermal springs 800 to 1800 ft (240 to 550 m) north of the site. These marshy areas, including several small ponds, are associated with Hunters Creek. At the headwaters of Hunters Creek, about 1800 ft (550 m) north of the site, a lodge serves tourists visiting the hot springs. Farther north is ranch land, including three residences about 0.5 mi (0.8 km) north of the site.

The area immediately east of the northern portion of the site is pastureland with about seven associated residences and a trailer park on Highway 395, about 1600 ft (480 m) east of the site. East of the southern portion of the site are pastureland, an auto repair shop, and a small lumber mill (about 1000 ft [300 m] east of the site) set among larger areas of undeveloped land. Farther east, along U.S. Highway 395, is the former uranium mill site, which is privately owned and used by local companies to store lumber. Land east of Highway 395 is primarily

residences. The area southeast of the former mill site is primarily heavy industry (lumber mills). Immediately south of the site is pastureland.

The nearest residences are about 1000 ft (300 m) south and southeast of the site. These are single family homes separated from the site by open fields. To the south of these are county fairgrounds and a few residences mixed with light industry. The area southwest and west of the site is pastureland and forage crop land irrigated by canals.

2.6 WATER USE

Information on private, municipal, and county wells in the Lakeview area is presented in Table 2.2. Of nearly 100 wells on file at the Oregon State Engineer's Office, approximately 23 private wells are approximately within 1 mi (2 km) of the Lakeview site. These private wells are south of the site. Figure 2.6 shows the locations of 15 private wells sampled by the UMTRA Project. Because of the lack of monitor well coverage between the site and the private wells, it has not been determined if these wells are crossgradient or downgradient from the site.

Surface water, primarily from Thomas and Warner Creeks, is used for irrigation through a system of irrigation ditches in areas west, southwest, and south of the site. Ground water is also used for irrigation.

Drinking water is supplied by the city of Lakeview within city limits; residents outside the city limits have private wells. Lakeview obtains its water from two sources. In the winter and spring, water is obtained from springs in the mountains east of the city. In summer and fall, as these springs dry up, water is obtained from six water wells within the city limits. These municipal water supply wells are in sections 15 and 16. All these wells are more than 1 mi (1.6 km) south of the site and are completed at depths significantly greater (approximately 250 to 350 ft [76 to 110 km] below land surface) than the known extent of site-related constituents. The municipal wells are analyzed routinely for water quality by the state of Oregon and to date have met all EPA primary drinking water quality standards. Iron and manganese have exceeded secondary drinking water quality levels. The Lakeview municipal wells comply with Oregon State Health Department wellhead protection regulations. These regulations include requirements that 1) wells must be installed with adequate surface seals to prevent contamination from surface waters, 2) well casings must extend at least 1 ft (0.3 m) above the floodplain, and 3) potential subsurface contamination sources are excluded within 100 ft (30 m) of the well.

Approximately 10 residences are along Missouri Avenue, about 1100 ft (340 m) south of the site. Another group of up to 10 residences is south of Missouri Avenue along Roberta Avenue, between 2700 and 5100 ft (820 and 1600 m) south of the site. A telephone survey of these two groups of residents indicates that while a few homes on Missouri Avenue are connected to city water, most use shallow wells as their only source of domestic water, including drinking

Table 2.2 Private and public wells, Lakeview, Oregon, site vicinity

Location	Number of wells	Depth range (ft)	Depth range (m)	Screen range (ft)	Screen range (m)
East of processing site					
Upgradient Section 3					
	1	685	209	None	None
	3	105-317	32-97	50-280	15-85
Crossgradient Section 10					
	4	155-310	47-94	70-310	21-94
	5	58-603	18-184	38-603	12-184
Downgradient Section 15					
City well	1	595	181	NA	NA
City well	2	1820-2380	555-725	NA	NA
City well	3	50-405	15-123	24-340	7-103
North/south of processing site					
Upgradient Section 4					
County well	4	8-509	2-155	8-505	2-154
Public well	16	70-415	21-126	32-360	10-110
	1	320	98	160-240	49-73
	5	100-300	30-91	50-300	15-91
	4	150-560	46-171	30-400	9-122
Downgradient Section 9					
	2	No information other than "drilled"			
	5	90-800	27-244	35-515	11-157
County well	4	17-60	5-18	NA	NA
County well	6	35-330	11-101	60-320	18-98
BLM well	2	46-115	14-35	40-100	12-30
Far downgradient Section 16					
County well	1	6	2	NA	NA
County well	5	101-140	31-43	NA	NA
	2	81-123	25-38	81-123	25-37

Table 2.2 Private and public wells, Lakeview, Oregon, site vicinity (Concluded)

Location	Number of wells	Depth range (ft)	Depth range (m)	Screen range (ft)	Screen range (m)
Far downgradient Section 16 (continued)					
City well	1	371	113	71-371	22-113
	3	81-132	25-40	59-131	18-40
	3	230-365	70-111	NA	NA
City well	3	80-360	24-110	22-340	7-104
	1	300	91	280-300	85-91
West of processing site					
Crossgradient Section 5					
	1	165	50	40-95	12-29
	1	130	40	NA	NA
	3	48-223	15-68	48-210	15-64
Downgradient Section 8					
County well	2	5-300	2-91	NA	NA
	2	43-?	13-?	NA	NA

Note: This information is from well logs on file at the Oregon Water Resources Department in Salem, Oregon. Data on depth and screen interval are not always provided. Screen interval includes perforation depths. Wells are private unless noted otherwise. Section numbers refer to sections in Township 39 South, Range 20 East.

NA – no information available.
? – unknown well depth.

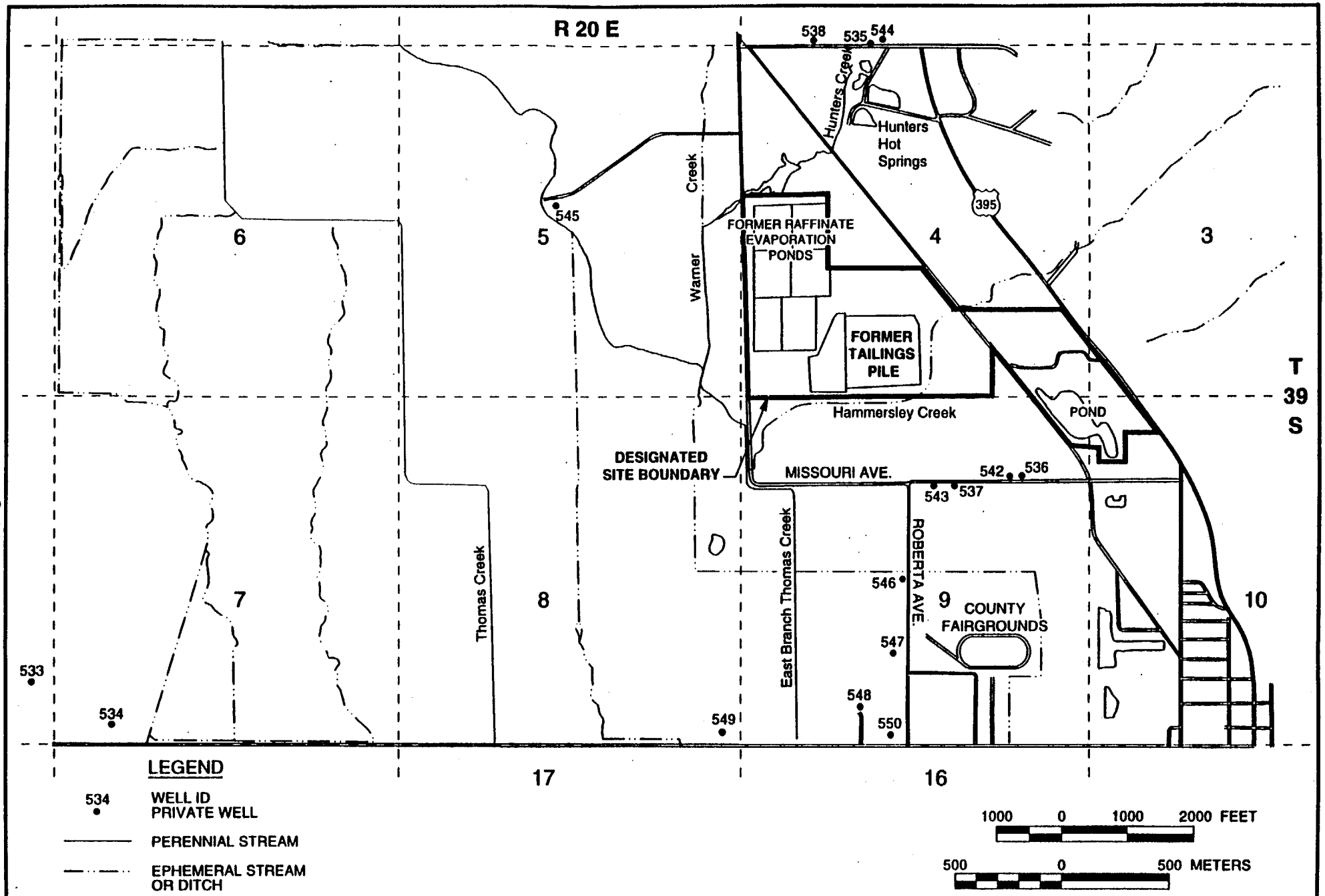


FIGURE 2.6
LOCATIONS OF SELECTED PRIVATE WELLS
LAKEVIEW, OREGON, SITE

MAC: SITE/LKV/BRA/BASE1-DOMWELLS

water. Due to poor water quality in some Roberta Avenue residences, private well water (wells 546, 547, 548, 549, and 550) is used only for domestic purposes other than drinking (cooking, laundry, livestock watering, etc.) (Figure 2.6). Bottled water is used for drinking.

3.0 EXTENT OF CONTAMINATION

Water quality data were collected from 1982 to 1993 from 34 monitor wells, located both on and off the site, and from 14 private wells (discussed in Section 3.3). The locations of monitor wells and private wells are shown in Figures 2.4 and 2.6, respectively. Well completion data and sampling information from the DOE monitor wells are provided in Table 3.1 (DOE, 1995b). Eighteen of the monitor wells were decommissioned during the 1989 surface remediation of the site, while two additional wells were completed after remediation. Two monitor wells were decommissioned in 1993 after they were noted in the field to have been seriously damaged since the September 1992 water quality sampling event. At present, 15 monitor wells exist at the Lakeview site.

Ground water quality data from 1984 through 1993 were used in this risk assessment (DOE, 1995b). Data from the 1982 sampling round were not incorporated because the reported concentrations of several key constituents were inconsistent with results of all subsequent sampling rounds.

With regard to background, the use of data collected both before and after 1988 allows a more rigorous statistical evaluation of background water quality. With regard to contaminated ground water, prior to surface remediation (1988 to 1989) the greatest concentrations of some site-related constituents were located beneath the evaporation pond and tailings pile. Monitor wells in these areas were removed during surface remediation of the site and water quality data are not available for these wells after 1988.

In the period following 1989, concentrations observed in areas beneath the tailings piles and evaporation ponds may have decreased. This is because constituents in ground water may have been diluted and dispersed after surface remediation. However, a review of data immediately downgradient of the evaporation pond and tailings pile areas has not supported this supposition. Constituent concentrations have remained relatively constant downgradient of the site (for example, sulfate) (Figure 3.1). Without information to support a decrease of concentrations beneath the site, water quality data collected prior to 1988 were used to characterize the possible range of site-related contamination. These data may overestimate current concentrations of ammonium, boron, chloride, iron, molybdenum, potassium, sodium, strontium, and sulfate. Therefore, while the highest historical levels of site-related constituents have been used to determine potential risk, information on the maximum observed concentrations in downgradient wells is also provided (Table 3.2).

An additional possible limitation to the use of older (pre-1988) data is that laboratory analytical methods and quality control have improved over time. However, a review of all data from the site indicates the analytical data collected since 1984 have been consistent through time, and there is no reason to expect analytical errors the in older data. Note that this is not true of data collected prior to 1984, and these data have not been incorporated into this risk assessment.

Table 3.1 Summary of DOE monitor wells, Lakeview, Oregon, site

Location ID	Depth (ft)	Depth (m)	Screen (ft)	Screen (m)	Sampling date	Number of rounds
Upgradient						
LKV-01-0501	25	8	20-25	6-8	1984-93	20
LKV-01-0502	85	26	80-85	24-26	1984-92	18
LKV-01-0530	31	9	16-15	5-8	1982-85	3
LKV-01-0523	25	8	20-25	6-8	1984-85	3
LKV-01-0524	80	24	70-75	21-23	1984-85	3
Downgradient, shallow evaporation pond area						
LKV-01-0503	25	8	20-25	6-8	1984-93	21
LKV-01-0505	30	9	23-28	7-8.5	1984-93	21
LKV-01-0511	34.5	10.5	27-32	8-10	1984-85	2
LKV-01-0513	29.5	9.0	17-22	5-7	1984-85	3
LKV-01-0515	24.5	7.5	20-25	6-8	1984-85	2
LKV-01-0518	29.5	9.0	24-29	7-9	1984-93	14
LKV-01-0519	34.5	10.5	30-40	9-12	1984	1
LKV-01-0521	24.5	7.5	16-21	5-6	1984-85	2
LKV-01-0525	29.5	9.0	24-29	7-9	1984-92	21
LKV-01-0529	26	8	23-37	7-11	1982, 1984, 1985	3
LKV-01-0541	30	9	28-33	8.5-10	1990-93	6
Downgradient, shallow tailings area						
LKV-01-0507	25	8	18-23	5.5-7	1984-93	21
LKV-01-0527	26.5	8	25-37	8-11	1982, 1984, 1985	3
LKV-01-0528	28	8.5	23-29	7-9	1982, 1984, 1985	3
LKV-01-0532	28	8.5	22-38	7-11.5	1982, 1984, 1985	4
LKV-01-0540	30	9	27-32	8-10	1990-93	6
Downgradient, shallow between tailings and evaporation ponds						
LKV-01-0509	35	11	29-34	9-10	1984-85, 1993	4
LKV-01-0531	43	13	38-51	11.5-15.5	1982, 1984, 1985	3
Downgradient, deep evaporation ponds						
LKV-01-0504	80	24	73-78	22-24	1984-92	20
LKV-01-0506	85	26	77-82	23.5-25	1984-92	20
LKV-01-0512	125	38	82-87	25-26.5	1984-85	2
LKV-01-0514	80	24	70-75	21-23	1984-85, 1991	4
LKV-01-0516	81	25	72-77	22-23.5	1984-85	2
LKV-01-0520	90	27	70-85	21-26	1984	1
LKV-01-0522	59	18	52-57	16-17	1984-85	2
LKV-01-0526	80	24	63-68	19-21	1984-92	19
Downgradient, deep tailings						
LKV-01-0508	80	24	72-77	22-23.5	1984-92	19
LKV-01-0517	80	24	70-75	21-23	1984-85	3
LKV-01-0510	75	23	70-75	21-23	1984-85	2

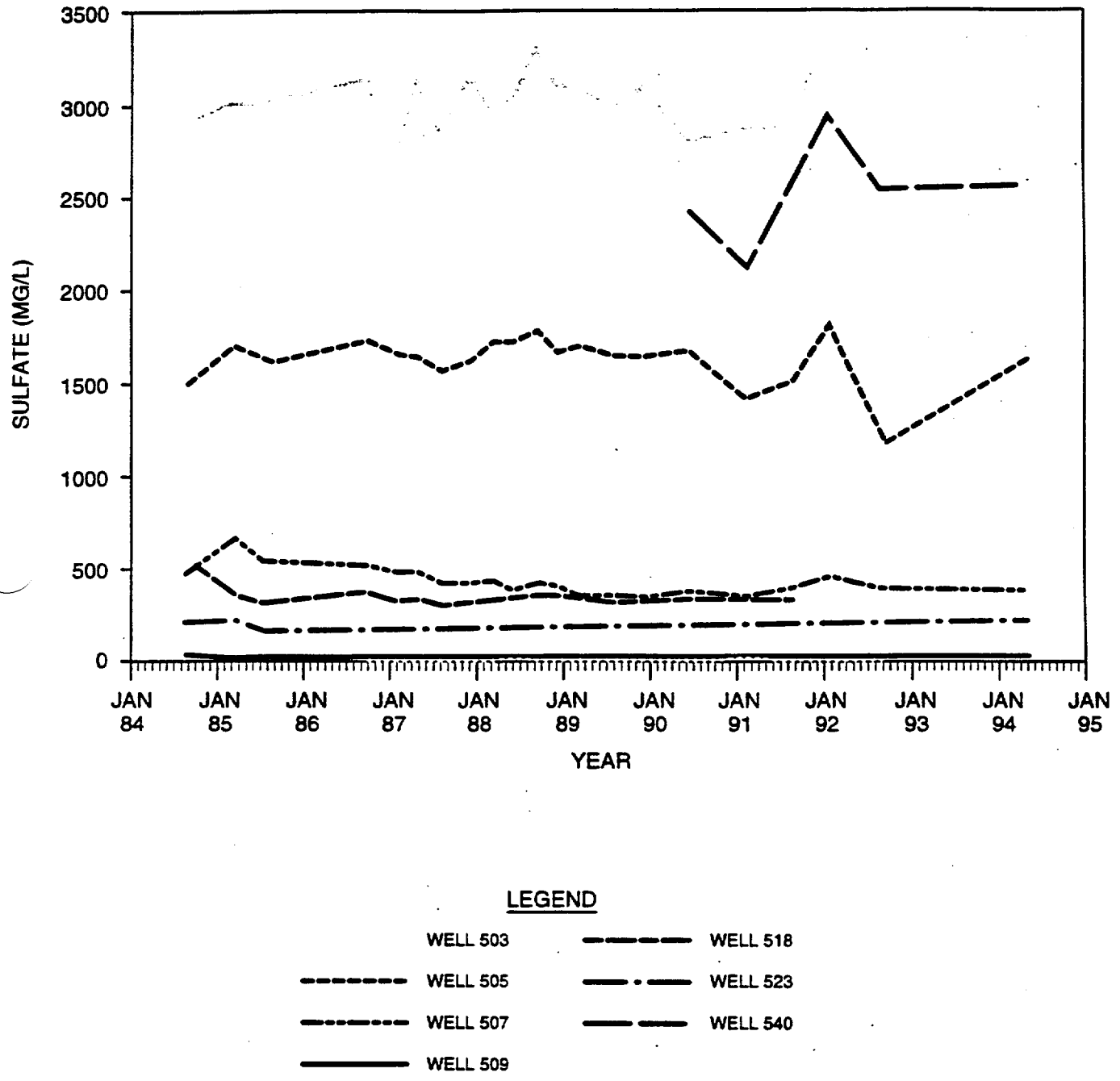


FIGURE 3.1
SULFATE CONCENTRATIONS
VERSUS TIME IN SELECTED WELLS
LAKEVIEW, OREGON, PROCESSING SITE VICINITY

Table 3.2 Summary of filtered ground water quality in the shallow zone, Lakeview, Oregon, site, 1984-1993

Parameter[c]	Frequency of detection[d]	Observed concentration[a] Minimum	Median[b]	Maximum
		(mg/L)		
Inorganic constituents				
Aluminum				
Nongeothermal background	0/7	<0.05	<0.05	<0.10
Geothermal background	0/2	<0.10	<0.10	<0.10
Plume (well LKV-01-0540)	4/5	<0.10	0.45	0.71
Ammonium				
Nongeothermal background	8/18	<0.1	<0.1	4.1
Geothermal background	2/3	<0.1	0.3	0.4
Plume (well LKV-01-0521)	2/2	1.6	1.7	1.8
Antimony				
Nongeothermal background	1/18	<0.001	<0.003	0.004
Geothermal background	2/2	0.006	0.008	0.010
Plume	7/23	<0.003	<0.004	0.027
Arsenic				
Nongeothermal background	3/20	<0.001	<0.01	0.003
Geothermal background	0/3	<0.01	<0.01	<0.01
Plume (well LKV-01-0503)	20/21	0.002	0.06	0.10
Barium				
Nongeothermal background	0/8	<0.01	<0.06	<0.10
Geothermal background	0/1	—	<0.10	—
Plume	8/14	0.02	0.04	<0.10
Beryllium				
Nongeothermal background	0/6	<0.005	<0.008	<0.01
Geothermal background		No data available		
Plume	0/11	<0.005	<0.01	<0.01
Boron				
Nongeothermal background	4/17	<0.01	<0.10	0.19
Geothermal background	3/3	4.6	4.8	5.2
Plume (well LKV-01-0521)	2/2	55	56	57
Bromide				
Nongeothermal background	1/3	<0.1	<0.1	0.3
Geothermal background		No data available		
Plume	5/6	<0.1	1.1	3.0

Table 3.2 Summary of filtered ground water quality in the shallow zone, Lakeview, Oregon, site, 1984-1993 (Continued)

Parameter[c]	Frequency of detection[d]	Observed concentration[a] Minimum	Median[b]	Maximum
		(mg/L)		
Cadmium				
Nongeothermal background	2/19	<0.001	<0.001	0.002
Geothermal background	1/3	<0.001	<0.002	0.003
Plume	5/25	<0.001	<0.001	0.031
Calcium				
Nongeothermal background	20/20	15	21	25
Geothermal background	3/3	7	9	10
Plume (well LKV-01-0540)	6/6	525	563	642
Chloride				
Nongeothermal background	20/20	1	2	5
Geothermal background	3/3	12	94	100
Plume (well LKV-01-0513)	3/3	2200	2300	3400
Chromium				
Nongeothermal background	1/18	<0.01	<0.01	0.02
Geothermal background	0/2	<0.01	<0.01	<0.01
Plume	6/24	<0.01	<0.01	0.03
Cobalt				
Nongeothermal background	0/8	<0.01	<0.05	<0.05
Geothermal background	0/2	<0.05	<0.05	<0.05
Plume	4/13	<0.01	<0.05	0.23
Copper				
Nongeothermal background	0/8	<0.01	<0.02	<0.02
Geothermal background	0/2	<0.02	<0.02	<0.02
Plume	3/13	<0.01	<0.02	0.03
Cyanide				
Nongeothermal background	1/5	<0.01	<0.02	0.03
Geothermal background		No data available		
Plume	2/9	<0.01	<0.01	0.11
Fluoride				
Nongeothermal background	11/17	<0.1	0.1	0.2
Geothermal background	3/3	2.0	3.2	4.2
Plume (well LKV-01-0503)	19/19	0.4	3.6	7.0

Table 3.2 Summary of filtered ground water quality in the shallow zone, Lakeview, Oregon, site, 1984-1993 (Continued)

Parameter[c]	Frequency of detection[d]	Observed concentration[a] Minimum	Median[b]	Maximum
		(mg/L)		
Iron				
Nongeothermal background	4/20	<0.02	<0.03	0.07
Geothermal background	1/3	<0.03	<0.03	0.03
Plume (well LKV-01-0513)	3/3	15	23	27
Lead				
Nongeothermal background	1/9	<0.001	<0.01	0.01
Geothermal background	0/2	<0.01	<0.01	<0.01
Plume	0/15	<0.001	<0.01	<0.02
Magnesium				
Nongeothermal background	20/20	6.8	8.2	9.6
Geothermal background	3/3	0.1	0.2	0.6
Plume (well LKV-01-0540)	6/6	200	222	245
Manganese				
Nongeothermal background	4/19	<0.01	<0.01	0.08
Geothermal background	3/3	0.01	0.02	0.03
Plume (well LKV-01-0540)	5/5	14	34	39
Mercury				
Nongeothermal background	0/8	<0.0002	<0.0002	<0.000
Geothermal background	0/1	–	<0.0002	–
Plume	1/14	<0.0002	<0.0002	0.000
Molybdenum				
Nongeothermal background	0/9	<0.01	<0.01	<0.01
Geothermal background	1/1	–	0.03	–
Plume (well LKV-01-0521)	1/1	0.44	0.44	0.44
Nitrate				
Nongeothermal background	19/19	1.2	3.5	13
Geothermal background	1/3	<1.0	<1.0	5
Plume	7/25	<0.1	<1.0	10
Nickel				
Nongeothermal background	1/8	<0.01	<0.04	0.01
Geothermal background	0/1	–	<0.04	–
Plume (well LKV-01-0540)	5/5	0.04	0.09	0.13

Table 3.2 Summary of filtered ground water quality in the shallow zone, Lakeview, Oregon, site, 1984-1993 (Continued)

Parameter[c]	Frequency of detection[d]	Observed concentration[a] Minimum	Median[b]	Maximum
		(mg/L)		
Phosphate				
Nongeothermal background	7/8	<0.1	0.3	1.4
Geothermal background	1/3	<0.1	<0.1	0.4
Plume	9/13	<0.1	0.2	0.8
Potassium				
Nongeothermal background	20/20	0.9	1.1	2.4
Geothermal background	3/3	5.3	6.8	7.4
Plume (well LKV-01-0513)	3/3	31	33	43
Selenium				
Nongeothermal background	0/9	<0.002	<0.005	<0.03
Geothermal background	0/2	<0.005	<0.005	<0.005
Plume	0/15	<0.002	<0.02	<0.05
Silica				
Nongeothermal background	6/6	38	44	52
Geothermal background	1/1	—	66	—
Plume	11/11	36	58	73
Silver				
Nongeothermal background	0/8	<0.01	<0.01	<0.01
Geothermal background	0/1	—	<0.01	—
Plume	1/14	<0.01	<0.01	0.01
Sodium				
Nongeothermal background	20/20	11	15	23
Geothermal background	3/3	160	179	184
Plume (well LKV-01-0529)	3/3	3370	4310	5760
Strontium				
Nongeothermal background	5/8	0.05	0.05	<0.1
Geothermal background	0/3	<0.1	<0.1	<0.1
Plume (well LKV-01-0513)	3/3	4.0	5.0	6.5
Sulfate				
Nongeothermal background	19/20	0.2	3.0	14
Geothermal background	3/3	160	200	210
Plume (well LKV-01-0529)	3/3	6100	6700	7300

Table 3.2 Summary of filtered ground water quality in the shallow zone, Lakeview, Oregon, site, 1984-1993 (Continued)

Parameter[c]	Frequency of detection[d]	Observed concentration[a] Minimum	Median[b]	Maximum
		(mg/L)		
Sulfide				
Nongeothermal background	0/5	<0.1	<0.1	<1.0
Geothermal background		No data available		
Plume	0/9	<0.1	<0.1	<1.0
Thallium				
Nongeothermal background	0/6	<0.01	<0.01	<0.1
Geothermal background		No data available		
Plume	0/11	<0.01	<0.01	<0.1
Tin				
Nongeothermal background	0/7	<0.005	<0.005	<0.03
Geothermal background	0/1	—	<0.005	—
Plume	5/15	<0.005	<0.01	0.062
Uranium				
Nongeothermal background	7/18	<0.001	<0.003	0.002
Geothermal background	0/1	—	<0.003	—
Plume (well LKV-01-0540)[e]	6/6	0.003	0.009	0.014
Vanadium				
Nongeothermal background	3/8	<0.01	<0.01	0.03
Geothermal background	0/1	—	<0.01	—
Plume	6/16	<0.01	<0.01	0.13
Zinc				
Nongeothermal background	9/19	<0.005	<0.005	0.25
Geothermal background	1/2	<0.005	<0.008	0.01
Plume (well LKV-01-0540)	6/6	0.078	0.30	0.40
Radionuclides		(pCi/L)		
Lead-210				
Nongeothermal background	3/4	0.1	0.5	1.0
Geothermal background	0/1	—	<1.0	—
Plume	6/7	0.0	0.3	1.6
Polonium-230				
Nongeothermal background	3/4	0.0	0.1	0.8
Geothermal background	0/1	—	<0.5	—
Plume (well LKV-01-0503)	5/5	3.8	6.8	9.1

Table 3.2 Summary of filtered ground water quality in the shallow zone, Lakeview, Oregon, site, 1984-1993 (Concluded)

Parameter[c]	Frequency of detection[d]	Observed concentration[a] Minimum	Median[b]	Maximum
			(pCi/L)	
Radium-226				
Nongeothermal background	16/17	0.0	0.0	1.6
Geothermal background	0/1	–	<1.0	–
Plume	22/23	0.0	0.1	0.7
Thorium-230				
Nongeothermal background	13/14	0.0	0.3	1.4
Geothermal background	0/1	–	<1.0	–
Plume	17/18	0.0	0.2	1.2

[a]Trend analyses with time indicate virtually no change in the chemistry of ground water in 12 wells (both upgradient and downgradient of the site) sampled from 1984 through 1993. Therefore, all data available for that period are used for statistical evaluation of ground water quality. However, no recent data (post-1988) are available for wells decommissioned during surface remediation. Thus, present concentrations in the area of wells 521, 513, and 529 may differ from those listed.

[b]The 50th percentile of the data. When only two data are available, the reported median is the arithmetic average of the two.

[c]Nongeothermal background water quality represented by monitor well 501. Geothermal background water quality represented by monitor well 523, sampled during 1984-1985 only. Plume water quality represented by monitor well 503 and monitor well 540, except as noted.

[d]Number of samples with concentrations reported above detection limit/total number of samples.

[e]Uranium concentrations in monitor well 540 have a statistically significant ($p = 0.03$) upward trend with time, from a low of 0.003 mg/L in 1990 to 0.014 mg/L in 1993.

Dash indicates only one measurement.
pCi/L – picocuries per liter.

Most monitor well water quality data were obtained from filtered water samples (0.45-micron filter). These data were used to evaluate the extent of contamination at the Lakeview site. For a few sampling rounds, both filtered and unfiltered water samples were collected and analyzed for most constituents. All available unfiltered data were examined and incorporated as needed for exposure assessment, as explained below (DOE, 1995b). In contrast to monitor well data, private well data were not filtered prior to laboratory analysis.

The samples were analyzed for the following inorganic chemicals: aluminum, ammonium, antimony, arsenic, barium, beryllium, boron, bromide, cadmium, calcium, chloride, chromium, cobalt, copper, cyanide, fluoride, iron, lead, magnesium, manganese, mercury, molybdenum, nitrate, nickel, phosphate, potassium, selenium, silica, silver, sodium, strontium, sulfate, sulfide, thallium, tin, uranium, vanadium, and zinc, and the following radionuclides: lead-210, polonium-210, radium-226, and thorium-230.

Organic solvents were used in the milling process (Merritt, 1971). In November 1988, ground water from the Lakeview processing site was screened for organic constituents (Hill, 1989; DOE, 1992) listed in Appendix IX of 40 CFR Part 264 of the Resource Conservation and Recovery Act. This screening included ground water samples from an upgradient background monitoring well (501) and a shallow well (503) immediately downgradient of the evaporation pond area. None of the organic constituents listed in Appendix IX were detected in samples from these wells.

3.1 BACKGROUND GROUND WATER QUALITY SUMMARY

Background ground water quality is defined as the quality of water that would exist if uranium milling activities had not occurred. At the Lakeview site, there are two distinct types of background ground water upgradient from the site: geothermal and nongeothermal. Geothermal ground water issues from at least two hot springs (Hunters Hot Springs) immediately upgradient from the evaporation pond area of the site (Figure 2.2). The second type of natural ground water (nongeothermal) is found upgradient of the tailings pile area. Monitor well 523, upgradient and off the site, is considered the geothermal background well. Monitor well 501, also upgradient, is representative of nongeothermal background water.

Shallow monitor well 530 also was upgradient from the site within the area of nongeothermal ground water. However, data from this well were not used for the statistical evaluation of background ground water quality because only three rounds of older data were available and because the water quality was similar to that of the nearby background monitor well 501, for which several sampling rounds, including recent data, were available. Thus, only data from monitor well 501 were used to establish background water quality in the shallow, nongeothermal ground water.

The chemistry of the two types of shallow background ground water is summarized in Table 3.2. The nongeothermal ground water has relatively low total dissolved solids (TDS), ranging from 98 to 256 milligrams per liter (mg/L).

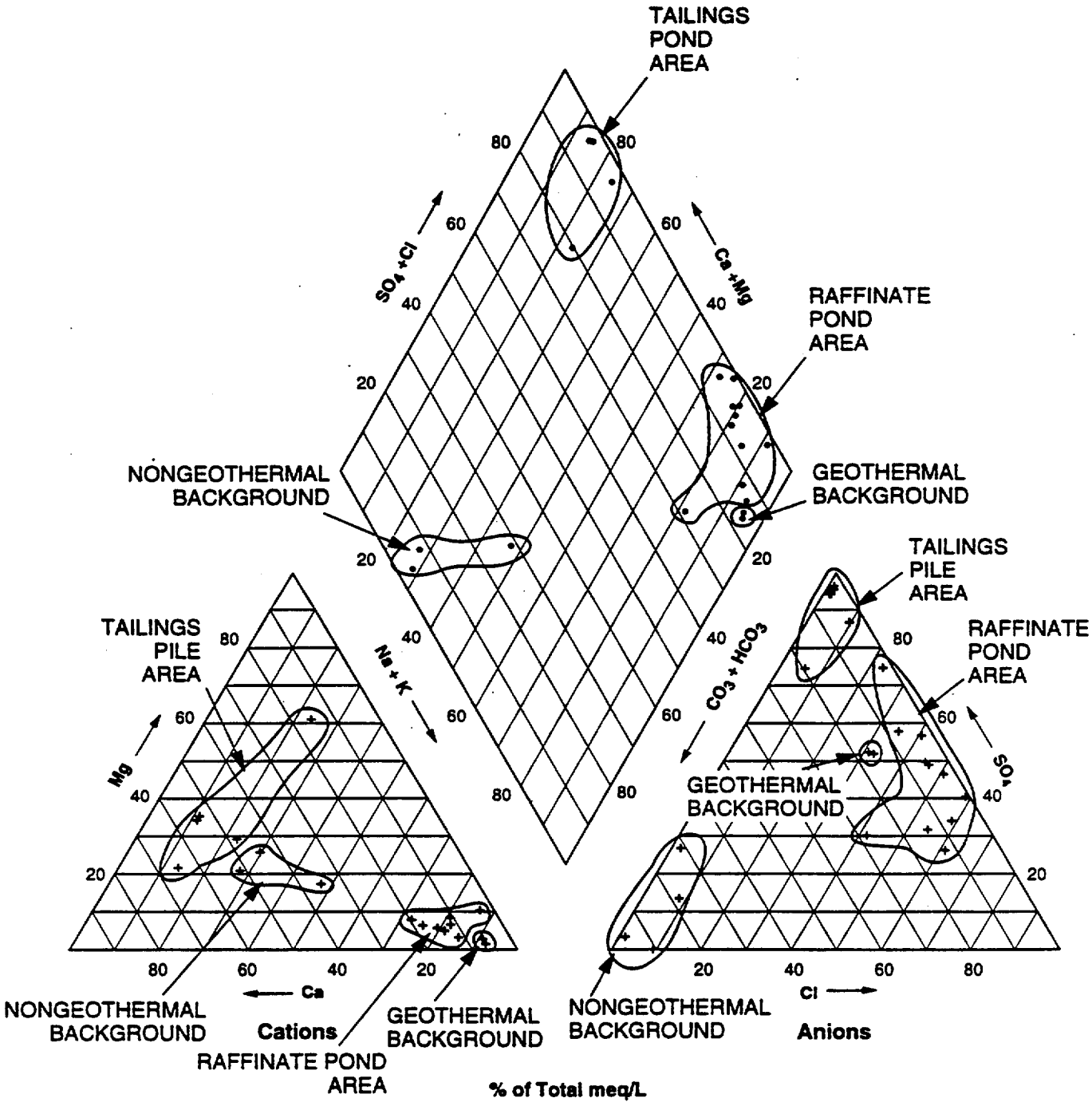
The water is sodium-calcium-magnesium-bicarbonate water, with notably low concentrations of chloride (1 to 5 mg/L) and sulfate (<1 to 14 mg/L). In contrast, the geothermal ground water has relatively high TDS, ranging from 657 to 714 mg/L, and is sodium-sulfate-chloride water, notably depleted in calcium and magnesium. Several elements commonly associated with geothermal water are found in elevated concentrations in the geothermal water at Lakeview, including silica, arsenic, boron, and fluoride. The differences in major ion proportions in the geothermal and nongeothermal water are illustrated by trilinear plots of major elements (Figure 3.2).

Background ground water quality in the deeper zone is summarized in Table 3.3. Analysis of changes in background ground water quality with depth indicates that in a given area (geothermal or nongeothermal), water quality remains relatively constant with depth (Figure 3.2). This risk assessment focuses on background and downgradient ground water in the shallow portion of the aquifer because it has the greatest magnitude of contamination.

The effects of geothermal activity on regional ground water quality in the Lakeview area has been studied (Brown et al., 1980). There are over 20 thermal springs and wells in the Lakeview area (Goose Lake basin). Seven of the thermal springs and wells studied and sampled were between 0.2 to 2 miles (0.3 to 3 km) upgradient of the site. Arsenic concentrations in ground water from these seven locations were notable, ranging from <0.005 to 0.162 mg/L, with the highest values occurring in Hunters Hot Springs and nearby thermal wells, just north of the site. Ground water in six of these seven thermal springs and wells upgradient of the site exceed the UMTRCA maximum concentration limit (MCL) for arsenic (0.05 mg/L) and the National Primary Drinking Water Regulation for arsenic (also 0.05 mg/L).

Arsenic also occurs in geothermal background ground water sampled from DOE well 524. Arsenic concentrations in this well, completed in the deeper zone, have ranged from 0.04 to 0.11 mg/L (Table 3.3). These values are similar to arsenic values reported in the thermal wells and springs upgradient of the site. By contrast, arsenic levels in geothermal background well 523 have been low (<0.01 mg/L) (Table 3.2) and are anomalous when compared to nearby and upgradient wells and springs. The reason for this anomaly is not known. There are no other notable differences between water quality in geothermal background wells 524 and 523.

The hydraulic gradient in the shallow portion of the aquifer (discussed in Section 2.3) indicates the evaporation pond area is downgradient from the area of geothermal ground water and the tailings pile area is downgradient from the area of nongeothermal ground water. The geochemistry of contaminated water supports this, demonstrating that the appropriate background ground water for the pond area is geothermal (monitor well 523), while the appropriate background ground water for the tailings area is nongeothermal (monitor well 501). However, there are too few geothermal background data to make a



NOTE: BACKGROUND INCLUDES BOTH DEEP AND SHALLOW MONITOR WELLS. TAILINGS AND RAFFINATE POND AREAS INCLUDE DATA FOR MONITOR WELLS COMPLETED ONLY IN THE SHALLOW PORTION OF THE AQUIFER.

FIGURE 3.2
TRILINEAR DIAGRAM OF MAJOR GROUND WATER CHEMISTRIES
LAKEVIEW, OREGON, SITE

Table 3.3 Summary of filtered ground water quality in the deeper zone, Lakeview, Oregon, site, 1984-1992

Parameter[c]	Frequency of detection[d]	Observed concentration[a] Minimum	Median[b]	Maximum
			(mg/L)	
Inorganic constituents				
Aluminum				
Nongeothermal background	0/6	<0.05	<0.05	<0.10
Geothermal background	0/2	<0.10	<0.10	<0.10
Plume	0/14	<0.05	<0.05	<0.10
Ammonium				
Nongeothermal background	6/17	<0.1	<0.1	0.2
Geothermal background	3/3	0.2	0.4	0.4
Plume (well LKV-01-0506)	18/19	0.2	0.5	0.7
Antimony				
Nongeothermal background	0/15	<0.001	<0.003	<0.003
Geothermal background	2/2	0.008	0.008	0.008
Plume (well LKV-01-0506)	5/16	<0.003	<0.003	0.008
Arsenic				
Nongeothermal background	4/18	0.001	<0.01	<0.01
Geothermal background	3/3	0.04	0.08	0.11
Plume (well LKV-01-0506)	15/20	0.001	0.01	0.02
Barium				
Nongeothermal background	0/6	<0.01	<0.01	<0.10
Geothermal background	0/1	–	<0.10	–
Plume	4/12	<0.01	<0.01	<0.10
Beryllium				
Nongeothermal background	0/5	<0.005	<0.01	<0.01
Geothermal background		No data available		
Plume	0/12	<0.005	<0.008	<0.01
Boron				
Nongeothermal background	3/16	<0.01	<0.1	0.2
Geothermal background	3/3	4.5	4.6	4.6
Plume (well LKV-01-0506)	19/19	0.4	6.0	6.7
Bromide				
Nongeothermal background	2/3	<0.1	0.4	0.4
Geothermal background		No data available		
Plume	5/6	<0.1	0.5	1.1

Table 3.3 Summary of filtered ground water quality in the deeper zone, Lakeview, Oregon, site, 1984-1992 (Continued)

Parameter[c]	Frequency of detection[d]	Observed concentration[a] Minimum	Median[b]	Maximum
		(mg/L)		
Cadmium				
Nongeothermal background	1/18	<0.0001	<0.001	0.002
Geothermal background	0/3	<0.001	<0.001	<0.001
Plume	2/39	<0.0001	<0.001	0.006
Calcium				
Nongeothermal background	18/18	14	19	23
Geothermal background	3/3	6	8	8
Plume (well LKV-01-0508)	19/19	10	30	34
Chloride				
Nongeothermal background	13/18	0.5	1.1	13
Geothermal background	3/3	89	94	97
Plume (well LKV-01-0506)	20/20	140	160	180
Chromium				
Nongeothermal background	1/17	<0.01	<0.01	0.02
Geothermal background	0/2	<0.01	<0.01	<0.01
Plume	2/38	<0.01	<0.01	0.05
Cobalt				
Nongeothermal background	0/5	<0.01	<0.03	<0.05
Geothermal background	0/2	<0.05	<0.05	<0.05
Plume	0/12	<0.01	<0.04	<0.05
Copper				
Nongeothermal background	0/5	<0.01	<0.01	<0.02
Geothermal background	0/2	<0.02	<0.02	<0.02
Plume	0/12	<0.01	<0.02	<0.02
Cyanide				
Nongeothermal background	1/3	<0.01	<0.01	0.04
Geothermal background		No data available		
Plume	0/6	<0.01	<0.01	<0.01
Fluoride				
Nongeothermal background	15/16	<0.10	0.20	0.32
Geothermal background	3/3	3.4	3.7	4.7
Plume (well LKV-01-0506)	19/19	2.0	2.5	3.3

Table 3.3 Summary of filtered ground water quality in the deeper zone, Lakeview, Oregon, site, 1984-1992 (Continued)

Parameter[c]	Frequency of detection[d]	Observed concentration[a]		
		Minimum	Median[b]	Maximum
		(mg/L)		
Iron				
Nongeothermal background	3/18	<0.02	<0.03	0.10
Geothermal background	1/3	<0.03	<0.03	0.04
Plume (well LKV-01-0506)	19/20	<0.03	0.06	0.13
Lead				
Nongeothermal background	1/6	<0.001	<0.007	<0.01
Geothermal background	0/2	<0.01	<0.01	<0.01
Plume	0/14	<0.001	<0.01	<0.01
Magnesium				
Nongeothermal background	18/18	5.3	6.0	6.6
Geothermal background	3/3	0.16	0.19	0.64
Plume (well LKV-01-0508)	19/19	5.7	8.8	10.1
Manganese				
Nongeothermal background	17/17	0.14	0.30	0.59
Geothermal background	2/3	<0.01	<0.01	0.02
Plume (well LKV-01-0508)	18/18	0.10	0.86	0.93
Mercury				
Nongeothermal background	0/6	<0.0002	<0.0002	<0.0002
Geothermal background	0/1	–	<0.0002	–
Plume	0/12	<0.0002	<0.0002	<0.0002
Molybdenum				
Nongeothermal background	0/6	<0.01	<0.01	<0.01
Geothermal background	1/1	–	0.11	–
Plume (well LKV-01-0506)	6/7	<0.01	0.03	0.04
Nitrate				
Nongeothermal background	8/18	<0.1	<1.0	5.0
Geothermal background	1/3	<1.0	<1.0	6.0
Plume	16/39	<0.1	<1.0	11.2
Nickel				
Nongeothermal background	0/5	<0.01	<0.04	<0.04
Geothermal background	0/1	–	<0.04	–
Plume	0/12	<0.01	<0.04	<0.04

Table 3.3 Summary of filtered ground water quality in the deeper zone, Lakeview, Oregon, site, 1984-1992 (Continued)

Parameter[c]	Frequency of detection[d]	Observed concentration[a] Minimum	Median[b]	Maximum
			(mg/L)	
Phosphate				
Nongeothermal background	7/7	0.4	1.0	1.3
Geothermal background	2/3	<0.1	0.2	0.75
Plume	15/15	0.2	0.6	1.1
Potassium				
Nongeothermal background	18/18	0.75	1.0	4.9
Geothermal background	3/3	7.2	9.9	14.4
Plume (well LKV-01-0506)	20/20	4.8	5.2	10.9
Selenium				
Nongeothermal background	0/6	<0.002	<0.005	<0.03
Geothermal background	0/2	<0.005	<0.005	<0.005
Plume	0/14	<0.002	<0.005	<0.03
Silica				
Nongeothermal background	6/6	6.0	32	38
Geothermal background	1/1	74	74	74
Plume (well LKV-01-0506)	6/6	55	57	66
Silver				
Nongeothermal background	0/6	<0.01	<0.01	<0.01
Geothermal background	0/1	<0.01	<0.01	<0.01
Plume	0/12	<0.01	<0.01	<0.01
Sodium				
Nongeothermal background	18/18	16	18	39
Geothermal background	3/3	160	173	178
Plume (well LKV-01-0506)	20/20	250	285	335
Strontium				
Nongeothermal background	7/7	0.07	0.07	0.10
Geothermal background	0/3	<0.10	<0.10	<0.10
Plume (well LKV-01-0506)	8/8	0.11	0.14	0.30
Sulfate				
Nongeothermal background	17/18	0.2	2.3	31
Geothermal background	3/3	130	190	220
Plume (well LKV-01-0506)	16/16	240	280	336

Table 3.3 Summary of filtered ground water quality in the deeper zone, Lakeview, Oregon, site, 1984-1992 (Continued)

Parameter[c]	Frequency of detection[d]	Observed concentration[a] Minimum	Median[b]	Maximum
		(mg/L)		
Sulfide				
Nongeothermal background	1/3	<0.1	<1.0	2.8
Geothermal background		No data available		
Plume	1/6	<0.1	<0.2	<1.0
Thallium				
Nongeothermal background	0/5	<0.01	<0.01	<0.10
Geothermal background		No data available		
Plume	0/12	<0.01	<0.01	<0.10
Tin				
Nongeothermal background	0/4	<0.005	<0.005	<0.01
Geothermal background	0/1	<0.005	<0.005	<0.005
Plume	1/9	<0.005	<0.005	<0.05
Uranium				
Nongeothermal background	7/16	0.0003	<0.003	0.012
Geothermal background	0/1	<0.003	<0.003	<0.003
Plume	6/36	<0.0003	<0.003	0.008
Vanadium				
Nongeothermal background	1/6	<0.01	<0.01	0.02
Geothermal background	0/1	<0.01	<0.01	<0.01
Plume	4/12	<0.01	<0.01	0.02
Zinc				
Nongeothermal background	4/15	<0.005	<0.005	0.038
Geothermal background	1/2	<0.005	<0.11	0.21
Plume	9/32	<0.005	<0.005	0.024
Radionuclides		(pCi/L)		
Lead-210				
Nongeothermal background	4	0.0	0.3	<1.0
Geothermal background	1	—	<1.0	—
Plume	8	0.0	0.7	20.3
Polonium-210				
Nongeothermal background	4	0.0	0.7	1.6
Geothermal background	1	—	<0.5	—
Plume	9	0.1	0.5	0.8

Table 3.3 Summary of filtered ground water quality in the deeper zone, Lakeview, Oregon, site, 1984-1992 (Concluded)

Parameter[c]	Frequency of detection[d]	Observed concentration[a]		
		Minimum	Median[b]	Maximum
		(pCi/L)		
Radium-226				
Nongeothermal background	17	0.0	0.1	1.0
Geothermal background	1	–	<1.0	–
Plume	35	0.0	0.0	<1.0
Thorium-230				
Nongeothermal background	14	0.0	0.2	1.5
Geothermal background	1	–	<1.0	–
Plume	27	0.0	0.5	1.7

[a]Trend analyses with time indicate virtually no change in the ground water chemistry in 12 wells (both upgradient and downgradient of the site) sampled from 1984 through 1993. Therefore, all data available for that period are used for statistical evaluation of ground water quality. However, no recent data (post-1988) are available for wells decommissioned during surface remediation. Thus, present concentrations in the area of wells 521, 513, and 529 may differ from those listed.

[b]The 50th percentile of the data. When only two data are available, the reported median is the arithmetic average of the two.

[c]Nongeothermal background water quality is represented by monitor well 502. Geothermal background water quality is represented by monitor well 524, sampled during 1984-1985 only. Plume water quality is represented by monitor wells 506 (ponds area) and 508 (tailings area), except as noted.

[d]Number of samples with reported concentrations above detection limit/total number of samples.

Dash indicates only one measurement.
pCi/L – picocuries per liter.

rigorous statistical comparison to contaminated ground water. Therefore, all downgradient ground water data initially were compared to the nongeothermal ground water to determine constituents of potential concern (discussed more fully below). The nongeothermal background ground water is a conservative benchmark because, with the exception of calcium and magnesium, the nongeothermal ground water has equal or lower concentrations of major and minor ions than geothermal ground water.

3.2 MAGNITUDE AND EXTENT OF SITE-RELATED CONSTITUENTS

3.2.1 Tailings and raffinate chemistry

Uranium ores were obtained from the White King and Lucky Lass mines, located about 15 mi (24 km) northwest of the mill, and hauled to the mill by truck for processing. The uranium ore deposits near Lakeview were formed by hydrothermal alteration of volcanic rhyolites and tuffs. Ores at the White King mine contained uraninite (UO_2), coffinite ($U(Si,H_4)O_4$) and other secondary uranium minerals in a silicified volcanic breccia. These ores were associated with other hydrothermal minerals including galena (lead sulfide), realgar and orpiment (arsenic sulfides), stibnite (antimony sulfide) and cinnabar (mercury sulfide) (Walker, 1980). The Lucky Lass Mine primarily contained secondary uranium minerals with some uraninite or coffinite. However, none of the other metallic minerals found at the White King mine were found at the Lucky Lass Mine (Walker, 1980).

The ore was leached using sodium chlorate and sulfuric acid. The uranium-bearing leachate then was separated from the solids (tails), which were sent to the tailings pile. Uranium was extracted from the leachate by amine solvent extraction, and the remaining leachate (raffinate) was then sent to the evaporation ponds. Sodium carbonate was used to strip uranium from the amine solvent, and additional sulfuric acid and magnesia were used to complete the precipitation of yellow cake (Merritt, 1971). Thus, the tailings and raffinates would have contained sodium, chloride, sulfate, and possibly magnesium. Also, the dissolution of the ore would have contributed uranium, thorium, radium, molybdenum, arsenic, mercury, antimony, and several other elements commonly found in rocks, such as aluminum, iron, manganese, and silica.

Analysis of water and acid leachable compounds in the tailings identified several of these components, including uranium, strontium, chloride, aluminum, calcium, manganese, iron, and arsenic (DOE, 1985a). Chemical profiles of solids, water-soluble extracts, and acid-soluble extracts from tailings and soils beneath the tailings revealed that large amounts of material dissolved in the tailings solutions (including uranium, strontium, arsenic, iron, and sulfate) were precipitated or adsorbed from solution within a few feet of the tailings-subsoil interface. Precipitation and sorption were primarily in response to neutralization of the low pH tailings solutions (pH of 2 to 3) by carbonate minerals in the soils, which caused the pH to increase to values of about 5 within 3 ft (1 m) below the base of the tailings.

3.2.2 Contaminated ground water chemistry

Contaminated ground water on the site is recognized by high TDS and sulfate concentrations relative to background levels. Elevated concentrations of radium, thorium, and heavy metals occur at relatively low levels in the contaminated ground water because they were adsorbed or coprecipitated in the subsoils beneath the source areas of contamination (DOE, 1985a). As a result, molybdenum and nickel concentrations in contaminated ground water are only 3 to 4 times those of background, and maximum uranium concentrations are below the MCL of 0.044 mg/L. These conclusions are discussed below.

Analyses of the major-element water chemistry of the contaminated shallow ground water beneath the site indicate two discrete types of contaminated ground water. The first, associated with the former tailings pile, is a sodium-calcium-magnesium-sulfate water relatively depleted in chloride. The second, associated with the former evaporation ponds, is a sodium-sulfate-chloride water relatively depleted in calcium and magnesium. When the relative proportions of major anions and cations are graphed on a trilinear diagram, these two types of contaminated ground water show relative ion proportions similar to their respective background water types (Figure 3.2). The exception is bicarbonate, which accounts for a larger proportion of the anions in the more dilute background water. Bicarbonate is held at near-constant levels in all ground water by equilibrium with calcite. However, while the relative proportions of major ions in the contaminated ground water are similar to their respective background water types, the absolute concentrations of ions in the contaminated ground water are 10 to 20 times greater than those in the background ground water.

The following hypothesis explains the similarity of ground water contaminated from tailings-seepage water to nongeothermal water and the similarity of evaporation pond seepage water to geothermal water. Prior to construction of the tailings piles and evaporation ponds, the soil on the site contained evaporite salts derived from the background ground water. These salts were leached from the soil by seepage from the tailings piles and evaporation ponds, producing contaminated ground water that is a mixture of constituents from both processing fluids and natural salts. This hypotheses explains why both types of contaminated ground water contain sulfate derived from ore processing, while only the evaporation pond water contains elevated chloride concentrations; the major source of this chloride may have been natural salts in soils formed by the evaporation of the geothermal water. This hypothesis also explains why contaminated ground water associated with the evaporation ponds contains high concentrations of sodium, boron, and fluoride (constituents that are relatively high in the geothermal ground water) and relatively low concentrations of calcium and magnesium (constituents that are depleted in the background geothermal waters, averaging 9 and 0.2 mg/L, respectively). Furthermore, it explains why the contaminated ground water from the tailings pile area contains relatively high calcium and magnesium concentrations, which are also relatively

high in the nongeothermal background water upgradient of the tailings pile area (averaging 21 and 8 mg/L).

The amount of salt in a saline soil required to produce the observed concentrations of chloride, boron, and fluoride was determined using the following values and assumptions: contamination extends to a depth of 40 ft (12 m) in an aquifer with 20 percent porosity; chloride, boron, and fluoride concentrations are approximately 1200, 42, and 3.6 mg/L, respectively, in the contaminated ground water; and natural chloride, borate, and fluoride salts were concentrated in the upper 39 inches (1 m) of the soil prior to leaching. The computation indicates that the soil, prior to leaching, would have contained 0.2 percent sodium chloride, 0.04 percent borate salt (as borax), and 0.0009 percent calcium fluoride, by weight (DOE, 1995b). Assuming these are present in the saline soil at the site is reasonable. The computation demonstrates that a small amount of salt can significantly affect water chemistry.

This model gains support from observations of natural salt deposits at the surface south and west of the site, though the composition of these salts has not been analyzed. Additional support comes from U.S. Department of Agriculture Soil Conservation Service soils maps for the area in the site vicinity. Soils in the area of the evaporation ponds and upgradient geothermal springs are described as "sodic and saline" and unfit for lawns, topsoil, and embankments, due to excess salt. Thus, it is possible that several constituents of the contaminated ground water, including sodium, calcium, magnesium, some sulfate, and especially chloride, boron, and fluoride, were derived at least in part from the dissolution of natural salts by tailings and evaporation pond seepage. Dissolution of natural salts elsewhere in the region also may explain the presence of high dissolved solids in some private wells, as discussed in Section 3.3.

Sulfate distribution was used to determine the extent of the constituents at the site, because this mobile major ion is common to both types of contaminated ground water. Data from March 1985 were used to delineate the extent of the constituents, since this database provides the greatest areal coverage. The 1985 ground water data appear to be pertinent to current conditions, because trend analyses with time indicate virtually no change in the chemistry of contaminated ground water in 12 wells sampled from 1984 through 1993 (Figure 3.1).

The sulfate distribution indicates two constituent plumes in the shallow ground water zone above 40 ft (12 m): one associated with the tailings pile, and a second associated with the evaporation ponds (Figure 3.3). This finding is consistent with the chemical identification of two types of contaminated ground water. Sulfate does not extend upgradient from either of these sources but does extend at least 2300 ft (700 m) downgradient from the evaporation ponds, and at least 690 ft (210 m) downgradient from the tailings ponds in directions that are consistent with the hydraulic gradient. Thus, constituents in the shallow

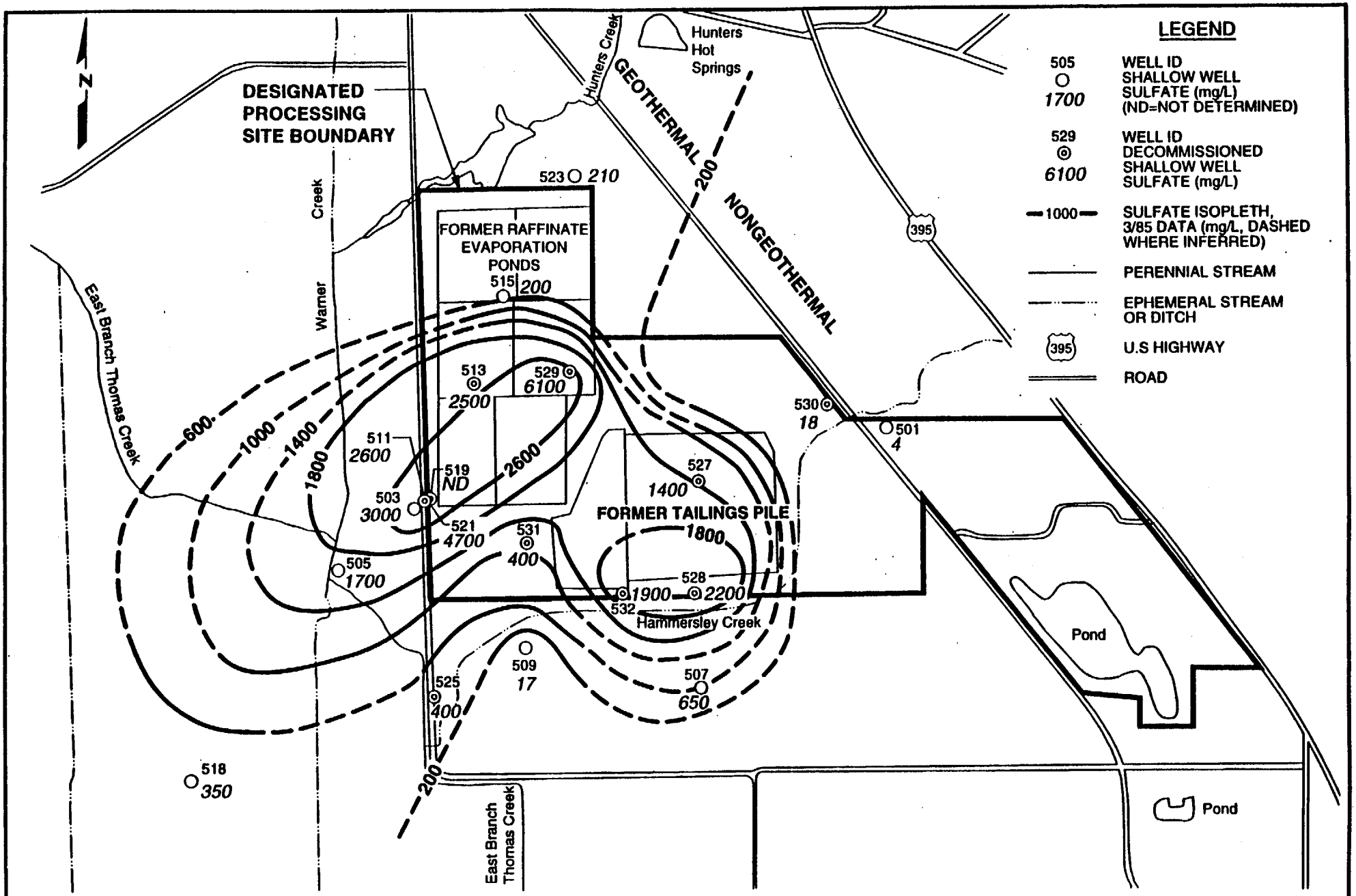


FIGURE 3.3
SULFATE ISOPLETHS
LAKEVIEW, C ON, SITE

MAC: SITE/LKV/BRA/BASE-ISOPLETHS

portion of the aquifer (0 to 40 ft [0 to 10 m]) extends beyond existing monitor wells and off the site (Figure 3.3). However, sulfate and other major constituent concentrations systematically decrease downgradient, and approach but do not reach background concentrations.

Table 3.3 summarizes filtered ground water quality in the deeper portion of the aquifer. The vertical extent of the constituents appears to be limited to depths of less than 80 ft (20 m). An intermediate depth well (522) screened between 52 and 57 ft (16 and 17 m) has elevated sulfate concentrations (880 mg/L), indicating contamination. The chemistries of the deeper wells, screened from about 63 to 87 ft (19 to 27 m), are similar to the geothermal background wells downgradient of the evaporation ponds, or to the nongeothermal wells downgradient of the tailings pile. Slightly elevated sulfate concentrations (220 to 300 mg/L) relative to geothermal background (200 mg/L) may indicate that a small amount of constituents has reached a depth of 80 ft (24 m) in monitor wells 504 and 506.

3.2.3 Statistical comparison of background and plume ground water quality

After determining the extent of the constituents (using sulfate as an indicator), water quality data collected between 1984 and 1993 were used to statistically identify the full suite of constituents elevated above background levels in shallow portions of the aquifer (DOE, 1995b). For the statistical evaluation, the 1984-1993 filtered water chemistry data from nongeothermal background well 501 were compared to concurrent data from well 503 in the vicinity of the evaporation ponds, and then to well 540 downgradient of the former tailings pile. Well 501 was chosen as background because it has the greatest number of sampling rounds and because it is within the shallow portion of the aquifer, the portion most affected by the constituents. It was necessary to use filtered water samples because very few unfiltered data were available. Wells 503 and 540 were selected for analysis because they consistently have the highest concentrations of key constituents among the current wells on or downgradient from the site.

The statistical comparison method used was the Wilcoxon signed-rank test, a nonparametric blocked comparison method that incorporates sampling dates as random blocks. Individual tests were conducted at the 0.05 level of significance. A constituent was identified as above background levels if a significant test result was obtained for either the evaporation pond monitor well (503) or the tailings area monitor well (540). Rigorous statistical comparison of plume water quality to the geothermal background was not done because of inadequate data on background geothermal water quality (monitor well 523 had only three rounds of data, collected between 1984 and 1985, and many of the chemicals were monitored only once). Constituents statistically above nongeothermal background levels include aluminum, antimony, ammonium, arsenic, boron, calcium, chloride, fluoride, iron, magnesium, manganese, molybdenum, nickel, polonium-210, potassium, silica, sodium, strontium, sulfate, uranium, and zinc.

After determining which constituents in the plume were above nongeothermal background levels, each identified constituent was compared to geothermal background levels to see if the average value for the contaminated ground water from either monitor well 503 or 540 was within the range of geothermal background water quality. This was done to identify constituents that might have a geothermal source rather than a contaminant source. Three constituents in the plume identified as above nongeothermal background levels were found to be within the range of geothermal background water quality: antimony, fluoride, and silica. On average, all remaining constituents identified as above nongeothermal background levels were present at levels above the range of geothermal background levels and therefore were identified as contaminants.

Antimony, fluoride, and silica were screened further to determine if they could be reasonably associated with a geothermal ground water source rather than the result of contamination. Antimony concentrations exceeded nongeothermal background levels only in the evaporation pond area monitor well (503). Antimony in the tailings area monitor well (540) was not statistically elevated above nongeothermal background levels. Because the pond area is downgradient from the geothermal water source, the antimony in the plume in this area likely is from a natural source, rather than a site-related constituent.

Fluoride in monitor wells 503 and 540 (up to 3.7 mg/L) was close to the range of geothermal background levels (up to 3.1 mg/L). Although fluoride in the tailings area ground water is statistically higher than its appropriate background levels, there is evidence that nongeothermal ground water near the site is naturally high in fluoride. The highest fluoride concentration observed at the site (9 mg/L) was found in monitor well 509, a downgradient well at the very edge of the area of contamination (Figure 3.3). Water from this well has very low sulfate (30 mg/L or less), chloride (13 mg/L or less), and TDS (344 mg/L or less), indicating that it has received little or no contamination and that the ground water is from a predominantly nongeothermal source. Thus, the fluoride in this well and the plumes is probably natural, derived from minerals in the aquifer matrix. For this reason, fluoride was not considered a site-related constituent.

Finally, silica concentrations in both the tailings and pond areas were found to be at levels near those in the geothermal ground water. However, in the tailings area, the appropriate background ground water is the nongeothermal ground water, which has relatively low silica concentrations. Therefore, silica is considered a site-related constituent in the tailings area, even though silica concentrations in contaminated ground water across the site are on average less than those in the natural geothermal water.

Table 3.2 summarizes the water quality measurements from filtered water samples collected between 1984 and 1993 from the shallow aquifer and compares ground water affected by the former milling-related activities to geothermal and nongeothermal background ground water quality. Most contaminated ground water concentrations presented were observed in well 503 (evaporation pond area) and/or well 540 (tailings area). In several cases,

however, well 503 water quality was supplanted by higher 1983-1985 levels recorded for one or more of the abandoned wells in the evaporation pond area prior to surface remediation activities. Because there is no evidence that ground water contamination has decreased significantly during the last 10 years, it is possible that these early high levels may still be present under the site or may have decreased, but are not accessible to current wells. Site-related constituents for which early data are reported in Table 3.2 include boron, chloride, iron, molybdenum, potassium, sodium, strontium, and sulfate.

For a limited number of sampling rounds, both filtered and unfiltered water samples were collected and analyzed for antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silica, silver, sodium, thallium, tin, uranium, vanadium, and zinc. These data pairs of filtered and unfiltered results were analyzed to assess the impact that filtering may have had on the constituent concentrations in monitor well samples. Arsenic, iron, manganese, and zinc concentrations were typically higher in unfiltered than in filtered samples. Conversely, calcium, magnesium, potassium, and sodium concentrations do not appear to be systematically affected by filtration. The remaining constituents are present at the Lakeview site at low concentrations (near or below the detection level); thus, the impacts of filtration are not discernible from the available data. The higher unfiltered arsenic levels were considered in evaluating potential risks from exposure to this constituent.

3.3 PRIVATE WELL WATER QUALITY

Water quality data were collected in 1982, 1984, and 1985 from 5 private wells north and southeast of the site and in 1993 from 15 private wells north, southeast, south, southwest, and west of the site, including wells on Missouri and Roberta Avenues (Table 3.4). Locations of the wells are shown in Figure 2.6. Unfiltered samples were collected and analyzed for major elements and trace elements indicative of the uranium milling process. Analytical data from private wells north of the site (upgradient), southeast of the site (crossgradient), and west of the site (crossgradient) were collected to determine variations in natural water chemistry in the area. Analytical data from wells south and southwest of the site were collected to determine if those wells were receiving contaminated ground water from the site. The depths of these wells range from 50 to 280 ft (15 to 85 m), but most are in the 50- to 100-ft (15- to 30-m) range (Table 3.4). Table 3.5 presents results of the latest water quality sampling tests for each well.

Ground water geochemistry and temperatures in private wells north of the site (upgradient wells 535, 538, and 544) indicate they are geothermal waters having relatively high concentrations of sodium, sulfate, chloride, and TDS. These geothermal waters also contain elevated concentrations of zinc and arsenic. Hunters Hot Springs are the source of these waters; the water quality is similar to that in DOE monitor wells used to establish upgradient geothermal background ground water quality (discussed in Section 3.1).

Table 3.4 Summary of private wells sampled, 1984 through 1994, Lakeview, Oregon, site vicinity

Location ID	Depth (ft)	Depth (m)	Sampling dates	Number of sampling rounds
LKV-01-0533	Unknown		1984, 1985, 1993	3
LKV-01-0534	92	28	1984, 1993	2
LKV-01-0535	150	46	1984, 1985, 1993	3
LKV-01-0536	Unknown		1982, 1984, 1985, 1993	4
LKV-01-0537	50	15	1984, 1993, 1994	3
LKV-01-0538	100	30	1982, 1984, 1993	3
LKV-01-0542	90	27	1993, 1994	2
LKV-01-0543	280	85	1993	1
LKV-01-0544	Unknown		1993	1
LKV-01-0545	71	22	1993	1
LKV-01-0546	50	15	1993, 1994	2
LKV-01-0547	68	21	1993, 1994	2
LKV-01-0548	85	26	1993, 1994	2
LKV-01-0549	80	24	1993, 1994	2
LKV-01-0550	Unknown		1994	1

Table 3.5 Summary of unfiltered water quality for private wells, Lakeview, Oregon, site vicinity

Location ID	Date	Alk	As	Ca	Cl	Fe	Mg	Mn	Mo	Ni	pH	K	SiO_2	Se	Na	SO_4	Temp	TDS	U	V	Zn
North of site (geothermal)																					
535	8/93	138	0.009	76	40	<0.03	12	<0.01	<0.01	<0.04	7.7	3.2	44	<0.005	27	74	20	380	0.001	<0.01	0.057
538	8/93	NA	0.013	5	96	<0.03	0.2	0.01	0.04	<0.04	NA	6.7	111	NA	196	222	NA	1010	<0.001	<0.01	0.066
544	8/93	NA	0.157	13	99	<0.03	<0.1	<0.01	0.04	<0.04	NA	8.6	145	NA	203	258	95	820	<0.001	<0.01	0.007
West of site																					
545	8/93	68	<0.005	<0.5	5	0.21	0.1	0.03	<0.01	<0.04	8.1	1.2	68	<0.005	39	9	16	180	0.003	<0.01	0.022
Southeast of site																					
536	8/93	138	<0.005	29	2	0.7	9.5	0.18	<0.01	<0.04	7.6	1.2	52	<0.005	17	3	13	200	<0.001	0.02	0.011
537	8/93	210	0.005	41	4	0.53	14	2.4	<0.01	<0.04	7.4	0.9	50	<0.005	30	9	13	270	<0.001	<0.01	0.014
542	8/93	138	<0.005	29	1	0.11	8.9	0.46	<0.01	<0.04	7.3	1.2	57	<0.005	18	2	15	190	<0.001	<0.01	0.074
543	8/93	232	<0.005	51	5	1.43	16	2.57	<0.01	<0.04	7.3	0.9	50	NA	33	18	11	320	0.001	<0.01	0.009
Southwest of site																					
533	8/93	158	<0.005	32	2	<0.03	12	0.04	<0.01	<0.04	7.0	4.3	70	<0.005	22	13	14	250	0.002	<0.01	0.137
534	8/93	137	0.006	29	1	<0.03	10	<0.01	<0.01	<0.04	6.9	4.3	70	<0.005	18	11	19	230	<0.001	<0.01	0.277
South of site																					
546	5/94	223	0.011	39	12	1.01	11.4	1.34	<0.01	<0.04	7.6	0.6	53	NA	36	7	11	308	<0.001	<0.01	0.11
547	5/94	152	0.007	61	538	1.44	65	8.6	<0.01	<0.04	7.2	5.2	61	NA	88	152	11	1440	<0.001	<0.01	<0.05
548	5/94	153	0.007	48	1484	4.04	153	28.7	<0.01	<0.04	7.2	9.2	55	NA	462	1030	11	4380	<0.001	<0.01	0.08
549	5/94	99	0.015	4	59	0.80	21.7	0.31	0.01	<0.04	7.8	3.4	59	NA	111	94	11	452	<0.001	<0.01	0.05
550	5/94	117	0.006	91	829	1.73	61	9.0	<0.01	<0.04	7.3	8.2	58	NA	301	483	12	2160	<0.001	<0.01	<0.05

Note: All data are in milligrams per liter except pH (standard units) and temperature.

Alk	Alkalinity	Se	Selenium
As	Arsenic	SiO_2	Silica
Ca	Calcium	Na	Sodium
Cl	Chloride	SO_4	Sulfate
Fe	Iron	Temp	Temperature (°C)
Mg	Magnesium	TDS	Total dissolved solids
Mn	Manganese	U	Uranium
Mo	Molybdenum	V	Vanadium
Ni	Nickel	Zn	Zinc
K	Potassium	NA	Not analyzed

Private wells west, southwest, and southeast of the site (crossgradient to downgradient wells 545, 533, 534, 536, 537, 542, and 543) have relatively low TDS (180 to 320 mg/L) and sulfate (3 to 18 mg/L) concentrations. Both site-related constituents and natural geothermal water are associated with much higher sulfate and TDS; thus, the low-sulfate private wells are believed to contain uncontaminated, nongeothermal. Several of these nongeothermal water wells have relatively high concentrations of manganese (up to 2.6 mg/L), iron (up to 1.4 mg/L), and zinc (up to 0.5 mg/L). The water quality in these private wells is similar to that in DOE monitor wells used to establish nongeothermal background ground water quality.

Four of five private wells due south of the site have elevated sulfate concentrations (locations 547, 548, 549, and 550), which could indicate constituents from the site have reached these wells. However, the areal pattern of sulfate distribution in these wells is inconsistent with site-related constituents. The wells with the highest sulfate (locations 548 and 550, having 1030 and 483 mg/L sulfate, respectively) are farthest from the site, whereas the well closest to the site (location 546) has the lowest sulfate concentration (7 mg/L) (Figure 3.4). Sulfate from the site in excess of 300 mg/L appears to be limited to an area within 2400 ft (730 m) of the site, whereas the private wells with high sulfate concentrations are about 5000 ft (1500 m) south of the site, placing them outside the apparent area of site-related constituents. Therefore, the private wells with high sulfate concentrations apparently are not affected by site-related constituents. However, few ground water quality data are available for the relatively large area between the site and the private wells. Therefore, the conceptual model of the extent of constituents ground water downgradient of the site is not completely substantiated. While it seems unlikely, based on limited existing information, that private wells south of the site are affected by site-related constituents, this conclusion is not certain. More monitoring wells are needed to confirm the site-conceptual model.

The private wells south of the site with high sulfate levels also have elevated concentrations of chloride, sodium, calcium, manganese, and iron. The concentrations of these components are greater than those observed in geothermal waters, so these waters probably are not geothermal. Field observations and discussions with area residents affected by the high sulfate ground water revealed that the originally low-lying land surface was filled during the last 12 years with about 1.5 ft (0.46 m) of wood chips, boiler ash, and dredgings from log ponds. Also, a drainage has been partially filled and dammed, providing a source of local recharge. The one resident who has lived in the area for more than 12 years stated that water quality began to deteriorate after the fill was added. A plausible explanation (other than site-related constituents) for the high salinity is that both rain water captured by the very permeable wood chip fill and surface water from the dammed drainage have leached natural salts in the soils and that this leachate is the source of saline ground water in this area. The mechanism of leaching salts from soils in disturbed areas also appears to have occurred on the former processing site. Like the conceptual model of the distribution of site-related ground water

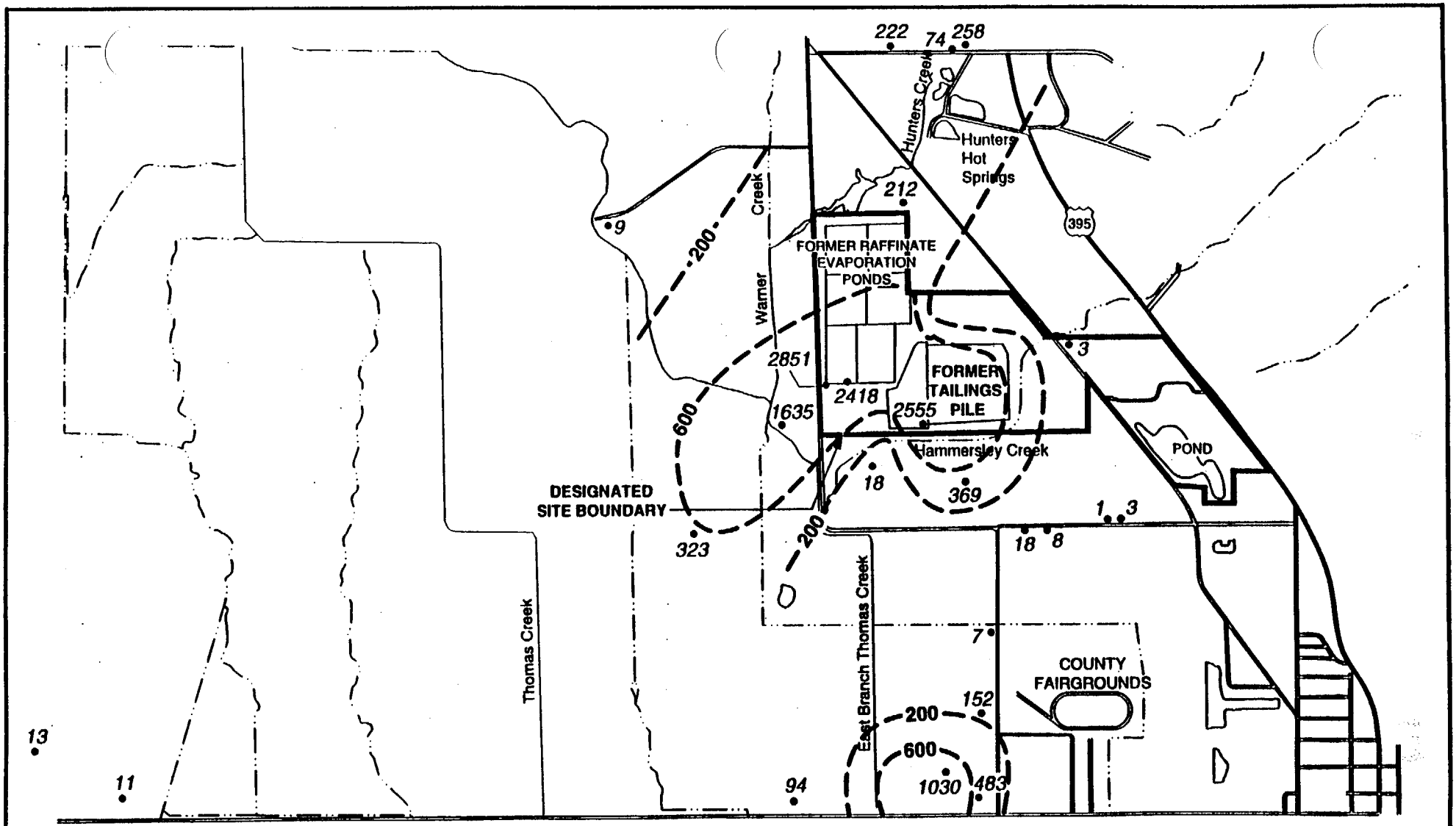


FIGURE 3.4

SULFATE DISTRIBUTION IN SHALLOW DOE MONITOR WELLS AND PRIVATE WELLS LAKEVIEW, OREGON, SITE

MAC: SITE/LKV/BRA/BASE1-SULFATE

contamination near the site, the conceptual model of saline salts in soil as a source of saline ground water has not been substantiated by direct tests for soluble salts in soil near the private wells south of the site.

3.4 CONSTITUENTS OF POTENTIAL CONCERN

The data presented in Sections 3.1 and 3.2 were used to compile a list of constituents of potential concern for this assessment of human health risks at the Lakeview site. A constituent was placed on the list of constituents of potential concern (Table 3.6) if reported concentrations in the shallow on-site or downgradient monitor wells were on average higher than background levels. The constituents in column 1 of Table 3.6 (constituents that exceed background levels) were screened for their impact on human health using the criteria discussed below. Column 4 of Table 3.6 is a final list of constituents of potential concern for human health (DOE, 1995b).

Two chemicals (potassium and zinc) detected above background levels were screened out because they are essential nutrients and the levels at which they occur are within nutritional ranges.

A second screening of the remaining constituents was made of the constituents that exhibited very low toxicity and relatively high dietary intake in comparison to the detected concentrations on the site. For human health, these screening criteria eliminated ammonium, aluminum, calcium, magnesium, silica, and strontium. The constituents of potential concern that remain after screening are arsenic, boron, chloride, iron, manganese, molybdenum, nickel, polonium-210, sodium, sulfate, and uranium (Table 3.6). The human health portion of this risk assessment focuses on these constituents.

Because ecological impacts differ from effects on human health, the list of constituents that will be considered for the ecological assessment is presented in Section 7.0.

3.5 CONSTITUENT FATE AND TRANSPORT

Constituent mobility, uptake, and toxicity depend on the species of ions in the aqueous environment. The types of ion species and complexes depend on the availability of various anions and cations to form complex ions and pH and Eh conditions. Species of the constituents of potential concern were computed using the geochemical speciation code PHREEQE (Parkhurst et al., 1980). Table 3.7 summarizes the predominant species and their molar percentages (DOE, 1995b).

In the following discussion, constituent dilution and dispersion in conjunction with ground water flow are cited as a major control on the fate of constituents in ground water at the site. The current rate of ground water transport of constituents appears to be slow, as indicated by little or no change in constituent concentrations downgradient of the site over the last 12 years.

Table 3.6 Constituents of potential concern for human health evaluation, Lakeview, Oregon, site

Constituents that exceed background levels	Constituents in nutritional range	Constituents of low toxicity and/or high dietary range	Constituents of potential concern
Ammonium		Ammonium	
Aluminum		Aluminum	
Arsenic			Arsenic
Boron			Boron
Calcium		Calcium	
Chloride			Chloride
Iron			Iron
Magnesium		Magnesium	
Manganese			Manganese
Molybdenum			Molybdenum
Nickel			Nickel
Polonium-210			Polonium-210
Potassium	Potassium		
Silica		Silica[a]	
Sodium			Sodium
Strontium		Strontium	
Sulfate			Sulfate
Uranium			Uranium
Zinc	Zinc		

[a]Although silica causes toxicity when inhaled, ingesting dissolved silica has not been demonstrated to produce adverse health effects in humans or animals.

Table 3.7 Predominant ionic species of constituents of potential concern, Lakeview, Oregon, site

Constituent	Common name	Dominant species	Molar percent	Valence
Arsenic	Arsenate	$HAsO_4^{2-}$	70	As(V)
	Arsenate	$H_2AsO_4^-$	30	As(V)
Boron	Borate	$H_3BO_{3\ aq}$	100	B(III)
Chloride	Chloride	Cl^-	100	Cl(I)
Iron	Ferric hydroxide	$FeOH^{2+}$	96	Fe(III)
	Ferric hydroxide	$Fe(OH)_{3\ aq}$	2	Fe(III)
Manganese	Manganese	Mn^{2+}	68	Mn(II)
	Manganese sulfate	$MnSO_{4\ aq}$	26	Mn(II)
Molybdenum	Molybdate	MoO_4^{2-}	100	Mo(VI)
Nickel	Nickel carbonate	$NiCO_{3\ aq}$	64	Ni(II)
	Nickel	Ni^{2+}	19	Ni(II)
Polonium-210		Not determined		
Sodium	Sodium	Na^+	97	Na(I)
Sulfate	Sulfate	SO_4^{2-}	79	S(VI)
	Sodium sulfate	$NaSO_4^-$	10	S(VI)
	Calcium sulfate	$CaSO_{4\ aq}$	8	S(VI)
Uranium	Uranyl hypophosphate	$UO_2(HPO_4)_2^{2-}$	99	U(VI)

During that period, for example, sulfate concentrations remained relatively constant in downgradient well 518 near the edge of the contaminated ground water. Nonetheless, the presence of site-related constituents in this downgradient well indicates ground water flow has occurred at the site. The apparent contradiction between the extent of constituents and the lack of time-dependent trends in constituent concentrations in individual wells represents a data gap in both the understanding of the hydrologic regime at the site and the prediction of constituent fate and transport. Without constituent movement, dispersion and dilution occur very slowly.

Arsenic

Arsenic concentrations in the contaminated ground water are about 60 times the detection limit of 0.001 mg/L, but they are actually lower than the arsenic concentrations measured in the deep background geothermal ground water and background geothermal surface water (with up to 0.24 mg/L arsenic reported in the samples collected). However, the shallow background geothermal ground water does not contain arsenic at concentrations above the detection limit, and these were used to determine background levels since data indicate that the most contaminated ground water is in the shallow portion of the aquifer.

Arsenic occurs as arsenate species $HAsO_4^{2-}$ in the ground water. Reaction of ferric hydroxides with arsenate may be an effective control on the concentration of arsenic (Hem, 1970), especially because the contaminated ground water is oversaturated with respect to iron hydroxides. Thus, concentrations may decrease by coprecipitation of arsenate with iron hydroxides over time. A similar mechanism may explain the lack of arsenic in the shallow geothermal ground water when this water is compared to both geothermal surface water and deep geothermal ground water.

Boron

Boron concentrations in the contaminated ground water are about 9 times those of background. Boron was not used to process the ores, and usually is not associated with uranium ores. It is commonly associated with geothermal water, including that upgradient of the site. Along with chloride, its presence at concentrations above background levels is due to its having been leached from natural soils as a result of uranium processing activities.

Boron occurs as borate in the contaminated and natural waters near the site. Borate forms very soluble salts, and precipitation of those salts will not occur at depth. Thus, dilution probably will play the greatest role in decreasing borate concentrations.

Chloride

Chloride concentrations in the contaminated ground water ranges up to about 12 times concentrations reported in background samples. Much of the chloride in

the contaminated ground water may have been leached from natural soils beneath the tailings and ponds by site-related seepage. Chloride does not form insoluble salts in low-salinity ground waters (less than 177,000 mg/L chloride concentrations), and concentrations are too great to be significantly affected by adsorption. Therefore, decreases in chloride concentrations within the contaminated ground water will be due to dilution.

Iron

Iron concentrations in the contaminated ground water are several hundred times those reported in background ground water samples. Iron is soluble under acid or reducing conditions but forms insoluble hydrated oxides under oxidizing conditions at a pH greater than 6. All water at the site is oversaturated with respect to these iron oxides, and it is expected that with time, as oxygen diffuses into the ground water, iron concentrations will decrease to background levels (0.12 mg/L) due to precipitation and dilution.

Manganese

Manganese concentrations in the contaminated water are about 1700 times background levels. Like iron, manganese is most soluble under acid or reducing conditions, though manganese can persist at greater concentrations than iron in oxidizing, slightly alkaline ground water. Several ground water samples taken at that site are saturated with respect to manganese carbonate (rhodochrosite), and the natural occurrence of this phase may explain the prevalence of manganese in ground water throughout the region. However, none of the contaminated ground water samples are oversaturated with respect to rhodochrosite; thus, the major decrease in concentration will be due to dilution, perhaps accompanied by coprecipitation with iron oxides and sorption.

Molybdenum

Molybdenum concentrations in contaminated ground water are four times those of the geothermal background ground water. Molybdenum occurs in both geothermal water and the contaminated ground water as molybdate (MoO_4^{2-}), a negatively charged ligand. As with most negatively charged ligands, molybdenum sorption is most effective under acidic conditions (pH in the 3 to 4 range). Thus, molybdenum sorption in the contaminated ground water will be less important than dilution as a mechanism for decreasing concentrations.

Nickel

Nickel concentrations are 3 times the detection limit for the analyses (0.01 and 0.04 mg/L) in ground water associated with the tailings pile. Nickel also was reported in unfiltered samples collected from monitor well 540. It is strongly sorbed by iron and manganese oxides (Hem, 1970), and sorption onto these hydroxides will be the most effective mechanism for removing the nickel from solution with time.

Polonium-210

Polonium-210 is a relatively short-lived daughter product in the uranium-238 decay chain, with a half-life of 138 days. Thus, its presence in the contaminated ground water indicates the additional presence of parent isotopes such as lead-210, radon-222, radium-226, thorium-230, uranium-234, or uranium-238. Lead-210, radium-226, thorium-230, and uranium were not detected in the contaminated ground water in amounts sufficient to support the observed activity of polonium-210. Therefore, the source of the polonium-210 is either dissolved radon-222, which was not monitored in ground water, or one of the other parent isotopes occurring in solid form within the aquifer. Radon-222 is commonly associated with geothermal water in amounts more than adequate to explain the observed activity of polonium-210; this could be the source of the polonium-210 at the Lakeview site (Davis and DeWiest, 1966). However, because polonium-210 was not observed in the geothermal background water, the geothermal radon-222 probably is not the source of the polonium-210. Thus, the most likely source for the polonium-210 is a solid parent isotope (lead-210, radium-226, thorium-230, uranium-234, or uranium-238). Of these, uranium is the most mobile in the ground water environment, and thus the parent most likely to have migrated into the aquifer in aqueous solution before being adsorbed onto soils.

Because the source of polonium-210 appears to be a solid that will not migrate with ground water flow and because polonium-210 has a short half-life, the distribution of dissolved polonium-210 will be restricted to the area near its source. The size of this area is dictated by the rate of ground water flow and the rate of polonium-210 decay. Assuming the rate of shallow horizontal ground water movement is approximately 50 ft per year (8×10^{-5} cm per second) (see Section 2.3) and the polonium-210 will decay almost entirely within 10 half-lives (3.8 years), the polonium will be restricted to a distance of about 190 ft (58 m) from its source. The daughter product of its decay is the stable isotope lead-208. This isotope probably will be sorbed by iron oxides, especially since the amount of stable lead produced by the polonium-210 decay is less than 5.8×10^{-12} mg/L per year.

Sodium

Sodium concentrations are about 10 times background levels in the most contaminated ground water. Sodium forms very soluble bicarbonate, chloride, and sulfate salts; much of the sodium in the contaminated ground water may have been leached from natural soils beneath the tailings and ponds by site-related seepage. Precipitation of those salts will not occur at depth, and dilution probably will play the greatest role in decreasing sodium concentration.

Sulfate

Sulfate concentrations in contaminated ground water vary across the site from 215 to 3380 mg/L. None of the water is oversaturated with respect to gypsum,

the phase that most likely will control the concentration of sulfate in this ground water. Therefore, decreased sulfate downgradient of the tailings pile and evaporation ponds (matched by decreased chloride) is due to dilution of the tailings solutions by natural waters. Further sulfate decreases will occur by dilution and dispersion during migration of the contaminated ground water.

This is supported by sulfur isotopic studies that indicate that the geothermal system is the primary source of sulfate at distances greater than 600 ft (180 m) from the site or depths greater than 25 ft (7.6 m) (DOE, 1992).

Uranium

Uranium in the contaminated ground water near the tailings is at relatively low levels (0.003 to 0.014 mg/L). The uranium occurs in the hexavalent state (+6 state) in the site ground water as a uranyl phosphate complex ($UO_2(HPO_4)_2^{2-}$). Low uranium levels in the contaminated ground water attest to the ability of the soil at the site to strongly adsorb uranium species, and further attenuation by adsorption probably will occur.

3.6 SURFACE WATER AND SEDIMENT

Surface water quality has been monitored in the water bodies in the vicinity of the Lakeview site. Surface water bodies at and adjacent to the site include ponds, ditches, and three creeks (Figure 2.2). Hunters Hot Springs are important to surface water hydrology and geochemistry; they feed geothermal water into a creek (Hunters Hot Springs Creek) and associated ponds north of the site.

Surface water has been sampled at five locations (Figure 3.5). Unfiltered surface water samples were collected in October 1993 from two locations along Hunters Hot Springs Creek (608 and 609), one location just downstream of the confluence of Warner Creek and Thomas Creek (605), and one location in Thomas Creek just upstream of the confluence with Hammersley Creek (606). Sediment sampling location 607, in Thomas Creek downstream of its confluence with Hammersley Creek, was dry during the October 1993 sampling event. One to three sampling rounds were conducted at these five locations (605 through 609) from 1982 through 1985. In addition, one sample (613) was taken from a pond northwest of a cemetery and southeast of the former mill buildings. This pond may have received runoff from the area where the former mill buildings were located.

The samples collected in October 1993 were analyzed for a select list of analytes (arsenic, calcium, iron, magnesium, manganese, molybdenum, nickel, sulfate, tin, uranium, vanadium, and zinc). These constituents were selected prior to the development of this risk assessment. Sediment samples were collected in October 1993 from all six locations.

Table 3.8 presents surface water data for constituents analyzed in the surface water samples that were above background levels in ground water.

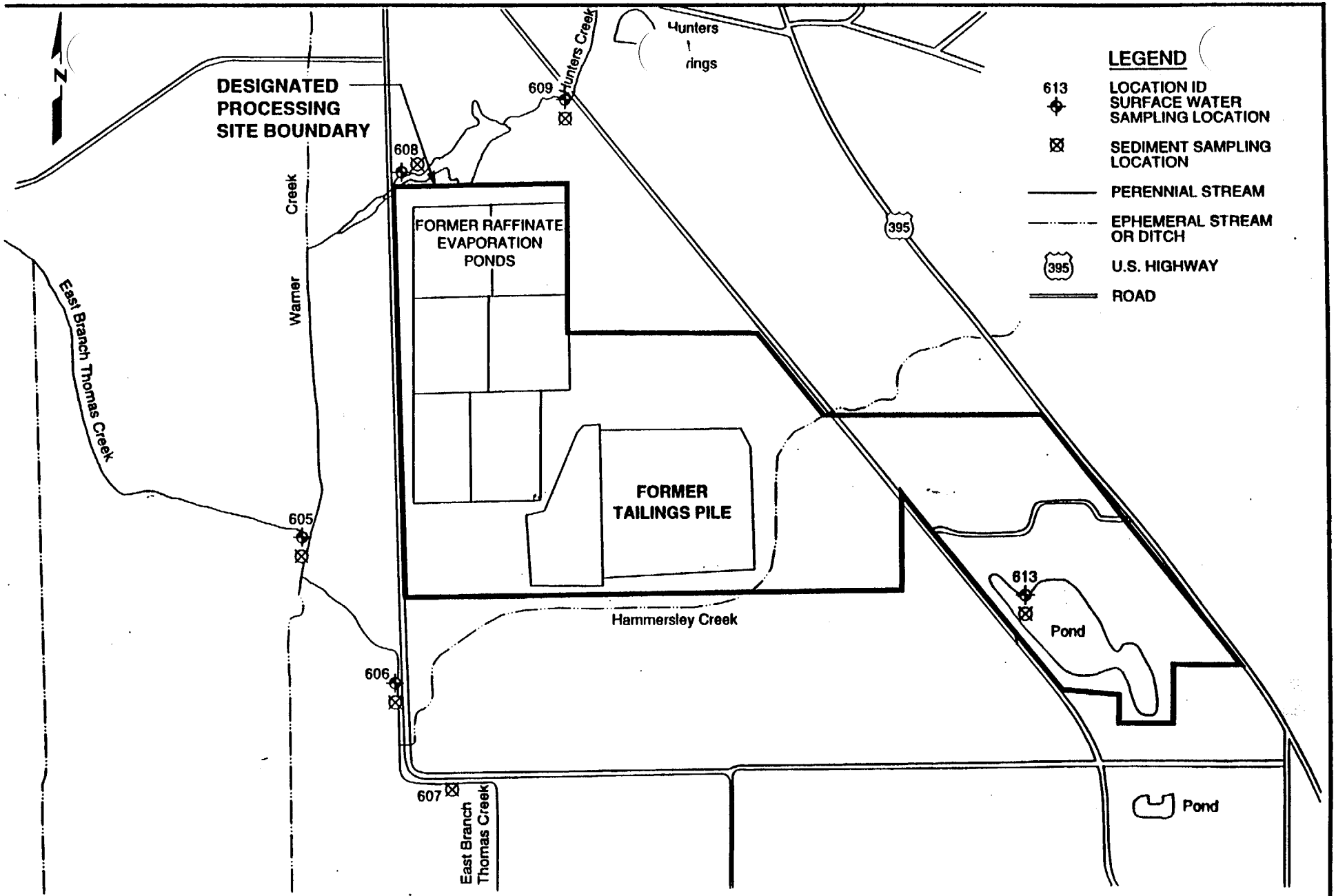


FIGURE 3.5
SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS
LAKEVIEW, OREGON, SITE

MAC: SITE/LKV/BRA/BASE-SURF&SED

Table 3.8 Constituents monitored in surface water collected from water bodies in the Lakeview, Oregon, site vicinity

	Upstream of site	Adjacent to site			Pond location
Constituent	LKV-01-0609	LKV-01-0608	LKV-01-0605	LKV-01-0606	LKV-01-0613
Arsenic	0.24	0.16	0.16	0.16	0.005
Iron	0.63	0.39	0.66	0.41	0.16
Manganese	0.11	0.04	0.06	0.05	0.03
Molybdenum	0.03	0.04	0.04	0.04	<0.01
Nickel	<0.04	<0.04	<0.04	<0.04	<0.04
Sulfate	300	260	260	260	4.5
Uranium	0.001	<0.001	<0.001	<0.001	<0.001

All results reported in milligrams per liter for unfiltered samples collected 26 October 1993.

Surface water data from these locations show that most of the constituent levels found at the adjacent locations were no greater than their respective background (upstream) concentrations. From the list of ground water constituents that exceed background ground water quality (Table 3.6), only iron and molybdenum were detected at concentrations slightly above background levels at the adjacent locations. However, the differences in concentrations are negligible.

Sediments are an integral part of the aquatic environment, providing habitat, feeding, and rearing areas for many aquatic organisms (Hull and Suter, 1994). The sediment layer includes solid particles (inorganic and organic) settling on the bottom of a body of water such as a river or a pond, and interstitial water (pore water), which fills the spaces between the sediment particles (Power and Chapman, 1992). In the environment, these particles are derived both from material originally suspended in the water and minerals that precipitate from the water. Pore water usually accounts for more than 50 percent (by volume) of the sediment layer. Results presented in this risk assessment represent the chemistry of both the solid and pore-water components of the sediment layer.

Surficial sediment samples (0 to 4 inches [0 to 10 cm]) were collected on 26 October 1993, from surface water sampling locations (Figure 3.4). Sediment samples had not been collected near the site before this sampling event. The sediment samples were analyzed for arsenic, iron, manganese, molybdenum, nickel, sulfate, tin, uranium, vanadium, and zinc. Table 3.9 presents data for the site-related constituents analyzed in the sediment samples (tin, vanadium, and zinc are not considered site-related constituents). The differences between the adjacent and downstream concentrations of arsenic, nickel, and sulfate were negligible. The differences between the adjacent and downstream concentrations of iron, manganese, and uranium were greater. However, the observed levels of these constituents (uranium up to 1.4 mg per gram, iron up to 9010 mg per gram and manganese up to 270 mg per gram are less than those typical of soils in the western United States where uranium averages 2.3 mg per gram, iron averages 18,000 mg per gram, and manganese averages 330 mg per gram (Shacklette and Boerngen, 1984). The observed increases downstream and adjacent to the site may reflect natural variation associated with different drainage areas such as Warner Creek, rather than site-related constituents.

Precipitation and snowmelt can carry both dissolved and suspended constituents along surface drainages. Metal constituents transported as dissolved species can become diluted after discharging to water bodies. Alternatively, dissolved species can precipitate, becoming adsorbed to sediments or absorbed into biota with varying biochemical and geochemical conditions. Variations in geochemical conditions or biological action can release constituents adsorbed onto sediments into surface water. Thus, deposited sediments can act as a source of site-related surface water contamination.

Table 3.9 Occurrence of constituents monitored in sediment collected from surface water bodies in the Lakeview, Oregon, site vicinity

	Upstream of site	Adjacent to site			Downstream of site	Pond
Constituent	LKV-01-0609	LKV-01-0608	LKV-01-0605	LKV-01-0606	LKV-01-0607	LKV-01-0613
Arsenic	17	12	11	25	12	4.8
Iron	1190	965	5350	8810	9010	8930
Manganese	25	16	115	192	195	270
Molybdenum	2.0	1.0	1.0	<1.0	1.0	<1.0
Nickel	<4.0	<4.0	4.0	<4.0	4.0	5.0
Sulfate	154	78	158	74	168	13
Uranium	0.1	0.3	1.1	0.8	1.4	1.3

All results reported in milligrams per kilogram dry weight. The samples were collected 26 October 1993.

Based on the limited data for surface water and sediment, it appears that surface water is not impacted and the elevated sediment concentrations (compared to background) may reflect natural variations in different drainage areas.

4.0 EXPOSURE ASSESSMENT

This section quantifies the potential exposures that could be incurred by current or future residents who use site-related contaminated ground water in the vicinity of the former Lakeview site. The methodology is consistent with the EPA guidance on exposure assessments, which recommends analysis based on a reasonable maximum exposure under both current and future land-use conditions (EPA, 1989b). Reasonable maximum exposure is defined as the greatest exposure that can reasonably be expected, based on the current evaluation of on- and off-site conditions. Ground water-use scenarios are based on current domestic ground water use in the region. This exposure assessment uses ground water quality data that were collected before complete site characterization.

4.1 POTENTIALLY EXPOSED POPULATIONS AND EXPOSURE PATHWAYS

An exposure pathway describes the course a constituent takes from the source to the exposed individual. To complete a pathway there must be a source of contamination, a release mechanism for the constituent (e.g., constituents leaching from tailings into the ground water), a point of contact with a population or individual, and a route of exposure (e.g., water ingestion). Evaluating potential exposure pathways involves determining not only the most likely pathways but also the major contributing pathways to risk as a function of exposure dose. Both direct and indirect exposures to contaminated ground water are assessed below. Given the chemical properties of the inorganic constituents of potential concern at UMTRA Project sites, direct exposure through drinking water ingestion is expected to result in the most significant constituent exposure dose. The main contributions to risk are identified by a screening process that compares exposures through the drinking water pathway to exposures through other pathways. For the screening exposure pathways the adult population was evaluated. Currently, no uses of site-related constituent ground water by human receptors have been identified at the Lakeview site. However, shallow ground water is used in the Lakeview area for domestic purposes such as drinking, bathing, and cooking. Additionally, ground water in this area is used for agricultural purposes such as forage crop irrigation and livestock watering. Using contaminated ground water to water crops and livestock could lead to indirect exposure to humans who eat contaminated produce and meat and drink contaminated milk. Access to the ground water at and downgradient of the former processing site is not restricted. Therefore, it is possible people could come into contact with site-related contaminated ground water and be exposed to constituents. Figure 4.1 presents the conceptual site model of potential exposure pathways at the Lakeview site.

Several of the constituents of potential concern for the Lakeview site (see Table 3.6) were detected in private wells south of the site (wells 546, 547, 548, 549, and 550). These constituents included arsenic, chloride, iron, manganese, molybdenum, sodium, and sulfate. As discussed in Section 3.3, it is unlikely that the presence of these constituents in the private wells is associated with the Lakeview site even though the source of these constituents

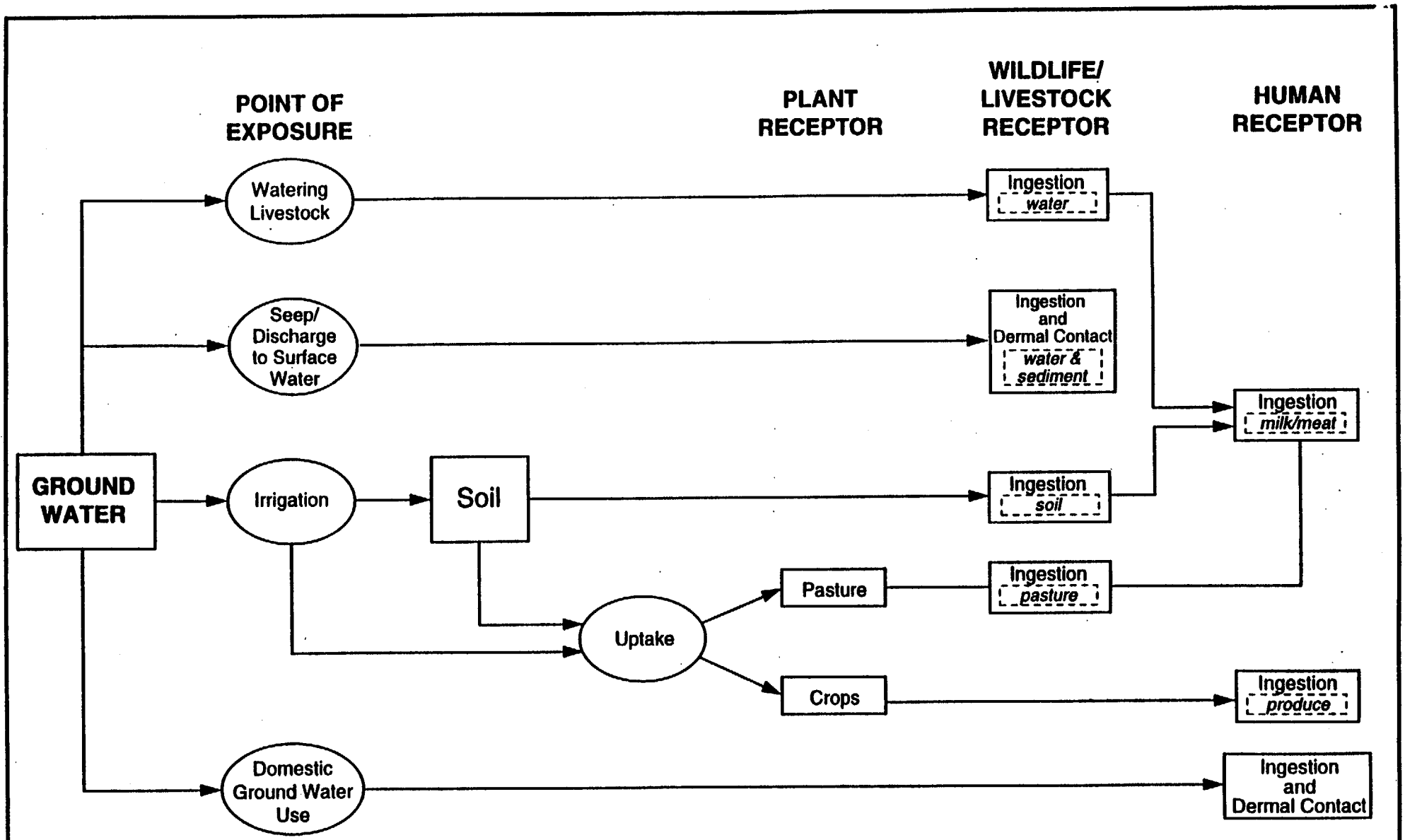


FIGURE 4.1
CONCEPTUAL MODEL
LAKEVIEW, (`ON, SITE

MAC: SITE/LKV/BRA/CONCEPTMOD

has not been determined. Regardless of the source, a discussion concerning the potential of these constituents to cause adverse human health effects is included in this document (Section 4.2). The inhabitants of this group of residences do not use the ground water for drinking water. However, the ground water is used for other domestic purposes such as cooking, bathing, watering livestock, and irrigating gardens.

4.1.1 Drinking water ingestion

Drinking water ingestion is generally the most significant exposure pathway for ground water contaminated with metals and other nonvolatile compounds. In this evaluation, drinking water consumption includes water consumed by drinking and water used directly in food preparation (e.g., reconstituted juices, soup, rice, and beans). To show relative pathway significance, a screening level assessment of drinking water intake is shown in Table 4.1. These calculations are based on estimates of the 95 percent upper confidence limit (UCL) on the mean constituent concentration from the most contaminated plume wells.

4.1.2 Dermal absorption

Dermal absorption is the process by which chemicals coming into contact with the skin are absorbed into the blood vessels near the skin surface. Some compounds are absorbed easily in this manner, though metals do not possess the chemical properties that are conducive to skin absorption.

To evaluate this exposure route, a screening calculation was performed to determine if a dermal absorption pathway would be significant compared to the drinking water pathway for the constituents of potential concern. The constituents were assumed to absorb across the skin at the same rate as water. This assumption probably will overestimate any potential contribution from dermal absorption. Additionally, the concentration in water is assumed to be the 95 percent UCL, which also could overestimate exposure.

The results of the screening are given in Table 4.1. Based on these results, dermal absorption was eliminated from more detailed evaluation because it contributed less than 1 percent of the total intake from drinking water for all constituents. However, any potential toxic effects from dermal contact exposure are discussed in Section 6.0.

4.1.3 Ingestion of ground water-irrigated produce

The exposure pathway of ingested ground water-irrigated produce also was evaluated for its relative significance compared to the drinking water ingestion route. Table 4.2 shows the results of the screening calculation. The assumptions for this evaluation probably will overestimate the exposure potential from this route also, because it is assumed that a domestic garden would be the source of all garden produce in the diet. This screening shows that for the constituents of potential concern at this site, ingesting garden

Table 4.1 Exposure dose calculations for ground water ingestion and dermal contact, Lakeview, Oregon, site

Constituents of potential concern	Cw (mg/L)	Ground water exposure doses (mg/kg-day)		Ratio of dermal: ingestion[a]
		Ingestion	Dermal contact	
Carcinogenic effects				
Arsenic	0.11	1E-03	3E-06	0.002
Polonium-210	8.5[b]	2E+05[b]	3E+02[b]	0.002
Uranium	14[b]	4E+02[b]	6E+02[b]	0.002
Noncarcinogenic effects				
Arsenic	0.11	3E-03	6E-06	0.002
Boron	58	2E+00	3E-03	0.002
Chloride	3000	8E+01	2E-01	0.002
Iron	27	7E-01	1E-03	0.002
Manganese	40	1E+00	2E-03	0.002
Molybdenum	0.46	1E-02	2E-05	0.002
Nickel	0.13	4E-03	7E-06	0.002
Sodium	4000	1E+02	2E-01	0.002
Sulfate	6900	2E+02	4E-01	0.002
Uranium[c]	0.02	3E-05	1E-06	0.002

Equation definitions for exposure dose calculations

Ingestion of ground water

Chemicals: Chronic daily intake (mg/kg-day) $= \frac{Cw \times IRw \times EF \times ED}{BW \times AT}$

Radionuclides: Lifetime intake (pCi/lifetime) $= Cw \times IRw \times EF \times ED$

Dermal contact with ground water

Chemicals: Chronic daily intake (mg/kg-day) $= \frac{(Cw \times SA \times Pc \times Cf) \times ET \times EF \times ED}{BW \times AT}$

Radionuclides: Lifetime intake (pCi/lifetime) $= Cw \times SA \times Pc \times Cf \times ET \times EF \times ED$

Where:

- Cw = Constituent concentration in ground water (95 percent UCL).
- IRw = Ingestion rate for water (L per day) (2 L per day for an adult).
- EF = Exposure frequency (350 days per year).
- ED = Exposure duration (30 years for an adult).
- BW = Body weight (70 kg for an adult).
- AT = Averaging time (365 days x ED for noncarcinogens; AT = 365 days x 70 years for carcinogens).
- SA = Skin surface area (19,400 square centimeters).
- Pc = Dermal permeability constant (0.001 cm per hour).
- Cf = Conversion factor (0.001 L/cm^3).
- ET = Exposure time (0.2 hour per day).

[a]Calculated by dividing the dermal contact exposure dose by the ground water ingestion exposure dose.
[b]Measured in picocuries per lifetime.
[c]Uranium-234 and uranium-238 combined.

UCL - 95th upper confidence limit on the mean constituent concentration from the most contaminated plume wells.

mg/kg-day - milligrams per kilograms per day.

Table 4.2 Exposure dose calculations for ground water-irrigated garden produce ingestion, Lakeview, Oregon, site

Constituent of potential concern	Cw (mg/L)	Kd (L/kg)	Bv	Br	Garden produce ingestion exposure doses[a] (mg/kg-day)	Ratio of produce ingestion: water ingestion[b]
Carcinogenic effects						
Arsenic	0.11	19.4	0.04	0.006	2E-06	0.002
Polonium-210	8.5[c]	14.9	0.0025	0.0004	1E+01[c]	0.00006
Uranium	14[c]	50	0.0085	0.004	3E+02[c]	0.0009
Noncarcinogenic effects						
Arsenic	0.11	19.4	0.04	0.006	4E-06	0.001
Boron	58	1.3	4	2	2E-02	0.009
Iron	27	15	0.004	0.001	8E-05	0.0001
Manganese	40	25.3	0.25	0.05	1E-02	0.01
Molybdenum	0.46	120	0.25	0.06	7E-04	0.07
Nickel	0.13	58.6	0.06	0.06	3E-05	0.008
Sodium	4000	0.2	0.075	0.055	4E-03	0.00004
Sulfate	6900	0	0.5	0.5	d	d
Uranium	0.02	50	0.0085	0.004	5E-07	0.001

Equation definitions for exposure dose calculations

Ingestion of garden produce irrigated with ground water

Chemicals: Chronic daily intake (mg/kg-day) $= \frac{Cw \times Kd \times Bv \text{ or } Br^{e} \times DF \times IRp \times FI \times EF \times ED}{BW \times AT}$

Radionuclides: Lifetime intake (pCi/lifetime) $= Cw \times Kd \times Bv \text{ or } Br^{e} \times DF \times IRp \times FI \times EF \times ED$

Where:

- Cw = Constituent concentration in ground water (95th UCL).
- Kd = Soil-water partition coefficient (L/kg); from PNL (1989), except uranium. The Kd for uranium is a site-specific value.
- Bv = Soil-to-plant concentration ratio for vegetative portions of plants (unitless).
- Br = Soil-to-plant concentration ratio for reproductive portions (fruits, tubers) of plants (unitless).
- DF = Dry weight fraction of plant (0.066 unitless).
- IRp = Ingestion rate for garden produce (0.05 kg per day for vegetative parts; 0.03 kg per day for reproductive parts).
- FI = Fraction of garden produce ingested from contaminated source (1.0 unitless).
- EF = Exposure frequency (350 days per year).
- ED = Exposure duration (30 years for an adult).
- BW = Body weight (70 kg for an adult).
- AT = Averaging time (365 days x ED for noncarcinogens; AT = 365 days x 70 years for carcinogens).

[a]Exposure doses shown are the sum of the vegetative parts plus the reproductive parts.
[b]Calculated by dividing the garden produce ingestion exposure dose by the ground water ingestion exposure dose.
[c]Measured in picocuries per lifetime.
[d]Value cannot be calculated because Kd is equal to zero.
[e]Exposure doses due to vegetative parts and reproductive parts of garden produce are calculated separately, then summed for total intake.

UCL - 95th upper confidence limit on the mean constituent concentration from the most contaminated plume wells.
mg/kg-day - milligrams per kilogram per day.

produce irrigated with contaminated ground water would represent potential exposures of 7 percent or less than would be associated with ingesting contaminated drinking water. Any potential toxic effects from exposure to these constituents through ingesting garden produce are discussed in Section 6.0.

4.1.4 Ingestion of milk or meat from ground water-fed livestock

The relative contribution from ingesting milk from ground-water-fed livestock is 4 percent or less for all constituents except molybdenum, which contributes 20 percent and sodium which contributes 30 percent (Table 4.3). Ingesting meat from these animals would also contribute 7 percent or less of the exposure anticipated from drinking water for all constituents except molybdenum, which contributes 20 percent (Table 4.4). This pathway may be important, but current data are insufficient to produce meaningful quantitative estimates. The contribution from these sources is not included in the exposure simulations, but the impact of these additional contributions is discussed in Sections 6.1 and 6.2.

4.1.5 Ingestion of fish

This pathway was not evaluated because the surface water bodies in the vicinity of the Lakeview site provide very limited fish habitat and would not support a fish population that humans would consume (i.e., game fish). No fish were observed in the streams and drainages near the site.

4.2 PRIVATE WELLS

Arsenic, chloride, iron, manganese, molybdenum, sodium, and sulfate are evaluated for the potential to cause adverse health effects to people using the ground water from the private wells south of the site. Of wells 546, 547, 548, 549, and 550, the highest concentrations of the constituents detected in the latest round of sampling (Table 3.5) are used to evaluate potential adverse health effects.

Exposure is evaluated by calculating exposure doses from dermal absorption, ingesting garden produce watered with ground water from the private wells, and eating meat and drinking milk from livestock watered with ground water from the private wells. Since this water is used for cooking, ground water ingestion is also evaluated. It is assumed that the water would be used for making soups and for other cooking purposes where the water would be directly ingested. The same equations and input parameters as presented on Tables 4.1 through 4.4 were used except for the ingestion rate for the drinking water route. For this route of exposure, 0.5 L per day was used. The exposure dose for each exposure route and each constituent is calculated and summed (Table 4.5). Also on this table are the carcinogenic risk estimates for arsenic. The total exposure doses are evaluated for the potential to cause adverse health effects. The exception is manganese, because this constituent is more bioavailable in water than in food; only the exposure doses for dermal contact and water used

Table 4.3 Exposure dose calculations for ingestion of milk from ground water-fed livestock, Lakeview, Oregon, site

Constituent of potential concern	Cw (mg/L)	Kd[a] (L/kg)	Bv	Fm	Milk ingestion exposure doses (mg/kg-day)	Ratio of milk ingestion: water ingestion[b]
Carcinogenic effects						
Arsenic	0.11	19	0.04	0.00006	9E-07	0.0009
Polonium-210	8.5[c]	15	0.0025	0.00035	6E+02[c]	0.003
Uranium	14[c]	50	0.0085	0.0006	2E+03[c]	0.007
Noncarcinogenic effects						
Arsenic	0.11	19	0.04	0.00006	2E-06	0.0007
Boron	58	1.3	4	0.0015	6E-02	0.03
Iron	27	15	0.004	0.00025	2E-03	0.003
Manganese	40	25	0.25	0.00035	1E-02	0.01
Molybdenum	0.46	120	0.25	0.0015	2E-03	0.2
Nickel	0.13	59	0.06	0.001	8E-05	0.02
Sodium	4000	0.2	0.075	0.035	3E+01	0.3
Sulfate	6900	0	0.5	0.005	d	d
Uranium	0.02	50	0.0085	0.0006	4E-06	0.008

Equation definitions for exposure dose calculations

Ingestion of milk from ground water fed livestock

Chemicals: Chronic daily intake (mg/kg-day) $= \frac{Cm \times IRm \times FI \times EF \times ED}{BW \times AT}$

Radionuclides: Lifetime intake (pCi/lifetime) $= Cm \times IRm \times FI \times EF \times ED$

Where:

- Cm = Constituent concentration in milk (mg/L), estimated using the following equation:
  Cm = Fm x ([Qp x Cp] + [Qs x Cs] + [Qw x Cw])
  where
- Fm = Feed-to-milk transfer coefficient (kilograms per day).
- Qp = The quantity of pasture eaten by cattle per day (19 kg per day).
- Qs = The quantity of soil eaten by cattle per day (0.38 kg per day).
- Qw = The quantity of water consumed by cattle per day (56 L per day).
- Cp = Constituent concentration in pasture (mg/kg); Cp = Kd x Cw x Bv.
- Cs = Constituent concentration in soil (mg/kg); Cs = Kd x Cw.
- Cw = Constituent concentration in ground water (95th UCL).
- Kd = Soil-water partition coefficient (L/kg); from PNL (1989), except uranium. The Kd for uranium is a site-specific value.
- Bv = Soil-to-plant concentration ratio for vegetative portions of plants (unitless).
- EF = Exposure frequency (350 days/year).
- ED = Exposure duration (30 years for an adult).
- BW = Body weight (70 kg for an adult).
- AT = Averaging time (365 days x ED for noncarcinogens; AT = 365 days x 70 years for carcinogens).
- IRm = Ingestion rate of milk (0.3 kg per day).
- FI = Fraction of milk ingested from contaminated source (1.0 unitless).

[a]Kd value was not available for chloride; therefore, it has been omitted.
[b]Calculated by dividing the milk ingestion exposure dose by the ground water ingestion exposure dose.
[c]Measured in picocuries per lifetime.
[d]Value cannot be calculated because Kd is equal to zero.

UCL - 95th upper confidence limit on the mean constituent concentration from the most contaminated plume wells.
mg/kg-day - milligrams per kilogram per day.

Table 4.4 Exposure dose calculations for ingestion of meat from ground water-fed livestock, Lakeview, Oregon, site

Constituent of potential concern	Cw (mg/L)	Kd (L/kg)	Bv	Ff	Meat ingestion exposure dose	Ratio of meat ingestion: water ingestion[a]
Carcinogenic effects						
Arsenic	0.11	19.4	0.04	0.002	8E-06	0.008
Polonium-210	8.5[b]	14.9	0.0025	0.00025	1E+02[b]	0.005
Uranium	0.14[b]	50	0.0085	0.0002	2E+00[b]	0.0005
Noncarcinogenic effects						
Arsenic	0.11	19.4	0.04	0.002	2E-05	0.006
Boron	58	1.3	4	0.00055	5E-03	0.003
Iron	27	15	0.004	0.02	3E-02	0.05
Manganese	40	25.3	0.25	0.0004	3E-03	0.003
Molybdenum	0.46	120	0.25	0.006	2E-03	0.2
Nickel	0.13	58.6	0.06	0.006	1E-04	0.03
Sodium	4000	0.2	0.075	0.015	3E+00	0.04
Sulfate	6900	0	0.5	0.033	c	c
Uranium	0.14	50	0.0085	0.0002	2E-06	0.0006

Equation definitions for exposure dose calculations

Ingestion of meat from ground water fed livestock

Chemicals: Chronic daily intake (mg/kg-day) $= \frac{Cb \times IRb \times FI \times EF \times ED}{BW \times AT}$

Radionuclides: Lifetime intake (pCi/lifetime) $= Cb \times IRb \times FI \times EF \times ED$

Where:

- Cb = Constituent concentration in beef (mg/kg), estimated using the following equation:
  Cb = Ff x ([Qp x Cp] + [Qs x Cs] + [Qw x Cw])
  where
- Ff = Feed-to-flesh transfer coefficient (kilograms per day).
- Qp = The quantity of pasture eaten by cattle per day (19 kg per day).
- Qs = The quantity of soil eaten by cattle per day (0.38 kg per day).
- Qw = The quantity of water consumed by cattle per day (56 L per day).
- Cp = Constituent concentration in pasture (mg/kg). Cp = Kd x Cw x Bv.
- Cs = Constituent concentration in soil (mg/kg). Cs = Kd x Cw.
- Cw = Constituent concentration in ground water (95th UCL).
- Kd = Soil-water partition coefficient (L/kg); from PNL (1989), except uranium. The Kd for uranium is a site-specific value.
- Bv = Soil-to-plant concentration ratio for vegetative portions of plants (unitless).
- EF = Exposure frequency (350 days per year).
- ED = Exposure duration (30 years for an adult).
- BW = Body weight (70 kg for an adult).
- AT = Averaging time (365 days x ED for noncarcinogens; AT = 365 days x 70 years for carcinogens).
- IRb = Ingestion rate of meat (0.075 kg per day).
- FI = Fraction of meat ingested from constituent source (1.0 unitless).

[a]Calculated by dividing the meat ingestion exposure dose by the ground water ingestion exposure dose.
[b]Measured in picocuries per lifetime.
[c]Value cannot be calculated because Kd is equal to zero.

UCL - 95th upper confidence limit on the mean constituent concentration from the most contaminated plume wells.
mg/kg-day - milligrams per kilogram per day.

Table 4.5 Exposure dose results for the private wells south of the Lakeview, Oregon, site

	Produce ingestion	Dermal contact	Meat ingestion	Milk ingestion	Ground water ingestion through cooking	Total
Carcinogenic effects						
Arsenic	3E-07	3E-07	1E-06	9E-08	4E-05	5E-05
Risk[a]	4E-07	6E-07	2E-06	2E-07	8E-05	8E-05
Noncarcinogenic effects						
Arsenic	6E-07	8E-07	2E-06	3E-07	1E-04	1E-04
Chloride	2E+00	8E-02	5E+01	4E+01	1E+01	10E+01
Iron	1E-05	2E-04	5E-03	3E-04	3E-02	3E-02
Manganese	9E-03	2E-03	2E-03	8E-03	2E-01	2E-01
Molybdenum	2E-05	5E-07	4E-05	4E-05	7E-05	2E-04
Sodium	5E-04	3E-02	2E+00	4E+00	3E+00	8E+00
Sulfate	–	6E-02	2E+00	1E+00	7E+00	1E+01

[a]Calculated by multiplying the exposure dose by the slope factor (SF). The SF is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen. For example, the estimated risk for the ingestion of produce is an increased probability of 4 chances in 10,000,000 of developing cancer. Total risk is calculated by combining all risk values over all exposure pathways.

Notes: 1. Values are reported in milligrams per kilogram per day.
2. Dash indicates constituent was not evaluated for this parameter.

for cooking are combined. The exposure dose evaluation is presented in Section 6.3.

It should be noted that the evaluation of the private wells is conservative because of the conservative assumptions. It was assumed that the people would get all of their garden produce, meat, and milk from their own garden or livestock and ingest the constituents for 350 days per year for 30 years, concurrently. Using these assumptions likely overestimates the true risks associated with using the ground water from these wells.

4.3 EXPOSURE CONCENTRATIONS

The exposure concentration of a constituent in ground water is defined as the concentration an individual is assumed to take in over a specific period. In this evaluation, the constituent concentrations are assumed to be in a steady state, although actual constituent concentrations (and therefore exposures) are expected to decrease with time because the tailings have been removed. However, no seasonal variations have been noted in the last 12 years of data. Nonetheless, these estimates are reasonable for chronic exposure soon after surface remediation. Chronic exposure for noncarcinogens is considered exposure for any period longer than 7 years.

For noncarcinogens, exposure concentrations are expressed as probability distributions. Distributions were derived from actual recorded water quality measurements of the well or wells currently in existence that consistently recorded the highest concentrations of each constituent. For example, the manganese distribution reflects concentrations in well 540, whereas the sulfate distribution reflects well 503 levels. The theoretical distribution was selected to have, to the extent possible, the same average concentration, standard deviation (spread), and pattern of occurrences (shape) as occurred in actual water quality data. The normal distribution provided an adequate fit of the data for all constituents.

Recent analytical data were used except in cases where 1982-1985 constituent concentrations from wells in the vicinity of the former evaporation ponds clearly and grossly exceeded more recent levels. In those cases, early data were used instead of more recent data, and the selected distribution was shifted upward to reflect the higher values. This approach was used because ground water constituent levels appear to be decreasing only slowly over time, and worst-case exposure may occur in areas of the former ponds where recent analytical data are not available. This shift was used for boron, chloride, molybdenum, sodium, and sulfate. The shift was multiplicative, so that the resulting mean of the distribution was centered on the higher values, but the spread about the mean was also proportionately larger. This procedure was necessary because early data were inadequate to provide information on distributional shape.

For example, the theoretical probability distribution developed to model concentrations of sulfate in well 503 was a normal distribution with a mean of

2985 mg/L and standard deviation of 189 mg/L. To reflect the 1984-1985 concentrations observed in monitor well 529 (measurements of 6100 and 7300 mg/L), the new distribution was shifted up by a factor of 2.24 (6700/2985 = 2.24) to become a normal distribution with a mean of 6700 mg/L and standard deviation of 425 mg/L.

The data used for distribution development were from filtered samples, except for arsenic. Several rounds of unfiltered arsenic measurements indicated the unfiltered levels were about 35 percent higher than levels measured in filtered samples. This information was incorporated into the arsenic distribution. For the other constituents of potential concern, unfiltered results were too limited in quantity to incorporate into the risk assessment.

Uranium concentrations from well 540 in the former tailings area appear to have increased with time between 1990 and 1994. This apparent trend may or may not be real, and if real, may or may not continue to rise in the future. However, the trend was significant at the 0.05 level of significance. Therefore, linear regression methods were used to estimate the current uranium concentration as 0.016 mg/L, and the theoretical distribution is centered on this estimated value.

The distributions are all truncated: values below 0 mg/L or above the 99th percentile are not used. The lower limit of 0 mg/L reflects the impossibility of negative exposures. The truncation of the upper end of the distribution places a reasonable limit on possible exposures. For every constituent, this highest allowable concentration was higher than the maximum observed concentration in the historical water quality data. The original distributions derived from existing wells were used to calculate the 95 percent UCL for the true mean concentration of that constituent. The software package @RISK was used to generate the probability curves for the noncarcinogenic constituents of potential concern (Palisade Corporation, 1992). The results are shown in Figures 4.2 through 4.11.

Radionuclide concentrations were represented by the same wells that represented the inorganic constituents. Potential carcinogenicity of ground water constituents is discussed in Section 5.0.

4.4 ESTIMATION OF INTAKE

Future residents are expected to vary with respect to water consumption habits, body weight, and length of time they reside in the potential contamination zone. Consequently, health risks associated with ground water consumption will vary among members of this population. To adequately describe the range of potential risks to this group, naturally occurring variability in daily water intake, body weight, and residence time were incorporated in this assessment through probability distributions; these distributions were generated from nationwide public health and census documents. All distributions were truncated at the

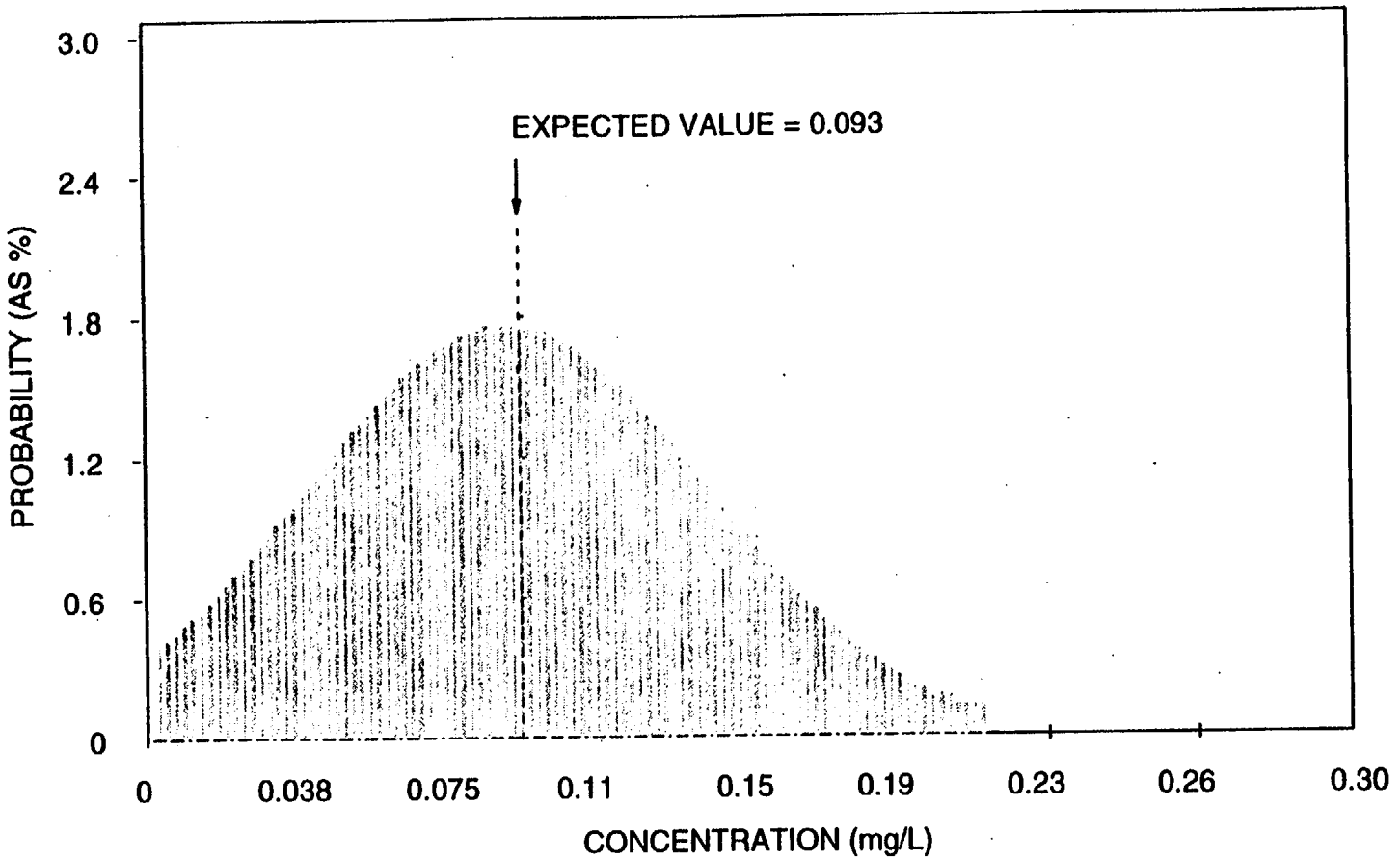


FIGURE 4.2
SIMULATED DISTRIBUTION OF ARSENIC CONCENTRATIONS
LAKEVIEW (GON, SITE

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ARSCON.DRW

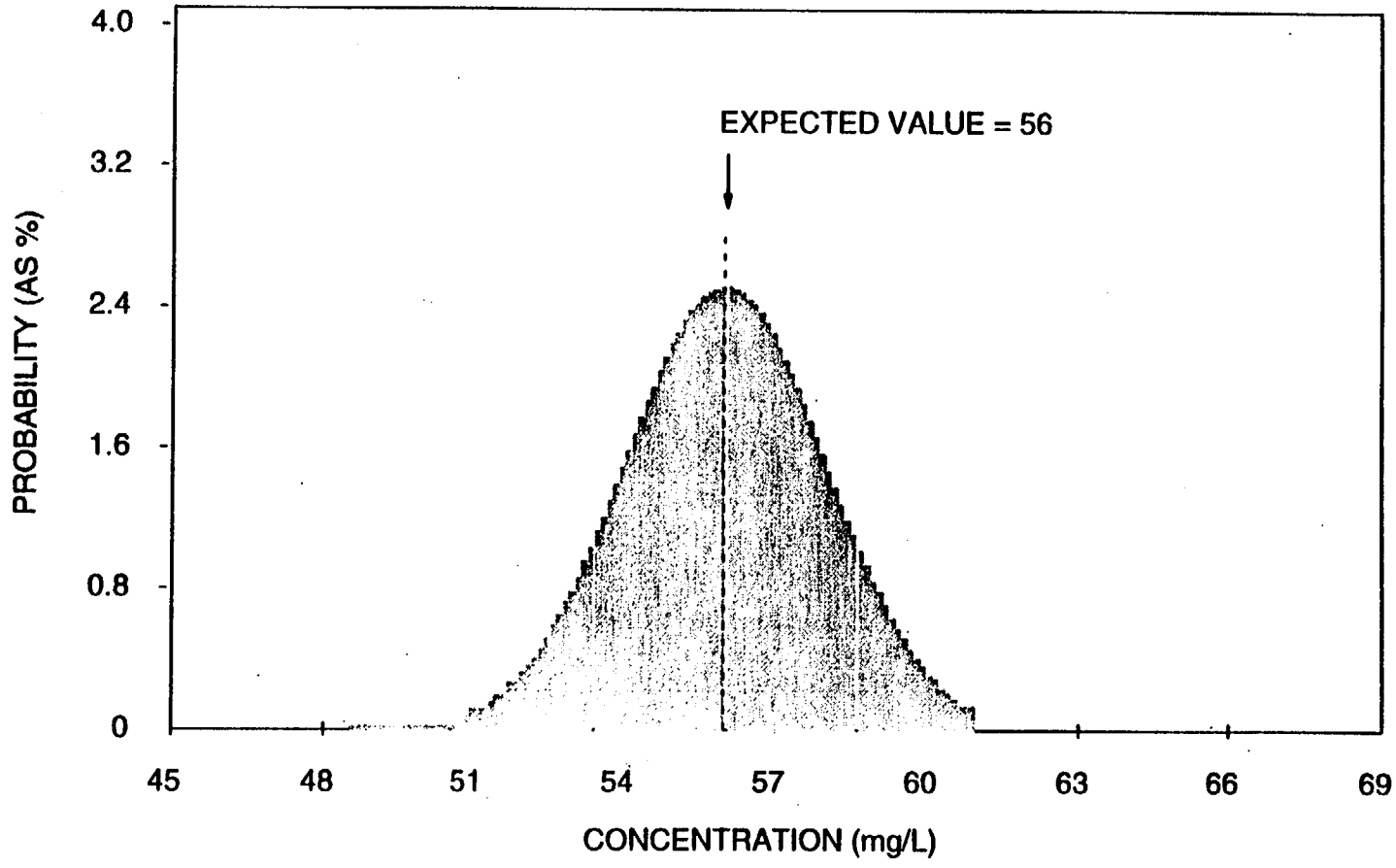

FIGURE 4.3
SIMULATED DISTRIBUTION OF BORON CONCENTRATIONS
LAKEVIEW, OREGON, SITE

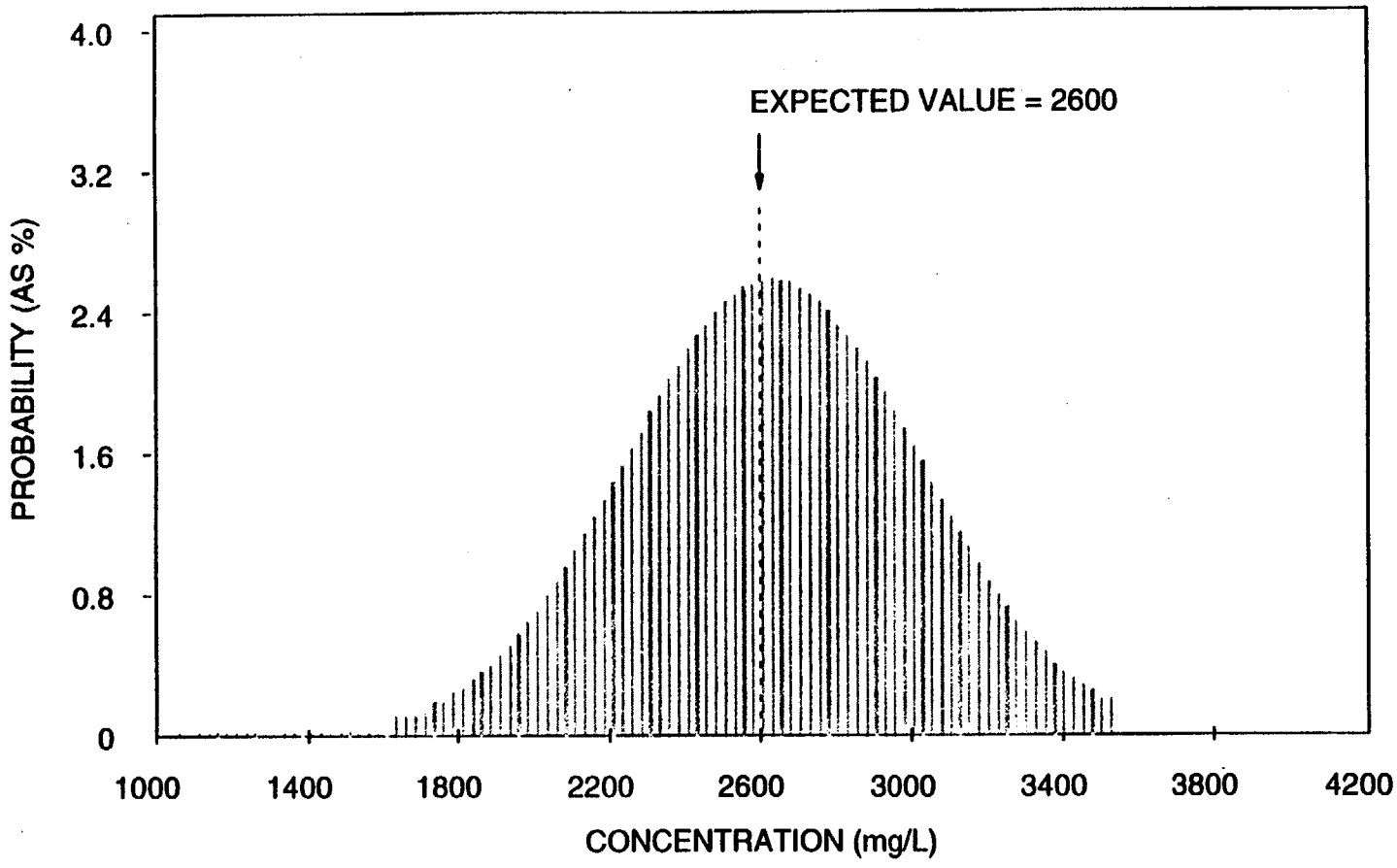

FIGURE 4.4
SIMULATED DISTRIBUTION OF CHLORIDE CONCENTRATIONS
LAKEVIEW, OREGON, SITE

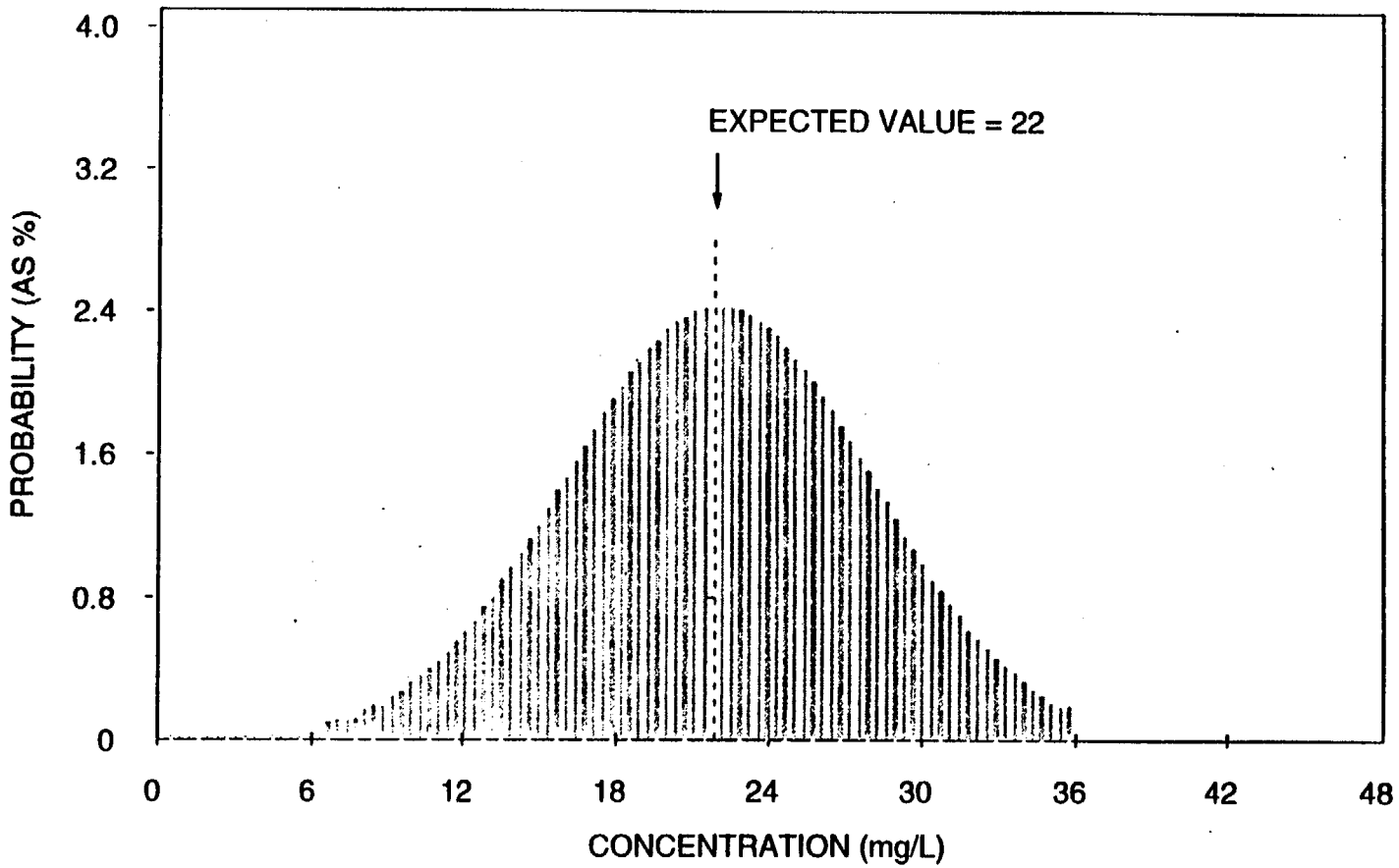

FIGURE 4.5
SIMULATED DISTRIBUTION OF IRON CONCENTRATIONS
LAKEVIEW, OREGON, SITE

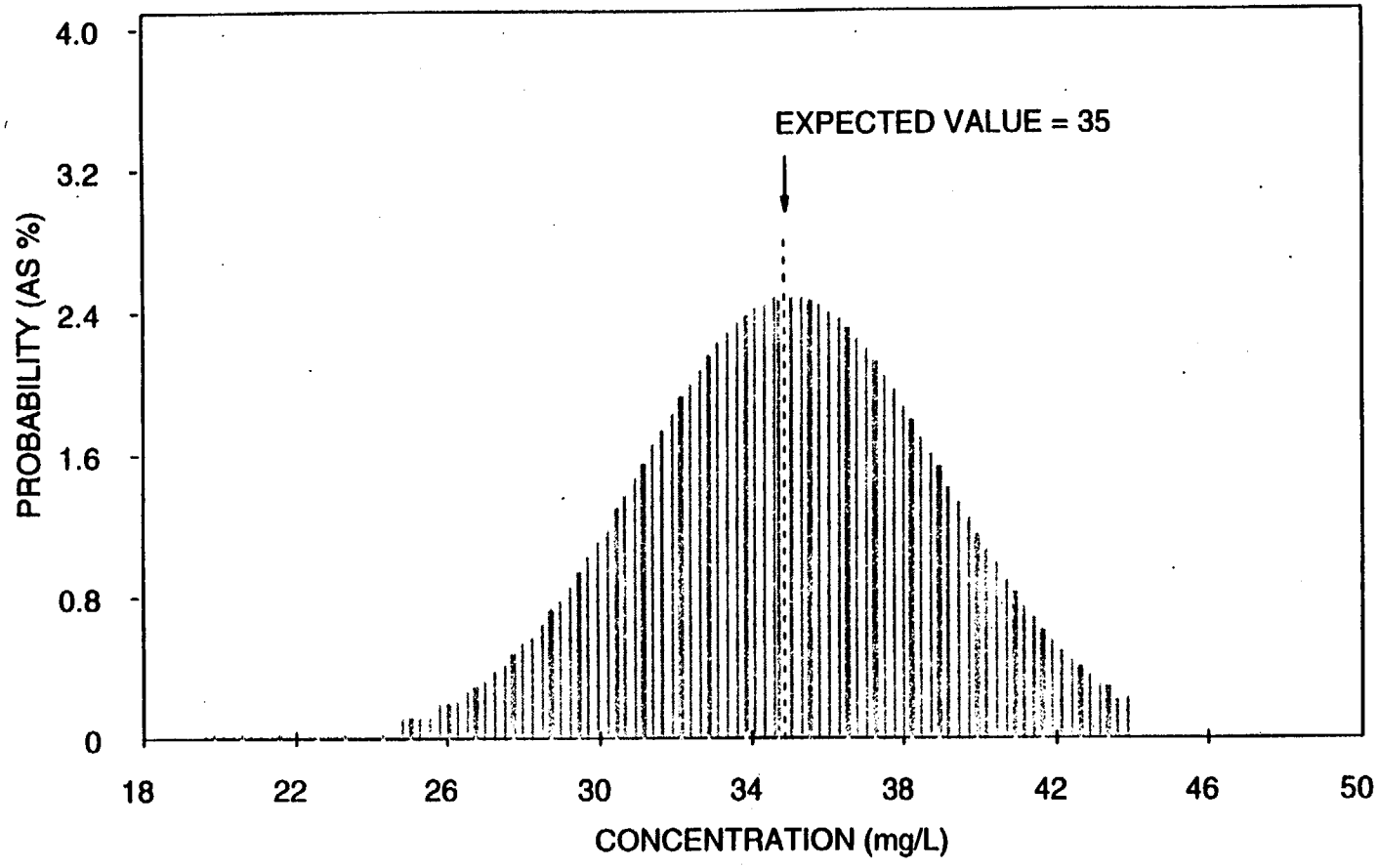

FIGURE 4.6
SIMULATED DISTRIBUTION OF MANGANESE CONCENTRATIONS
LAKEVIEW [illegible]GON, SITE

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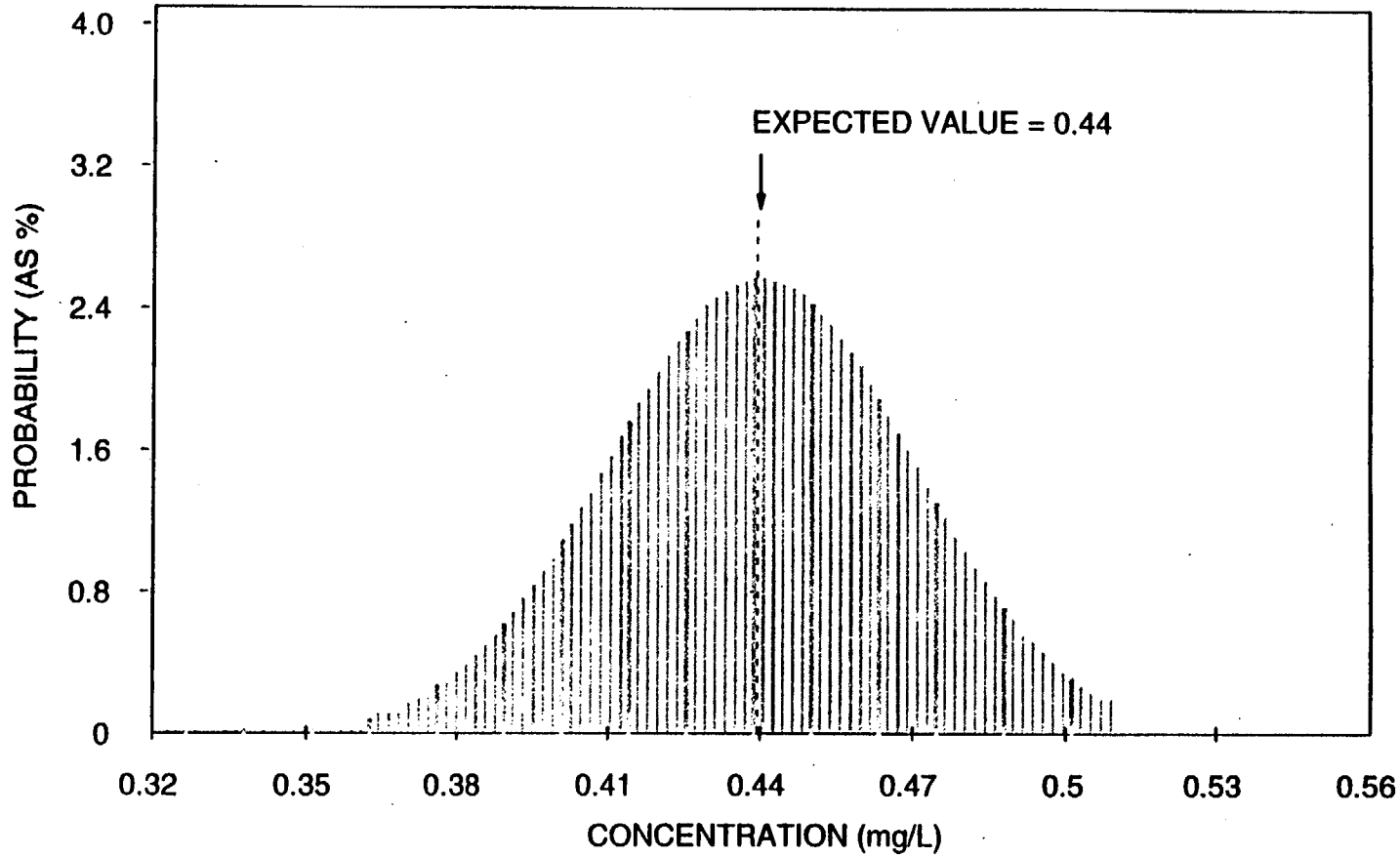

FIGURE 4.7
SIMULATED DISTRIBUTION OF MOLYBDENUM CONCENTRATIONS
LAKEVIEW, OREGON, SITE

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MOLYCON.DRW

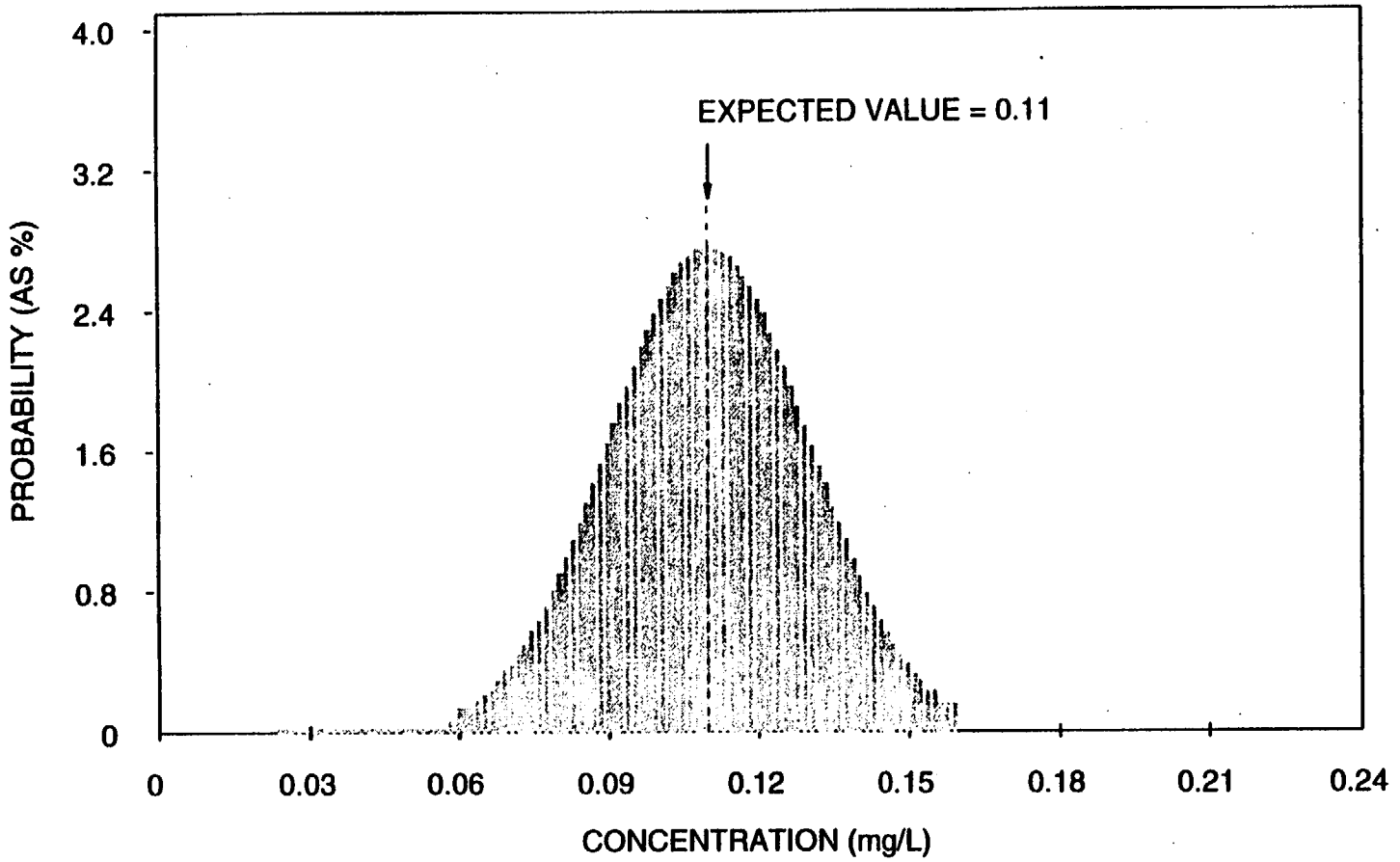

FIGURE 4.8
SIMULATED DISTRIBUTION OF NICKEL CONCENTRATIONS
LAKEVIEW [illegible]GON, SITE

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NICKCON.DRW

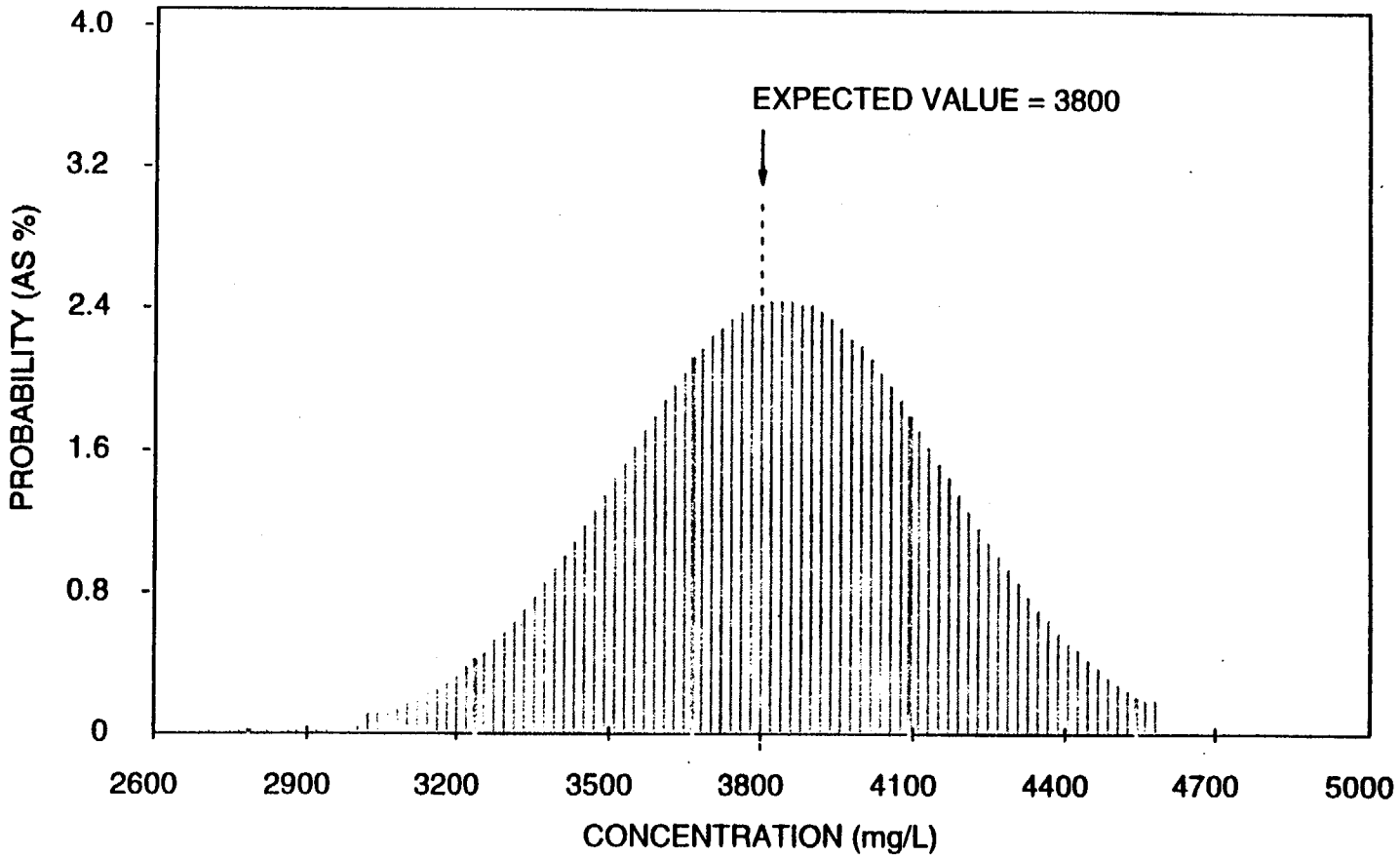

FIGURE 4.9
SIMULATED DISTRIBUTION OF SODIUM CONCENTRATIONS
LAKEVIEW, OREGON, SITE

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SODICON.DRW

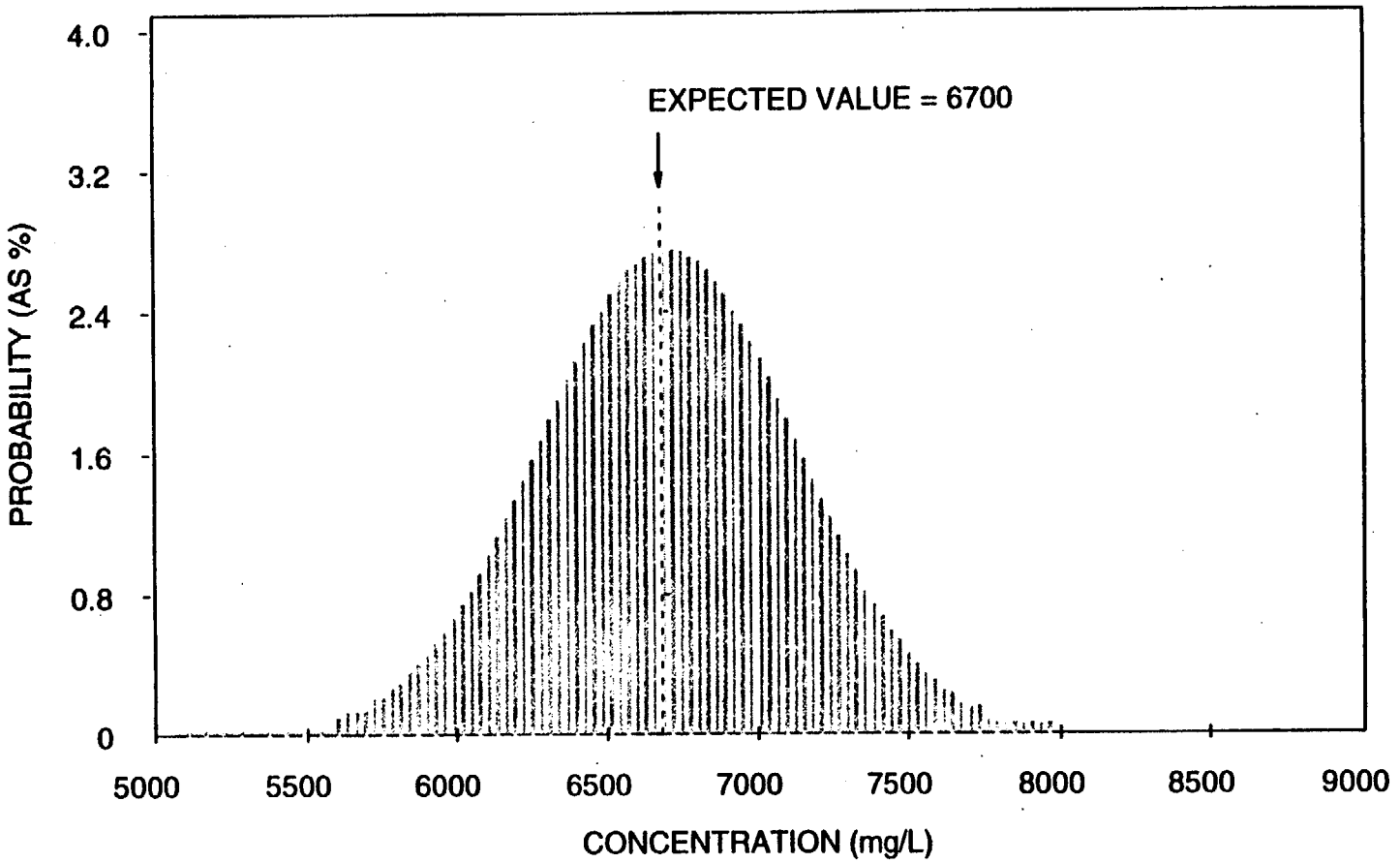


FIGURE 4.10
SIMULATED DISTRIBUTION OF SULFATE CONCENTRATIONS
LAKEVIEW, OREGON, SITE

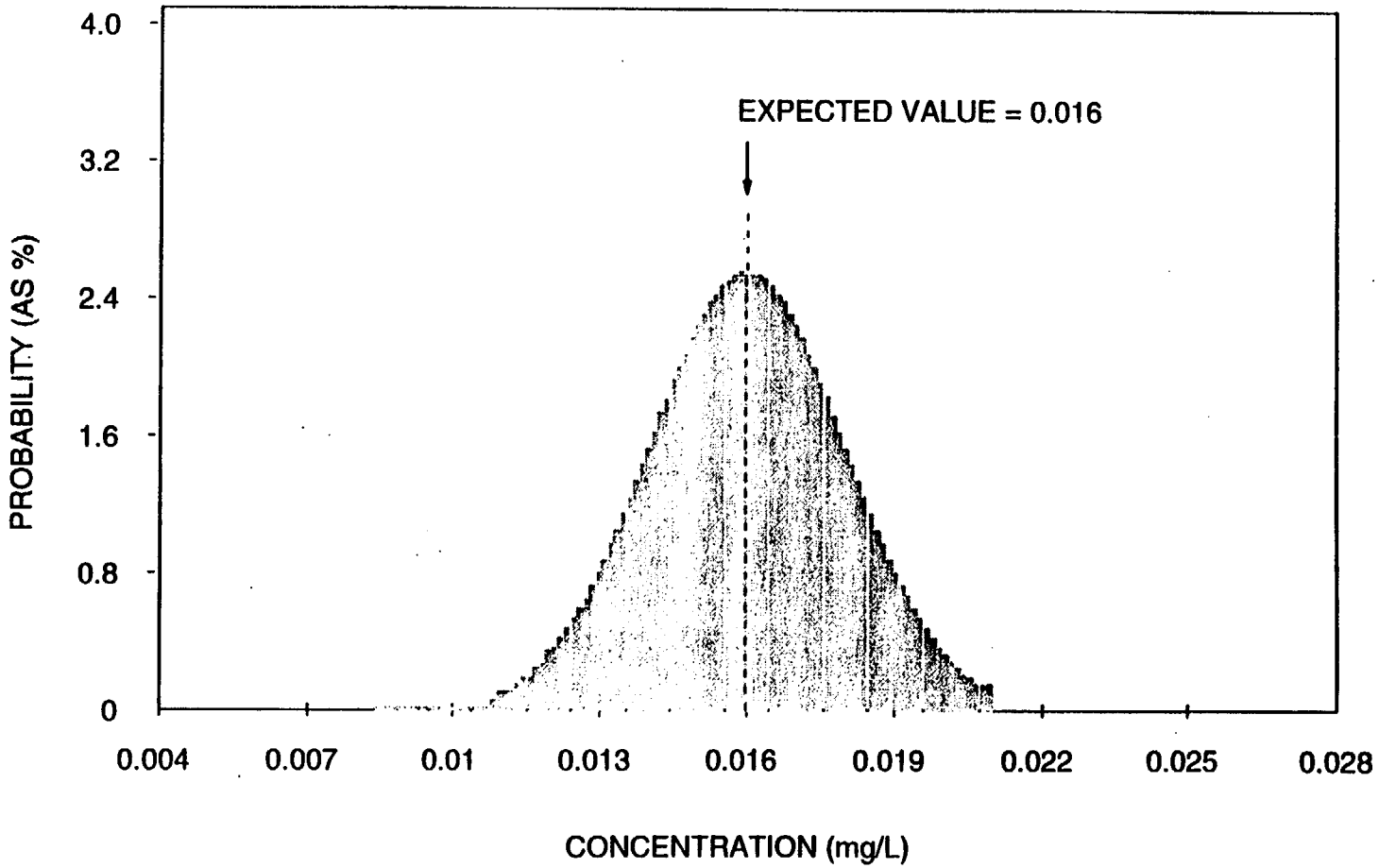


FIGURE 4.11
SIMULATED DISTRIBUTION OF URANIUM CONCENTRATIONS
LAKEVIEW, OREGON, SITE

PATH I:\FL3.01\LKVBRA

URACON.DRW

upper and lower 0.01 percentile. Within the hypothetical population, values disallowed through this truncation may occur with a probability of less than 1 in 10,000.

The potential toxicity of noncarcinogenic constituents in drinking water depends primarily on long-term average daily consumption of the constituent per kilogram of body weight. For probability distributions of noncarcinogens, the chronic daily intake is calculated as follows:

$$\text{Intake (mg/kg-day)} = \frac{\text{Concentration (mg/L)} \times \text{ingestion rate (L per day)} \times \text{exposure frequency (days per year)} \times \text{exposure duration (years)}}{\text{Body weight (kg)} \times 365 \text{ (days/year)} \times \text{exposure duration (years)}}$$

Potential carcinogenicity is thought to increase with *total* intake over time, instead of with *average daily* intake as for noncarcinogens. The only carcinogens elevated above background levels at the Lakeview site are arsenic and the radionuclides polonium-210 and uranium. Intake of a radioactive carcinogen therefore is quantified as total exposure to radioactivity throughout the residency period of an individual:

$$\underset{\text{(pCi)}}{\text{Intake}} = \text{Concentration (pCi/L)} \times \text{ingestion rate (L per day)} \times \text{exposure frequency (days per year)} \times \text{exposure duration (years)}$$

Intake of a chemical carcinogen such as arsenic is quantified using the following equation:

$$\underset{\text{(mg/kg-day)}}{\text{Intake}} = \frac{\text{Concentration (mg/L)} \times \text{ingestion rate (L per day)} \times \text{exposure frequency (days per year)} \times \text{exposure duration (years)}}{\text{Body weight (kg)} \times 365 \text{ (days per year)} \times \text{lifetime (years)}}$$

Populations

The potentially exposed populations evaluated in this risk assessment include individuals of the following age groups: infants (birth to 1 year old); children (1 to 10 years old); and adults (11 to 64 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.
- Toxicological variables are similar within these age groups, including responsiveness of sensitive subgroups (infants and children) to the contaminants of potential concern, toxicant intake-to-body-weight ratios, and toxicokinetics.

Average daily intake (L per day)

Lognormal probability distributions were used to describe variations in average daily tap water intake among members of the population (Roseberry and Burmaster, 1992). These distributions were developed from data collected during a 1977-1978 food consumption survey conducted nationwide by the U.S. Department of Agriculture. During the survey, total tap water consumption during a 3-day period was recorded for 26,081 survey participants nationwide (Figure 4.12).

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, separately by sex. The distributions for males and females were then combined using census data on the national ratio of males to females within each age group (Figure 4.13).

Exposure duration (years)

Distributions of total residence time (or exposure duration) for the populations described above were developed by Israeli and Nelson (1992) using data collected by the U.S. Department of Commerce, the Bureau of the Census, and the U.S. Department of Housing and Urban Development in 1985 and 1987. However, a fixed exposure duration of 30 years for adults, 10 years for children, and 1 year for infants was assumed for the populations in the Lakeview site risk assessment.

Using exposure concentration distributions discussed in Section 4.3 and the intake parameter distributions described in this section, total intake distributions were simulated for the three age groups. The 1- to 10-year age group is used in risk evaluation unless one of the other age groups has demonstrated increased sensitivity to a particular constituent. Therefore, simulated intake distributions for 1- to 10-year old children for the constituents at this site (with the exception of sulfate, where intake by infants was assessed) are presented in Figures 4.14 through 4.23.

4.5 EXPOSURE ASSESSMENT UNCERTAINTIES

A number of potential sources of error may arise in all phases of the exposure assessment, including the following more significant sources of uncertainty:

- Uncertainties resulting from a lack of thorough environmental sampling data (ground water, surface water, sediment, biota, and tissue analyses of livestock), which could lead to an underestimate or overestimate in the exposure analysis.

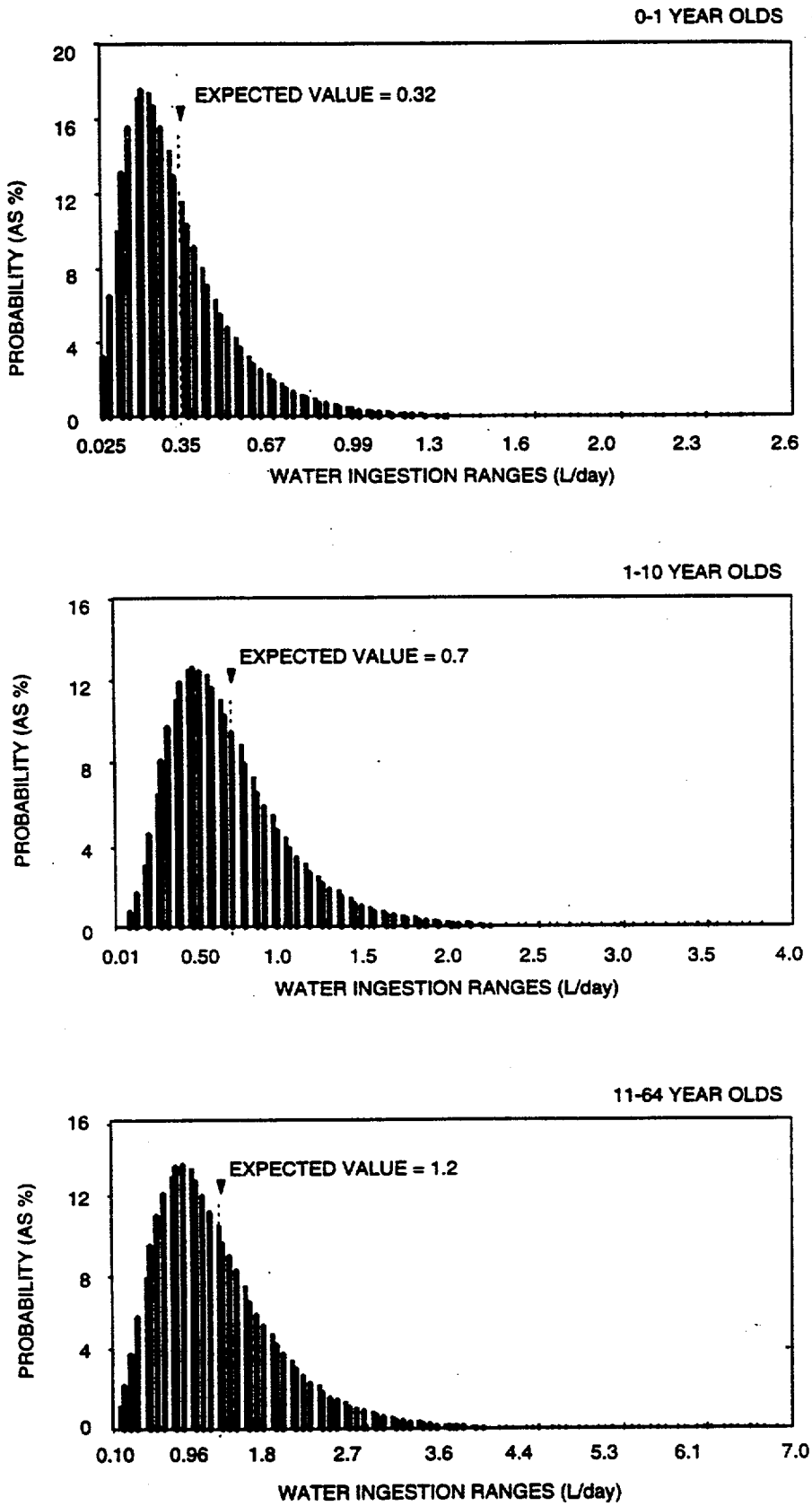


FIGURE 4.12
PROBABILITY DISTRIBUTIONS FOR TAP WATER INGESTION RATES

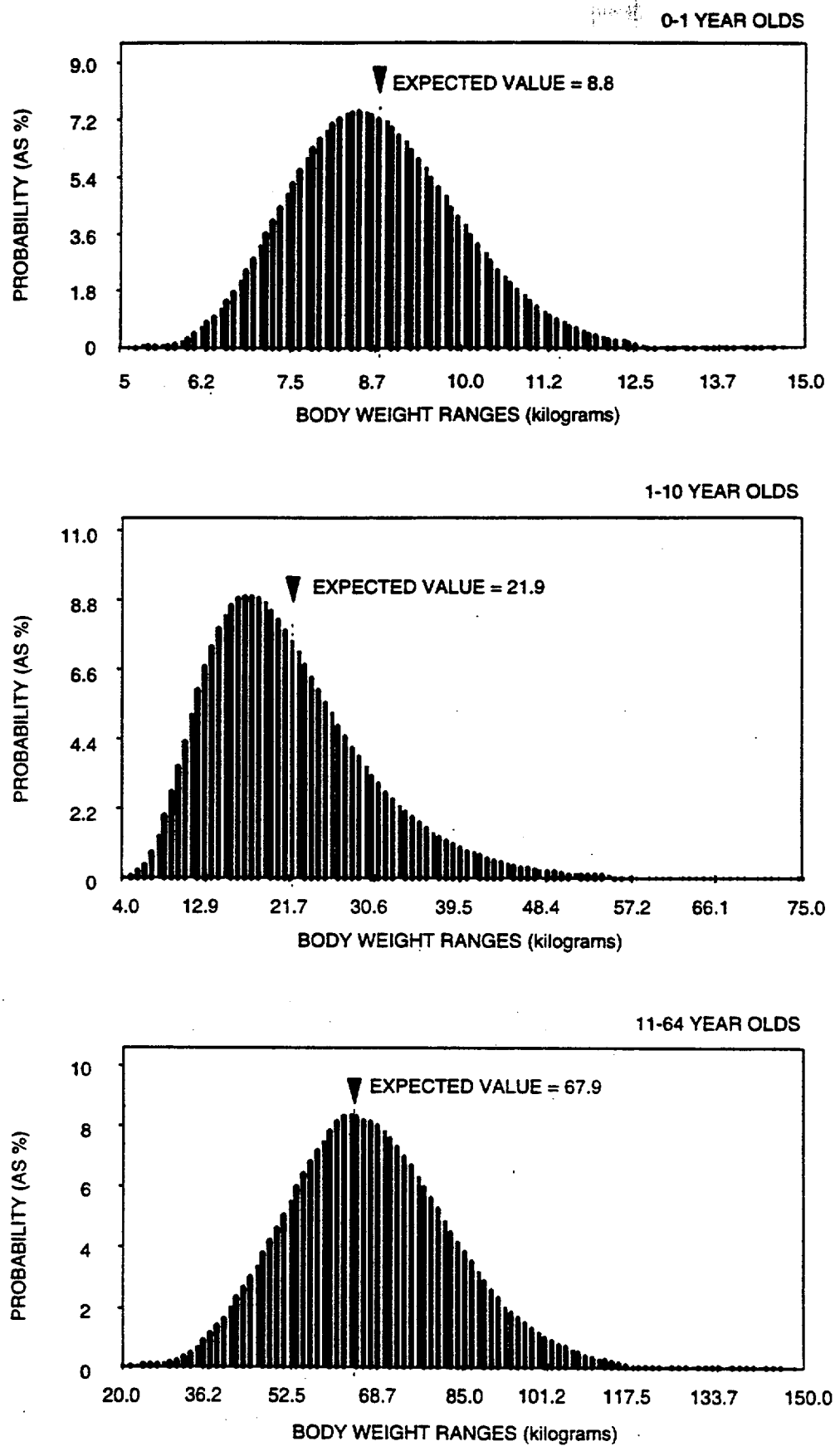
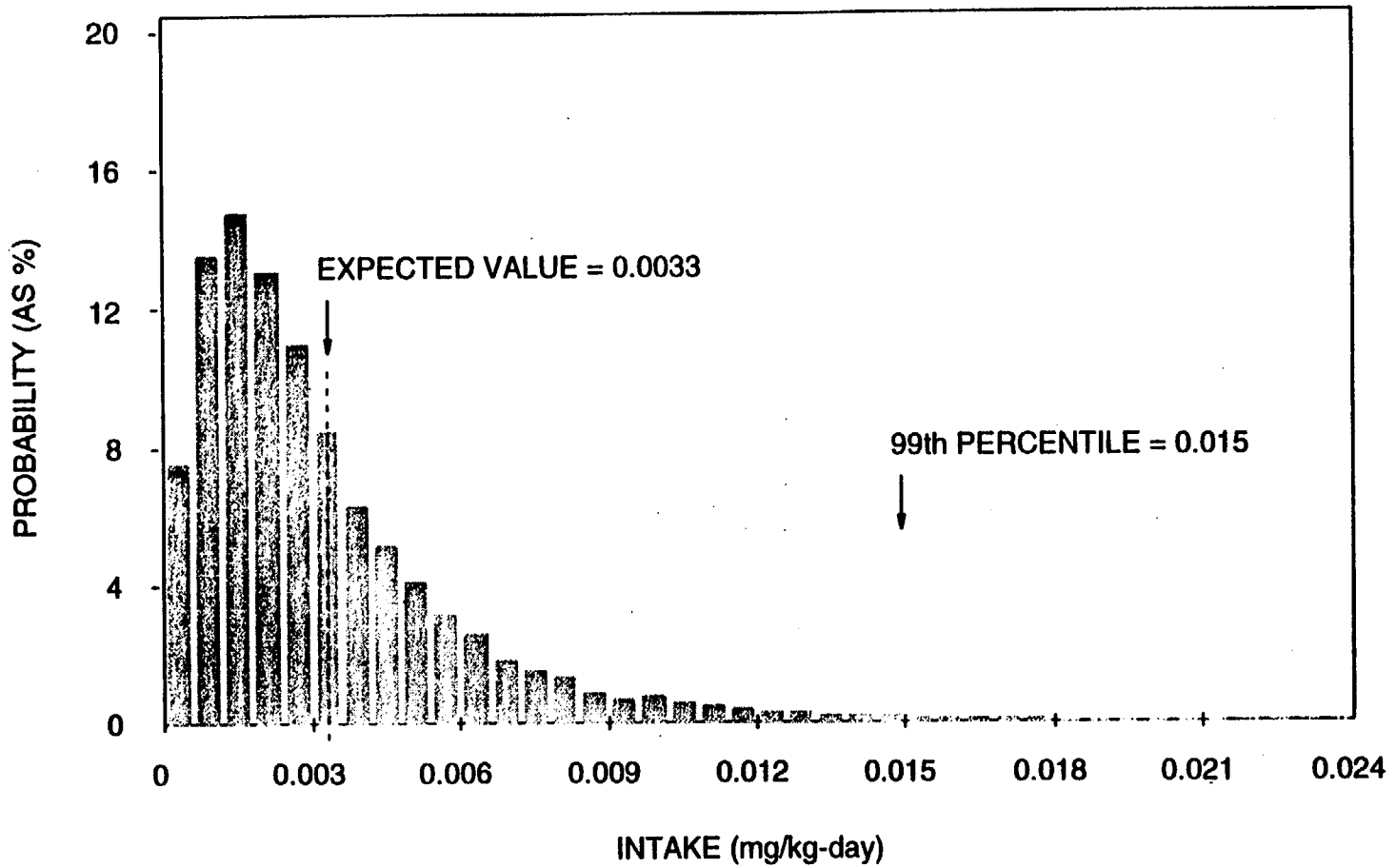


FIGURE 4.13
PROBABILITY DISTRIBUTIONS FOR BODY WEIGHT



NOTE: AVERAGE POTENTIAL INTAKE IS 0.0033 ARSENIC/kg BODY WEIGHT/DAY. INTAKES FOR CHILDREN HAVE BEEN MODELED BECAUSE THEIR INTAKE/kg BODY WEIGHT IS GREATEST AND NO SENSITIVE POPULATION HAS BEEN IDENTIFIED.

FIGURE 4.14
DISTRIBUTION OF POTENTIAL ARSENIC INTAKES FOR CHILDREN AS A RESULT OF GROUND WATER INGESTION LAKEVIEW, OREGON, SITE

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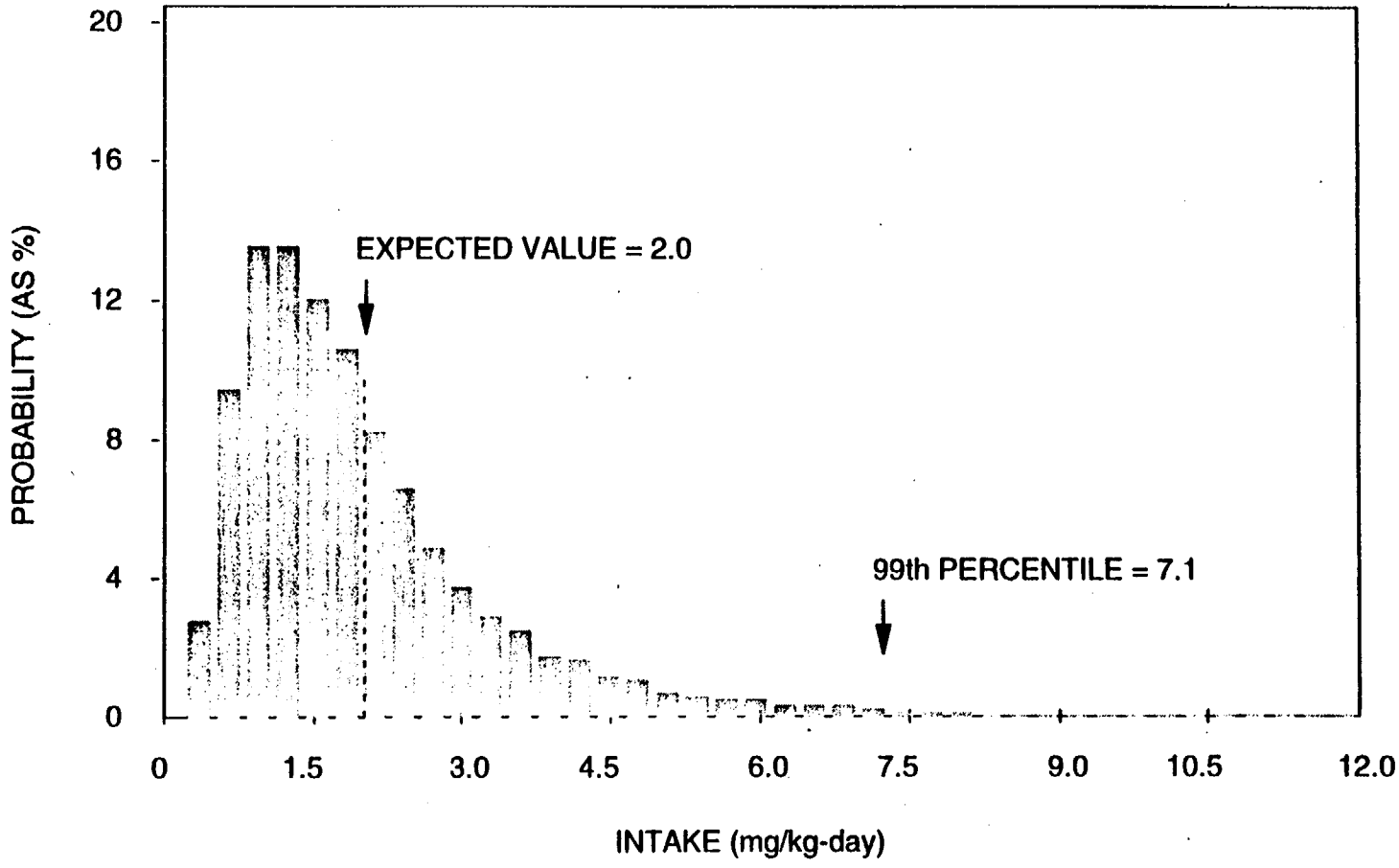
ARSINT.DRW



NOTE: AVERAGE POTENTIAL INTAKE IS 2.0 mg BORON/kg BODY WEIGHT/DAY. INTAKES FOR CHILDREN HAVE BEEN MODELED BECAUSE THEIR INTAKE/kg BODY WEIGHT IS GREATEST AND NO SENSITIVE POPULATION HAS BEEN IDENTIFIED.

FIGURE 4.15
DISTRIBUTION OF POTENTIAL BORON INTAKES FOR CHILDREN AS A RESULT OF GROUND WATER INGESTION LAKEVIEW, OREGON, SITE

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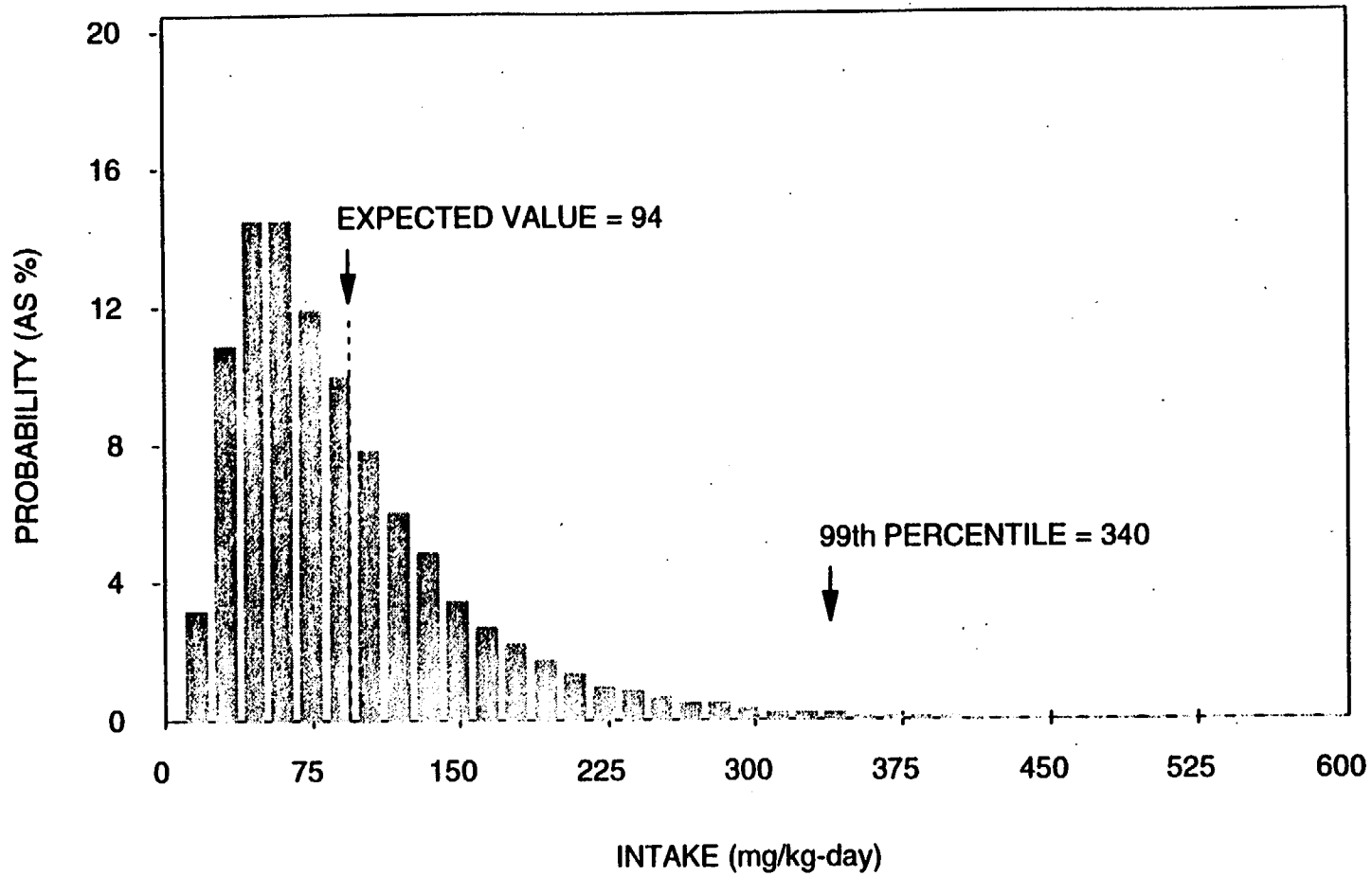
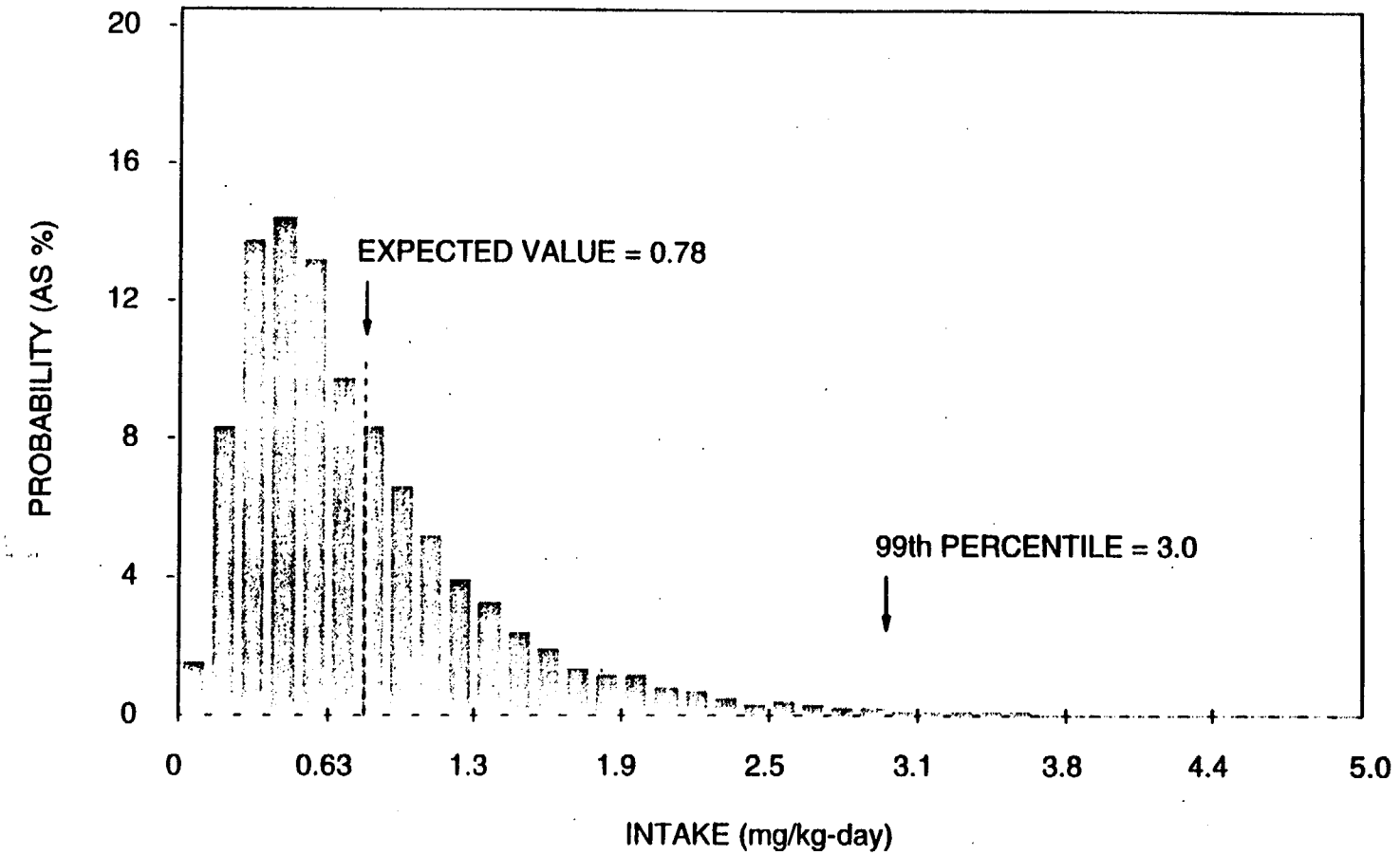
BORINT.DRW



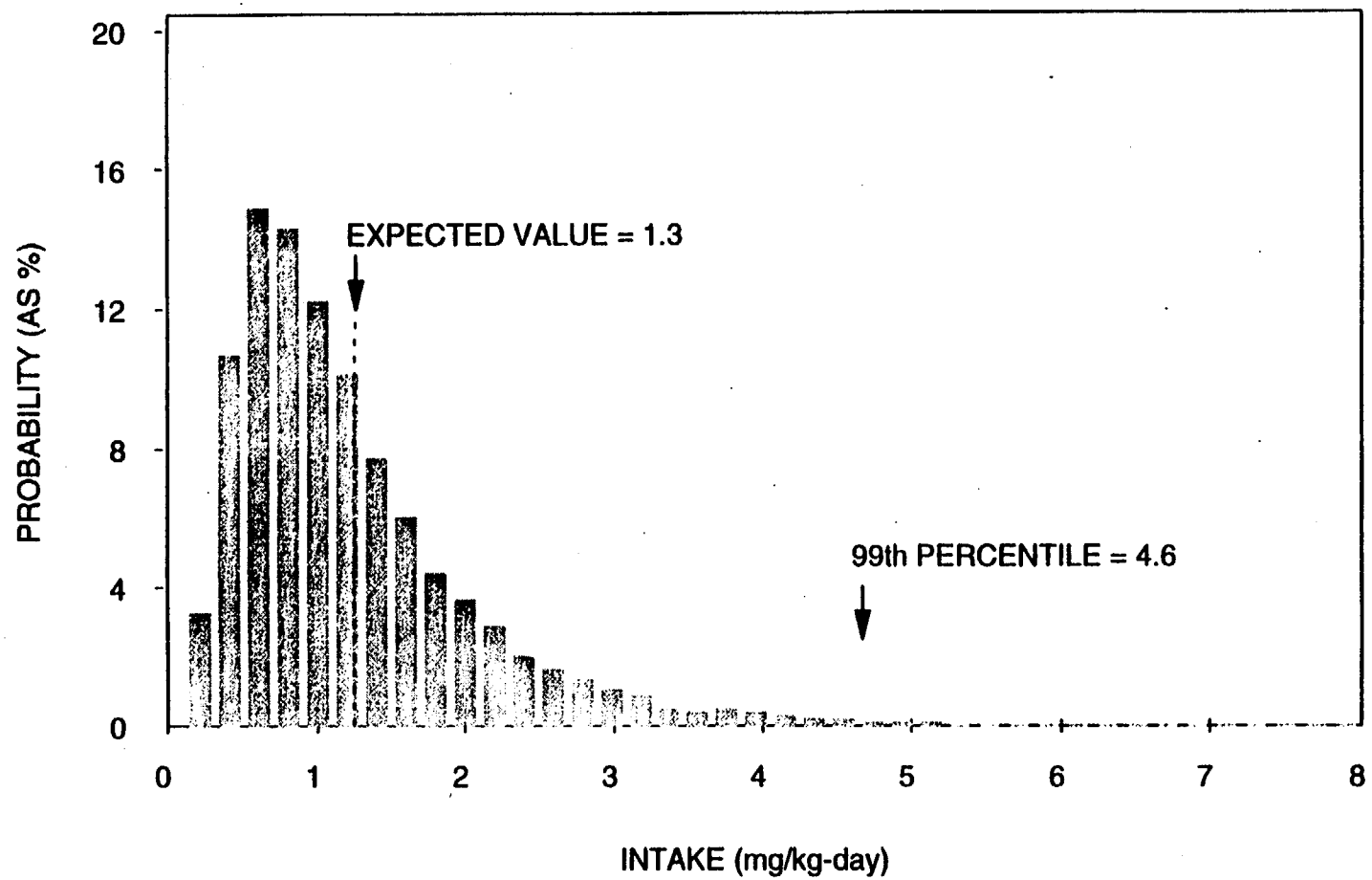
NOTE: AVERAGE POTENTIAL INTAKE IS 94 mg CHLORIDE/kg BODY WEIGHT/DAY. INTAKES FOR CHILDREN HAVE BEEN MODELED BECAUSE THEIR INTAKE/kg BODY WEIGHT IS GREATEST AND NO SENSITIVE POPULATION HAS BEEN IDENTIFIED.

FIGURE 4.16
DISTRIBUTION OF POTENTIAL CHLORIDE INTAKES FOR CHILDREN AS A RESULT OF GRO' 'D WATER INGESTION LAKEVIEW, (GON, SITE



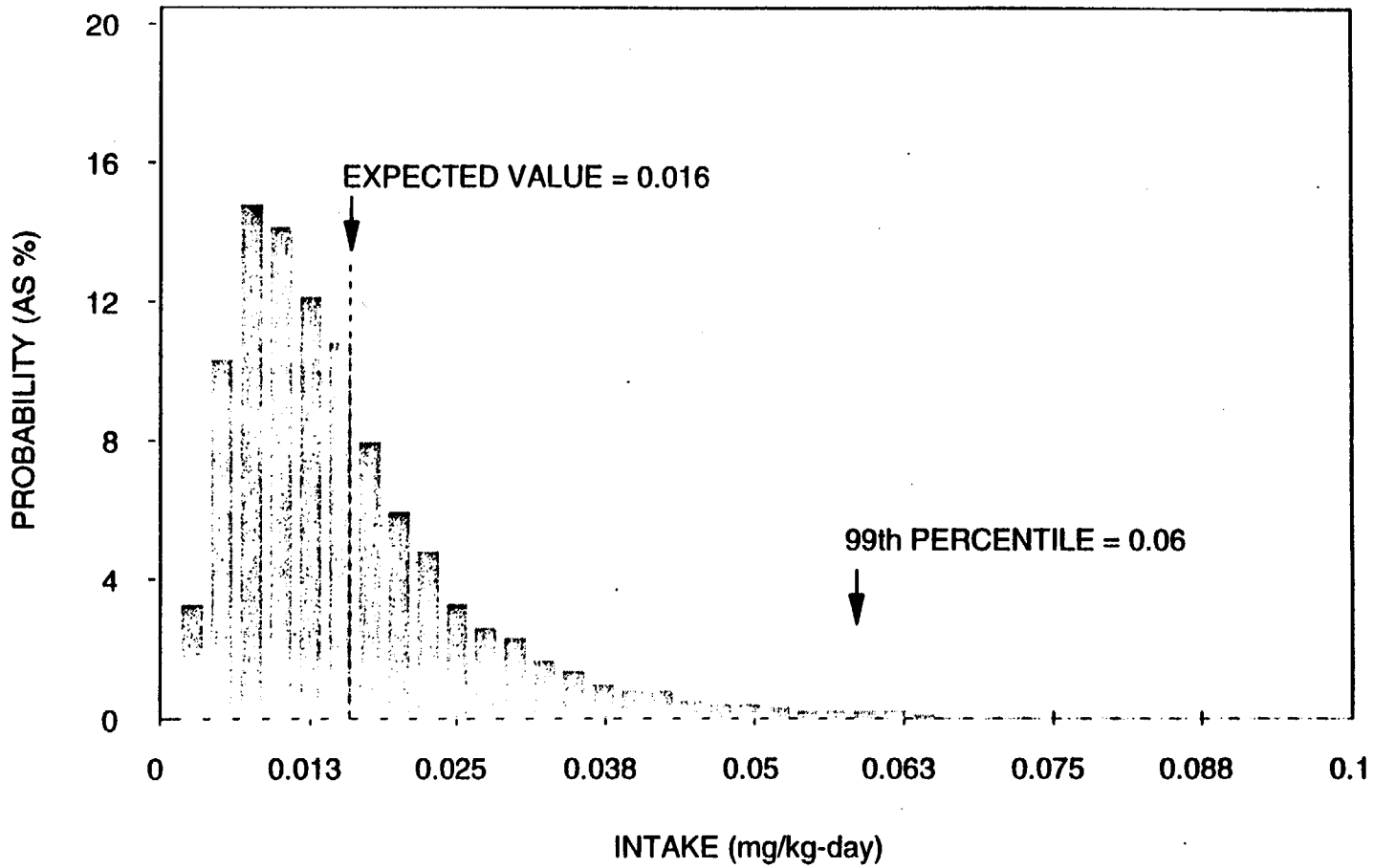
NOTE: AVERAGE POTENTIAL INTAKE IS 0.78 mg IRON/kg BODY WEIGHT/DAY. INTAKES FOR CHILDREN HAVE BEEN MODELED BECAUSE THEIR INTAKE/kg BODY WEIGHT IS GREATEST AND NO SENSITIVE POPULATION HAS BEEN IDENTIFIED.

FIGURE 4.17
DISTRIBUTION OF POTENTIAL IRON INTAKES FOR CHILDREN AS A RESULT OF GROUND WATER INGESTION LAKEVIEW, OREGON, SITE



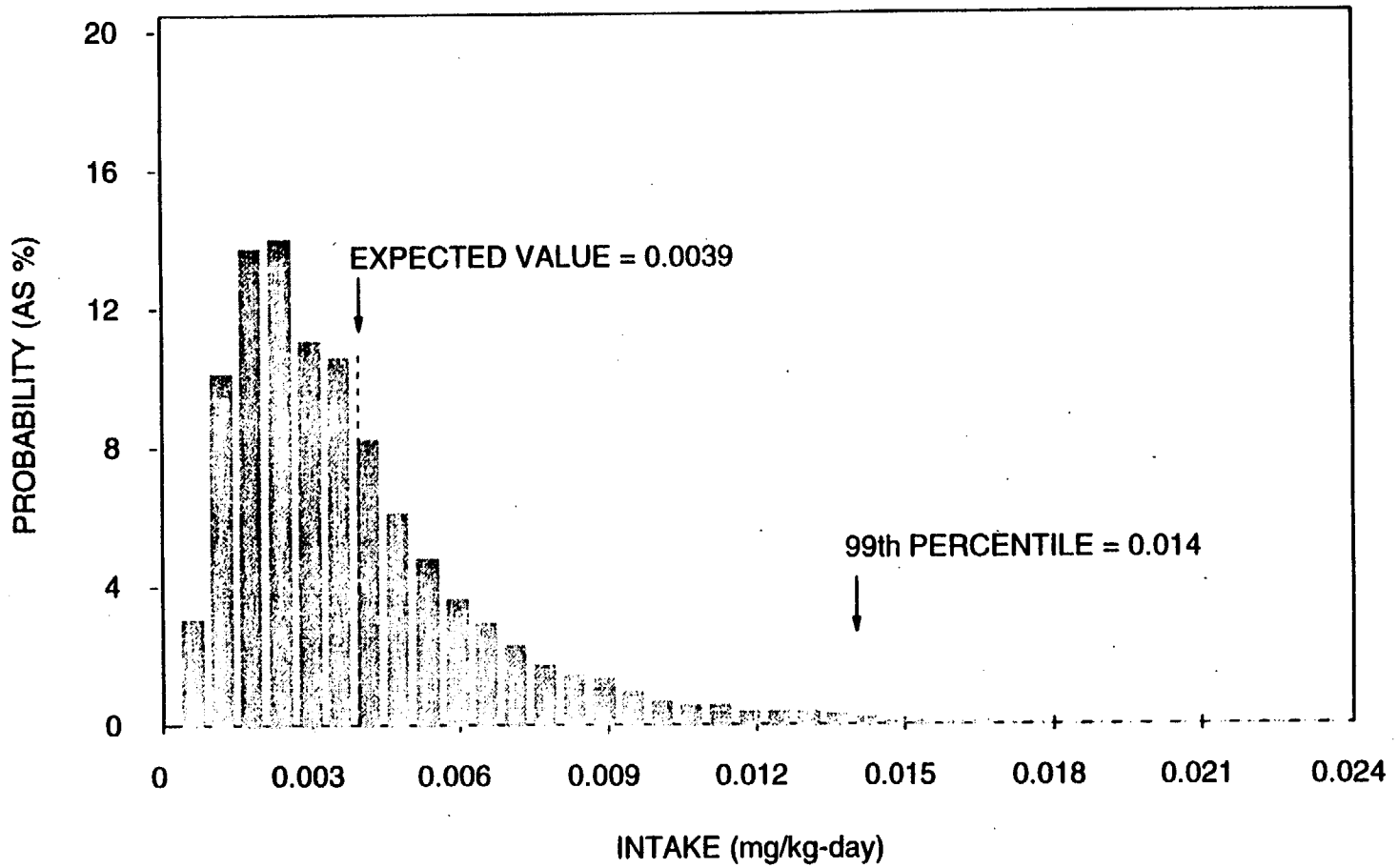
NOTE: AVERAGE POTENTIAL INTAKE IS 1.3 mg MANGANESE/kg BODY WEIGHT/DAY. INTAKES FOR CHILDREN HAVE BEEN MODELED BECAUSE THEIR INTAKE/kg BODY WEIGHT IS GREATEST AND NO SENSITIVE POPULATION HAS BEEN IDENTIFIED.

FIGURE 4.18
DISTRIBUTION OF POTENTIAL MANGANESE INTAKES FOR CHILDREN AS A RESULT OF GROUND WATER INGESTION LAKEVIEW, OREGON, SITE



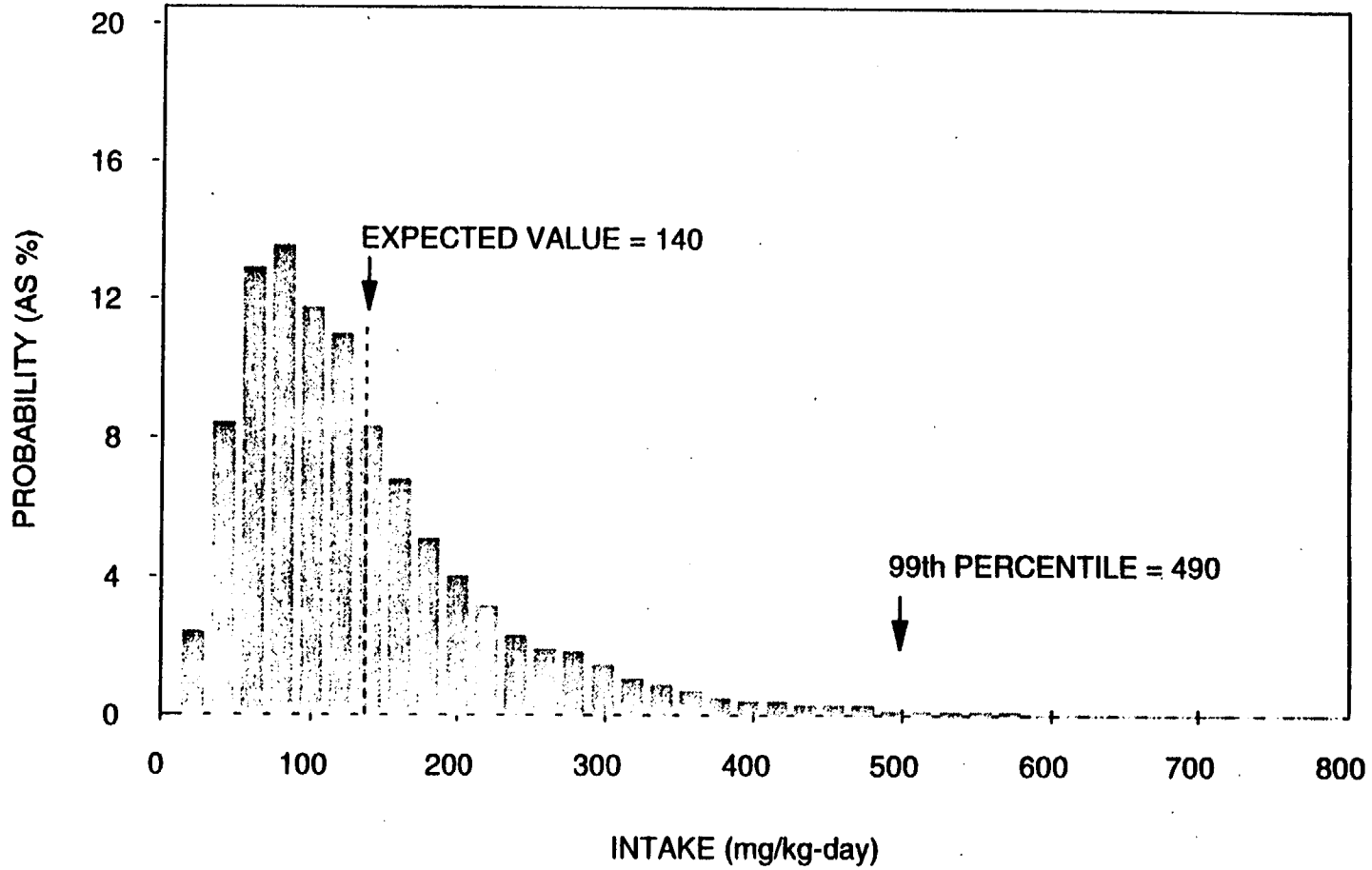
NOTE: AVERAGE POTENTIAL INTAKE IS 0.016 mg MOLYBDENUM/kg BODY WEIGHT/DAY. INTAKES FOR CHILDREN HAVE BEEN MODELED BECAUSE THEIR INTAKE/kg BODY WEIGHT IS GREATEST AND NO SENSITIVE POPULATION HAS BEEN IDENTIFIED.

FIGURE 4.19
DISTRIBUTION OF POTENTIAL MOLYBDENUM INTAKES FOR CHILDREN AS A RESULT OF GROUND WATER INGESTION LAKEVIEW, OREGON, SITE



NOTE: AVERAGE POTENTIAL INTAKE IS 0.0039 mg NICKEL/kg BODY WEIGHT/DAY. INTAKES FOR CHILDREN HAVE BEEN MODELED BECAUSE THEIR INTAKE/kg BODY WEIGHT IS GREATEST AND NO SENSITIVE POPULATION HAS BEEN IDENTIFIED.

FIGURE 4.20
DISTRIBUTION OF POTENTIAL NICKEL INTAKES FOR CHILDREN AS A RESULT OF GRO[illegible] WATER INGESTION LAKEVIEW, [illegible]ON, SITE



NOTE: AVERAGE POTENTIAL INTAKE IS 140 mg SODIUM/kg BODY WEIGHT/DAY. INTAKES FOR CHILDREN HAVE BEEN MODELED BECAUSE THEIR INTAKE/kg BODY WEIGHT IS GREATEST AND NO SENSITIVE POPULATION HAS BEEN IDENTIFIED.

FIGURE 4.21
DISTRIBUTION OF POTENTIAL SODIUM INTAKES FOR CHILDREN AS A RESULT OF GROUND WATER INGESTION LAKEVIEW, OREGON, SITE

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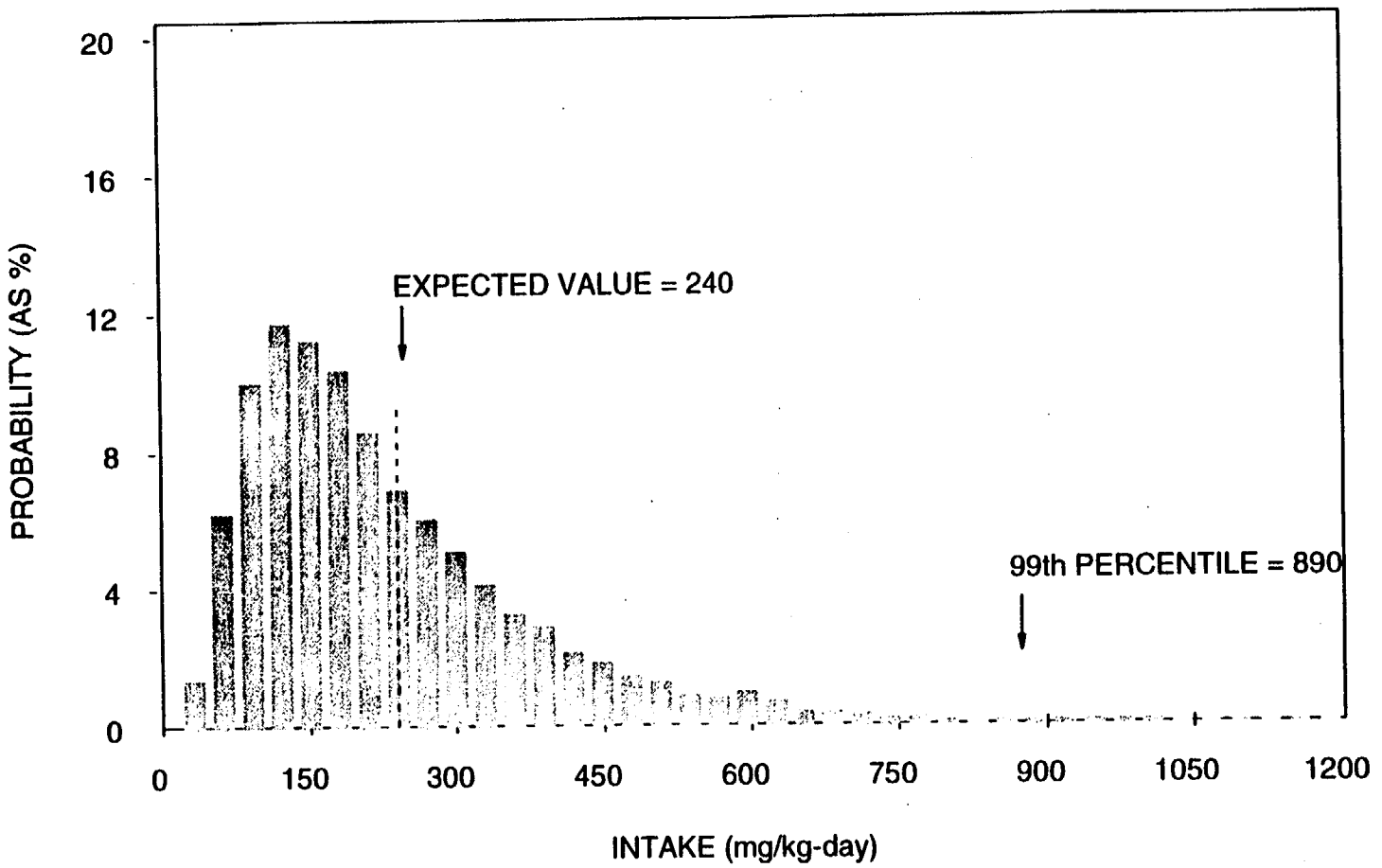
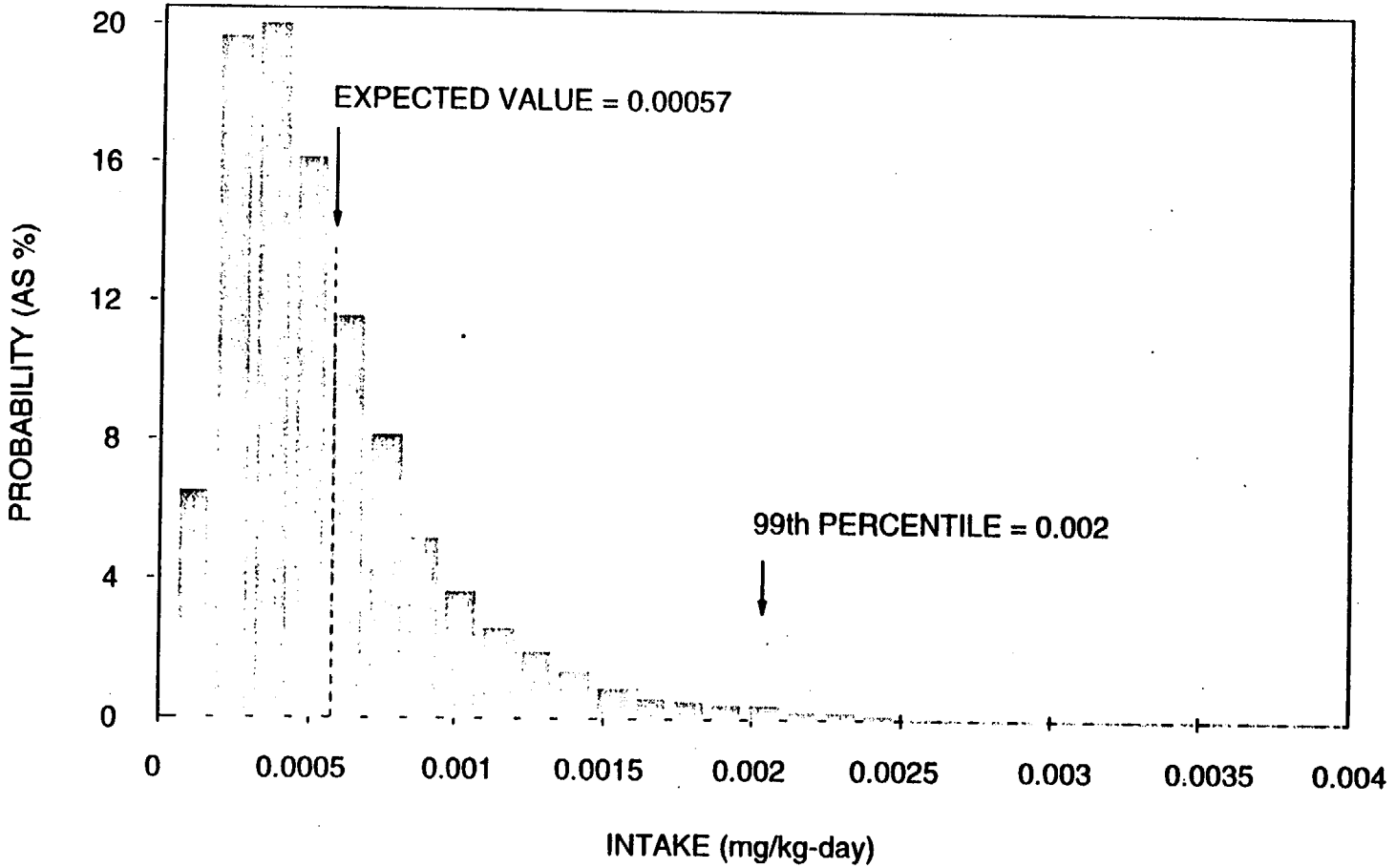
SODINT.DRW



NOTE: AVERAGE POTENTIAL INTAKE IS 240 mg SULFATE/kg BODY WEIGHT/DAY. INTAKES FOR INFANTS HAVE BEEN MODELED BECAUSE THEY ARE THE MOST SUSCEPTIBLE RECEPTORS TO SULFATE TOXICITY.

FIGURE 4.22
DISTRIBUTION OF POTENTIAL SULFATE INTAKES FOR INFANTS AS A RESULT OF GROUND WATER INGESTION LAKEVIEW, OREGON, SITE



NOTE: AVERAGE POTENTIAL INTAKE IS 0.00057 mg URANIUM/kg BODY WEIGHT/DAY. INTAKES FOR CHILDREN HAVE BEEN MODELED BECAUSE THEIR INTAKE/kg BODY WEIGHT IS GREATEST AND NO SENSITIVE POPULATION HAS BEEN IDENTIFIED.

FIGURE 4.23
DISTRIBUTION OF POTENTIAL URANIUM INTAKES FOR CHILDREN AS A RESULT OF GROUND WATER INGESTION LAKEVIEW, OREGON, SITE

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- Uncertainties arising from the assumption that the ground water constituent source term at the site has reached a steady state and that constituent concentrations at the exposure point will remain constant for chronic periods of exposure (generally greater than 7 years). Because the source of constituents at Lakeview has been removed, and although ground water contamination appears to be decreasing slowly, the assumption of a constant source probably will lead to an overestimation of risk.

- Uncertainties associated with the model used to estimate constituent uptake into plants for the irrigated garden produce pathway. Site-specific plant uptake factors could vary substantially from the default literature estimates. Additionally, bioconcentration factors (BCF) used for livestock are not well defined. Therefore, uncertainty is associated with the calculation of potential exposure levels in livestock. As with environmental sampling, the net effect on risk estimates of this uncertainty cannot be predicted.

Despite these uncertainties, the use of probability distributions that incorporate all definable sources of variability provide a representative picture of the potential range of exposures at the Lakeview site.

5.0 TOXICITY ASSESSMENT

Several constituents that have the potential to cause adverse human health effects have been detected in ground water at the Lakeview site. The toxicological effects of the chemical constituents and carcinogenic potentials of the radionuclides are described below. The following source materials were used in developing these toxicological profiles: when available, EPA's Integrated Risk Information System (IRIS) (EPA, 1994a); EPA's Health Effects Assessment Summary Tables (HEAST) (EPA, 1994b); the Agency for Toxic Substances Disease Registry Toxicological Profiles published by the U.S. 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 for certain constituents. Basing toxicity information on the standardized review documents cited above, risk evaluations at UMTRA Project sites should be consistent with evaluations at sites regulated under different legislation.

The EPA Office of Research and Development has calculated acceptable intake values, or reference doses (RfD), for long-term (chronic) exposure to noncarcinogens. These values are estimates of route-specific exposure levels that would not be expected to cause adverse effects when exposure occurs for a significant portion of the lifetime. The RfDs include safety factors to account for uncertainties associated with limitations of the toxicological database, including extrapolating animal studies to humans and accounting for variability in response from sensitive individuals. These values are updated quarterly and published in the HEAST or are provided through the EPA's IRIS database.

The toxicity profiles presented here focus on drinking water-based toxicity source material for humans when they are available. Animal data are included only if human data are not available. Animal data on the toxicity range graphs are represented by widely spaced dotted lines. Uncertainty about the beginning or ending points of an exposure range that produces specific toxic effects is represented by closely spaced dots at the appropriate end of the line denoting range.

5.1 CONSTITUENT TOXICITY SUMMARIES

The following summaries address the basic toxicokinetics and toxicity of the contaminants of potential concern at the Lakeview site based on the preliminary screening discussed above. These constituents of potential concern are arsenic, boron, chloride, iron, manganese, molybdenum, nickel, polonium-210, sodium, sulfate, and uranium. Although these constituents have a wide range of toxic effects, depending on the exposure levels, the following discussions focus on toxic effects observed in the exposure range most relevant to contamination at the Lakeview site.

5.1.1 Arsenic

Absorption

Arsenic effectively is absorbed through the gastrointestinal tract and inhalation. Relative to gastrointestinal absorption, dermal absorption is negligible. In humans, approximately 80 percent of an ingested amount of dissolved inorganic trivalent (arsenite) or pentavalent arsenic (arsenate) is absorbed from the gastrointestinal tract (Pershagen and Vahter, 1979; Marafante and Vahter, 1987).

Tissue accumulation and clearance

After absorption by the gastrointestinal tract, arsenic is transported through the blood to most tissues. In humans as well as in most animal species, exposure to either arsenite or arsenate leads to initial accumulation in the liver, kidneys, and lungs. Clearance from these tissues is very rapid, and long-term retention of arsenic is seen in organs rich in sulfhydryl-containing proteins, such as hair, skin, squamous epithelium of the upper gastrointestinal tract, epididymis, thyroid, lens, and skeleton (Lindgren et al., 1982). Specific target tissue is dependent on the form of arsenic. Higher arsenic retention occurs after exposure to trivalent arsenic than to the pentavalent form and tissue distribution is altered (Webb, 1966; Casarett and Doull, 1991).

In humans and rats, inorganic arsenic passes through the placental barrier. It also has been demonstrated to enter both cow and human milk (Marcus and Rispin, 1988).

In the human body, where methylcobalamine acts as a major methyl group donor in the biotransformation process, inorganic arsenic is converted to methylated compounds. Marcus and Rispin (1988) demonstrated that the major site of arsenic methylation is the liver. Trivalent arsenic is the substrate for methylation, and pentavalent arsenic must be reduced to trivalent arsenic before methylation can occur. Dimethylarsenic acid is a major metabolite found in animals and humans. Methylation results in a detoxification of inorganic arsenic (about 1 order of magnitude per methyl group) and increases the rate of arsenic excretion from the body.

The major excretion route following human exposure to inorganic arsenic is through the kidneys (Ishinishi et al., 1986). Only a low percentage is excreted in feces. The excretion rate in urine varies, depending on the chemical form of arsenic and the species exposed. In humans exposed to a single low dose of arsenite, about 35 percent was excreted in urine over a period of 48 hours (Buchet et al., 1980; 1981). With continuous human intake over a few days, 60 to 70 percent of the daily dose is excreted in urine (Buchet et al., 1981). Following exposure to arsenate, the limited human data available indicate an arsenate excretion rate similar to that of arsenite. Other less important routes of elimination of inorganic arsenic include skin, hair, nails, and sweat.

After oral intake of radiolabeled pentavalent arsenic, 66 percent was excreted with a half time of 2.1 days, 30 percent with a half time of 9.5 days, and 3.7 percent with a half time of 38 days (Marcus and Rispin, 1988).

Environmental sources of arsenic

Arsenic is ubiquitous in nature in both inorganic and organic compounds. Water is the major means of transport of arsenic under natural conditions. In oxygenated water, arsenic occurs in a pentavalent form; under reducing conditions (e.g., in artesian well waters), the trivalent form predominates. Sedimentation of arsenic in association with iron and aluminum represents a considerable factor in environmental transport and deposition of this element (Marcus and Rispin, 1988).

As a result of its widespread occurrence, the general human population is exposed to arsenic primarily from drinking water and foodstuffs. Certain target groups are exposed to arsenic from industrial and agricultural uses. Medicinal use also has been a significant means of human exposure.

Drinking water usually contains a few micrograms of arsenic, predominantly as inorganic salts in the trivalent and pentavalent states (WHO, 1981). However, concentrations of up to 1.1 mg/L in drinking water have been reported in Chile, Argentina, Taiwan, the United States, and the United Kingdom (WHO, 1981).

Certain foodstuffs contain appreciable amounts of arsenic. Arsenic concentrations in fish and seafood, particularly shellfish, is generally 1 or 2 orders of magnitude higher than in other foods. Wine and mineral waters can contain several hundred micrograms of arsenic per liter (Crecelius, 1977; WHO, 1981).

Toxicity of arsenic

Levels of exposure associated with acute arsenic toxicity vary with its valency form. Trivalent arsenicals (arsenites) are generally more toxic than pentavalent (arsenates) (Morrison et al., 1989), and inorganic arsenic compounds are more toxic than organic (Shannon and Strayer, 1989). Based on geochemical models for the Lakeview site, arsenic occurs primarily in the pentavalent form in ground water (Table 3.7). For arsenic trioxide, the reported estimated acute oral lethal dose in humans ranges from 70 to 300 mg (1 to 4 milligrams per kilogram per day [mg/kg-day]) (EPA, 1984). Acute exposure to inorganic arsenic compounds may lead to severe inflammation of the gastrointestinal tract, encephalopathy, and acute renal failure after ingestion.

Teratogenic effects of arsenic compounds administered intravenously or intraperitoneally at high doses have been demonstrated in laboratory animals only (Ferm, 1971; Hood, 1972; EPA, 1984).

Chronic arsenic intoxication results from exposure to small doses of arsenic over a long period of time. These intoxications frequently are caused by arsenic in drinking water and in food. Skin changes leading to skin cancer commonly are seen in populations exposed to high concentrations of arsenic in drinking water. Endemic arsenic poisoning is seen in Cordoba, Argentina, where the concentration of arsenic in drinking water ranges from 0.9 to 3.4 mg/L (equivalent to 0.026 to 0.097 mg/kg-day). Certain areas in Taiwan also have high natural arsenic concentrations in drinking water that cause blackfoot disease (a peripheral extremity vascular disorder resulting in gangrene). A dose-response relationship between the incidence of blackfoot disease and the duration of exposure to arsenic has been documented (Tseng, 1977; EPA, 1994a).

Hyperpigmentation, hyperkeratoses, and skin cancer with prevalence of 7.1 percent, 18.4 percent, and 1.1 percent, respectively, were reported in Taiwanese studies of more than 40,000 people exposed to arsenic in drinking water at daily intakes ranging from 1.4 to 6.3 mg per day. However, these adverse health effects also were observed at lower exposure levels.

Increasing chronic oral ingestion doses of arsenic progressively produces systemic effects, including 1) arterial thickening in children and adults (0.02 mg/kg-day); 2) neurological symptoms, including peripheral neuropathy (0.04 mg/kg-day); 3) fibrosis of the liver (0.05 mg/kg-day); and 4) cirrhosis of the liver (0.8 mg/kg-day) (DHHS, 1993).

Certain characteristics of exposed human populations may influence arsenic toxicity at high exposure levels. Genetic dispositions (rapid versus poor acetylators) and protein-deficient diet may decrease arsenic methylation. This can result in an increased arsenic deposition in the target organs (e.g., lung or skin).

The EPA classifies inorganic arsenic as a Group A (human) carcinogen (EPA, 1994a), based on the occurrence of increased lung cancer mortality in populations exposed primarily through inhalation, and of increased skin cancer in populations exposed through consumption of drinking water containing high arsenic concentrations. The EPA currently is reviewing the cancer slope factor (SF) in light of recent data suggesting arsenic ingestion may result in increased cancers in internal organs as well as skin cancers. Figure 5.1 summarizes the health effects of exposure to arsenic as a function of dose.

5.1.2 Boron

Absorption

Although boron can be measured in blood following ingestion and recovered in urine, no quantitative studies on absorption have been found (DHHS, 1992a).

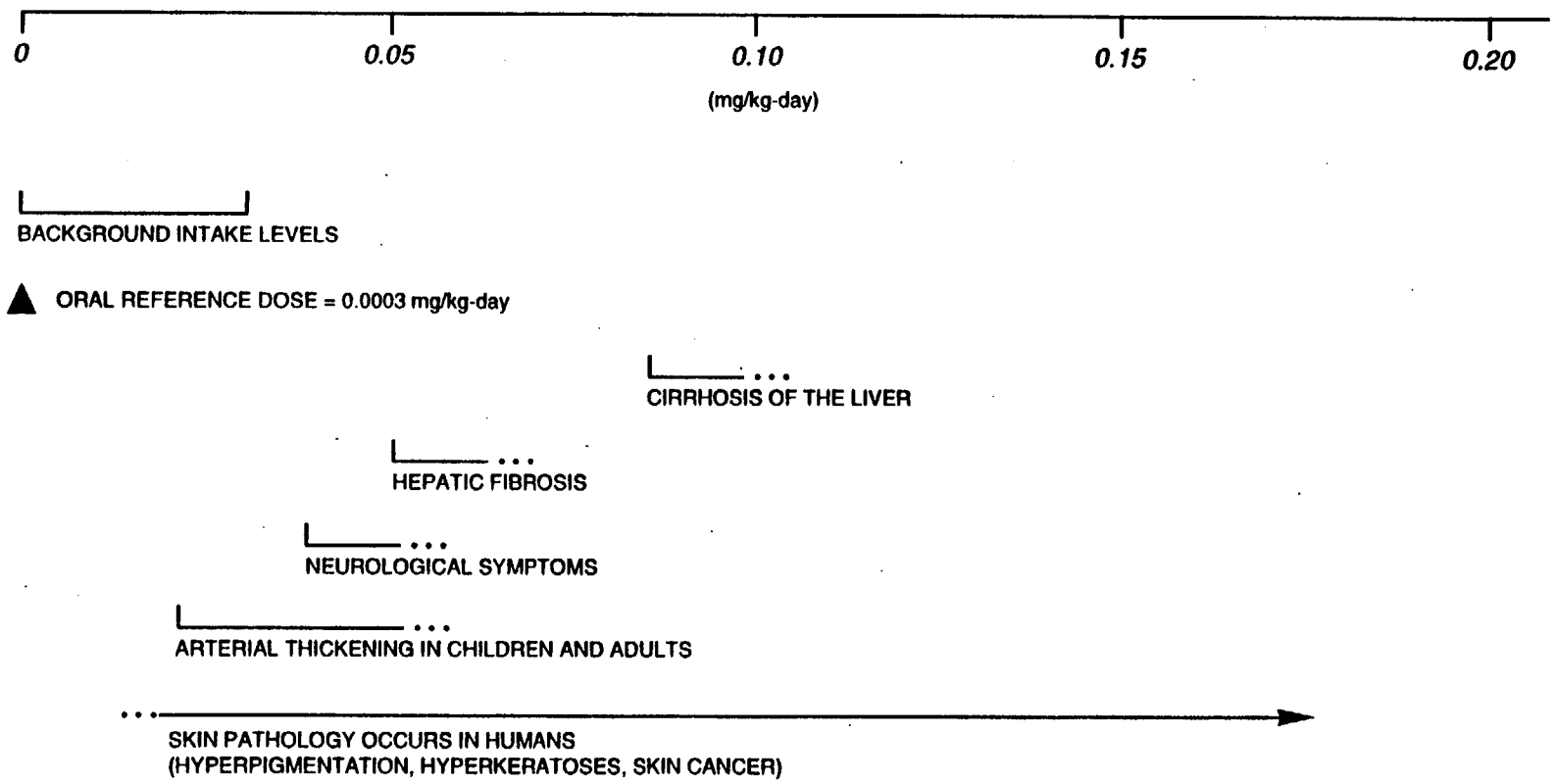


FIGURE 5.1
ARSENIC TOXICITY RANGES

MAC: SITE/LKV/BRA/ARSENTOX

Tissue accumulation and clearance

No studies on tissue distribution and clearance of boron are available. Observations of liver, kidney, and neurological damage following ingestion of very high doses of boron (more than 500 mg/kg-day) suggest these tissues receive some concentration of an ingested dose.

One study of six male volunteers indicated urine was the main route of excretion, with 93 percent of the ingested dose recovered in urine within 96 hours of ingestion. Boric acid could be detected in the patients' urine 23 days after a single ingestion (DHHS, 1992a).

Environmental sources of boron

A major source of boron in water is the natural weathering of boron-containing rocks. Environmental releases of boron from industrial sources include fertilizers, herbicides, glass production, coal-burning power plants, and copper smelters. Although the average surface water concentration in the United States is 0.1 mg/L, concentrations as high as 360 mg/L have been reported in areas of California with boron-rich rock formations (DHHS, 1992a). The concentration of boron in drinking water is not generally reported, but studies of boron in tap water and public water supply systems have shown 99 percent contain less than 1 mg/L. The maximum reported value was 3.28 mg/L (DHHS, 1992a).

Plants take up boron from soil, and boron occurs in many foods (primarily fruits and vegetables). The estimated average daily intake from food and water ranges from 10 to 25 mg per day (0.14 to 0.35 mg/kg-day).

Accidental home exposures to boron occur primarily through ingestion of insecticides used to control cockroaches. Boron also can be absorbed from cosmetics or medical preparations through mucous membranes or damaged skin.

Toxicity of boron

No epidemiological studies are available on human chronic ingestion of boron. Some data are available on acute toxicity in humans. These data are from infants ingesting formula prepared with boric acid (DHHS, 1992a). The dose ranged from 4.5 to 14 grams. Based on the body weights of two infants who died, the lethal acute doses ranged from 505 to 765 mg/kg-day. Doses of 184 mg/kg-day and greater produced nausea, persistent vomiting, diarrhea, and colicky abdominal pain. Doses greater than 500 mg/kg-day could damage the liver and kidneys and produce skin lesions. Neurological effects, including headache, tremors, restlessness, and convulsions followed by weakness and coma, also were reported in some of the infants who ingested high levels of boron (more than 500 mg/kg-day). In adults, ingestion of 241 or 895 mg/kg in suicide attempts produced only vomiting, which resolved in 24 to 96 hours. In one case, extensive redness and irritation of the skin occurred following ingestion of 14 grams of boron.

Chronic toxicity data are available only from animal studies. In both rats and dogs, the primary toxicity was observed in the reproductive organs. Male dogs showed testicular atrophy and no spermatogenesis following 38 weeks of ingesting 29 mg/kg-day of boron. Following 2 years of dietary boron intake of 58.5 mg/kg-day, rats showed a significant decrease in both testicular weight and in the testes-to-body-weight ratio, as well as other histological changes in testicular and seminiferous tubules. Rats in this study also showed decreased brain weight and brain-to-body-weight ratios. The next lower doses tested showed no adverse effects in either species: 8.8 mg/kg-day for dogs and 17.5 mg/kg-day for rats. Intermediate doses were not tested for either species. However, a lifetime study in mice given 8.1 mg/kg-day also showed no effects.

Because no human data are available to evaluate the toxicity of chronic oral boron ingestion, the EPA has applied a standard uncertainty factor of 2 orders of magnitude to allow for extrapolating from the no-observed-adverse-effect level (NOAEL) in animals (8.8 mg/kg-day in dogs) to humans. This correction results in an oral RfD of 0.09 mg/kg-day.

No human cancer has been associated with boron exposure, and only one negative study in mice has evaluated the carcinogenicity of boron. Therefore, no conclusive evaluation of boron can be made with respect to cancer. Boron toxicity is summarized in Figure 5.2 as a function of dose.

5.1.3 Chloride

Absorption

Chloride is rapidly and fully absorbed from the gastrointestinal tract.

Tissue accumulation and clearance

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). It occurs in plasma at concentrations of 96 to 106 milliequivalents per liter (meq/L) (3408 to 3763 mg/L), and in more concentrated form in cerebrospinal fluid and gastrointestinal secretions (National Research Council, 1989). Its concentration in most cells is low. A daily chloride turnover in adults (intake/output) ranges from 3018 to 8875 mg. Chloride excretion is mainly urinary, 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.

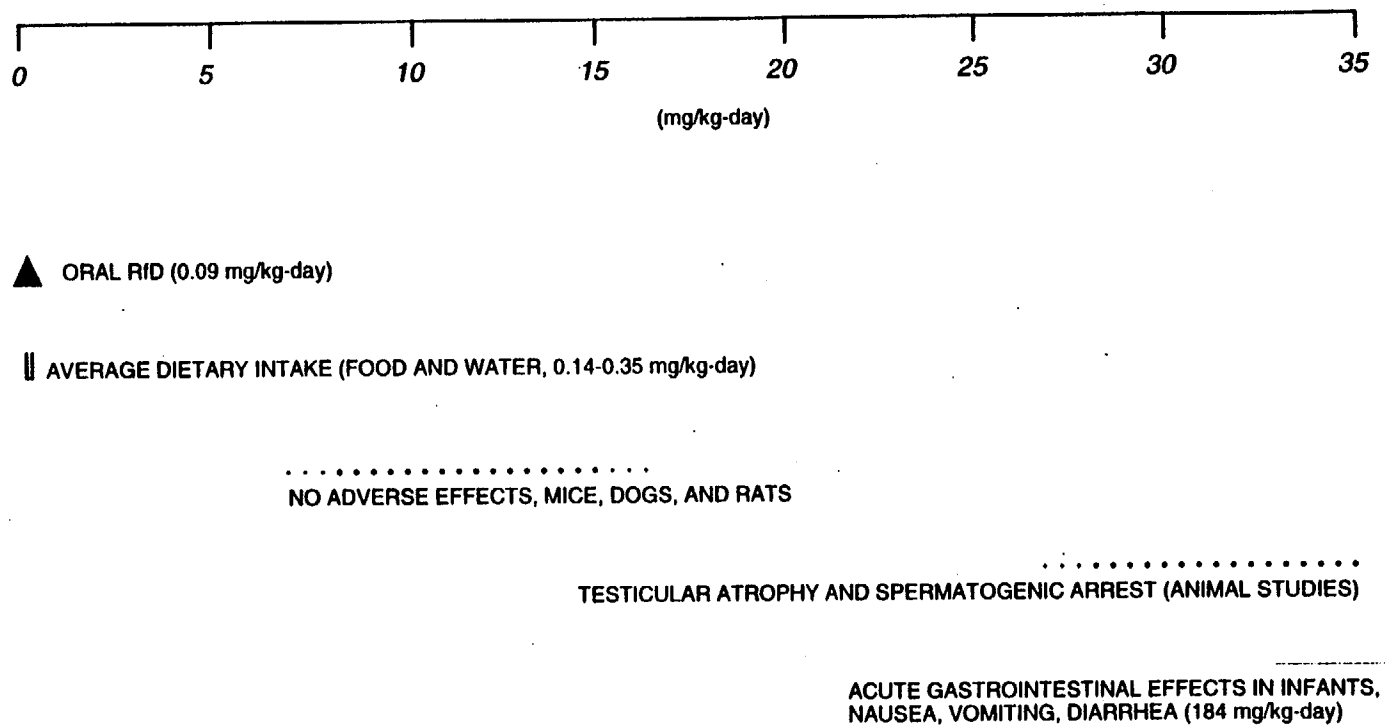


FIGURE 5.2
BORON TO[illegible]Y RANGES

MAC: SITE/LKV/BRA/BOROTOX

Thus, dietary sources of chloride are essentially the same as those for sodium, and processed foods are the major source of chloride. Rich sources of chloride are salt, cereals, breads, dried skim milk, teas, eggs, margarine, salted butter, bacon, ham, corn beef, canned meats, seafood, vegetables, salted snack food, and olives. Dietary chloride intakes varies largely with salt intake. Estimates range from 2400 to 14,400 mg chloride per day from sodium chloride (equivalent to 34 to 206 mg/kg-day for a 70-kg man).

Human milk contains 11 meq/L of chloride (391 mg/L), and 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 waters. Surface waters contain 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 processes. 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 chloride per liter (about 3 mg/kg-day, assuming a daily consumption of 2 L and a 70-kg body weight) (National Research Council, 1980).

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

The recommended drinking water limit for chloride is set at 250 mg/L (equivalent to 7 mg chloride per kilogram per day, for a 70-kg man and assuming consumption of 2 L of water per day) (National Research Council, 1980). This amount of chloride in drinking water causes a salty taste in water, which may be objectionable to many people. The taste threshold for the chloride anion in water varies from 210 to 310 mg/L.

Toxicity of chloride

Chloride is the most 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, and renal disease) will also cause chloride loss, resulting in hypochloremic metabolic alkalosis.

Although the essentiality of the chloride ion is generally recognized, no recommended dietary allowance (RDA) has been determined. The estimated

minimum chloride requirement for good health ranges from 180 mg per day for infants to 750 mg per 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 results in hyperkalemic metabolic acidosis (National Research Council, 1980). When metabolic acidosis develops, potassium leaves cells and is excreted by the kidney (Brater, 1992).

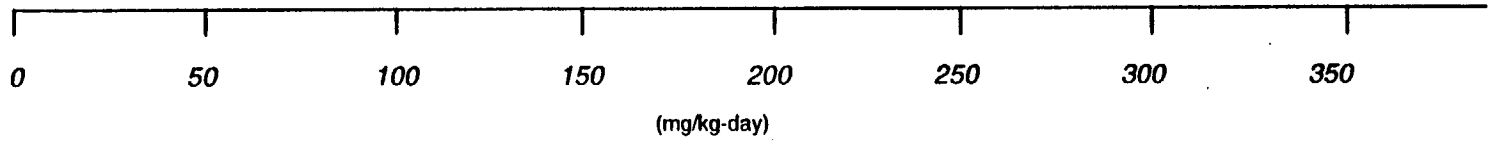
The only known dietary hyperchloremia results from water-deficiency dehydration. Sustained ingestion of high chloride levels (as salt) is associated with hypertension in sensitive individuals and in animal models. Although the level of chloride attributable to hypertension has not been determined, it 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 5.3 summarizes chloride toxicity as a function of dose.

5.1.4 Iron

Absorption

The percentage of dietary iron that is absorbed ranges from 2 percent in individuals with diseases of the gastrointestinal tract to 35 percent in rapidly growing, healthy children (Casarett and Doull, 1986; Whitney et al., 1990). Normally, 10 to 15 percent of dietary iron is absorbed, but this percentage varies to compensate for the level of iron in the body (Elinder, 1986). For example, patients with iron-deficiency anemia can absorb as much as 60 percent of an oral dose of iron (Josephs, 1958).

Iron absorption is also influenced by factors such as the source and chemical form of the ingested iron, other substances in the diet, and the condition of the gastrointestinal tract (Elinder, 1986). Very little is known about the absorption of iron from water and about the chemical species of iron in drinking water from the tap. Although the amount of ferric ion (Fe^{3+}), ferrous ion (Fe^{2+}), and organic complexes of iron in water that are absorbed by humans is unknown, it is clear that a reducing agent such as ascorbic acid increases the absorption of iron in food (National Research Council, 1980). Ferrous ion appears to have better availability than does ferric ion. Iron from animal sources is absorbed by humans more effectively than iron from vegetables and grains. Soluble forms of iron such as iron sulfate are taken up more readily than insoluble forms such as iron oxide. The presence of other metals also affects iron absorption. Absorption decreases in the presence of high levels of phosphate, cobalt, copper, and zinc (Elinder, 1986). Excess manganese can significantly decrease



INTAKE FROM DRINKING WATER

RECOMMENDED INTAKE LIMIT FROM WATER

DIETARY INTAKE LEVELS

HYPERTENSION IN HUMANS

FIGURE 5.3
CHLORIDE TOXICITY RANGES

iron absorption by impairing hemoglobin regeneration in the blood (National Research Council, 1980). In the contaminated ground water at the Lakeview site, iron is present predominantly in the form of ferric ion (Table 3.7).

Tissue accumulation and clearance

Iron absorption from the gastrointestinal tract occurs in two steps. First, ferrous ions from the intestinal lumen are absorbed into the mucosal cells. Second, they are transferred from the mucosal cells to plasma, where they are bound to transferrin for transfer to storage sites. As ferrous ion is released into plasma, it is oxidized by oxygen in the presence of ferroxidase I (Casarett and Doull, 1986).

Normally, the adult human body contains about 3 to 5 grams of iron. Two-thirds of this amount is found in the blood, bound to hemoglobin. Less than 10 percent of the body iron is found in myoglobin and iron-requiring enzymes. About 20 to 30 percent of the remaining iron in the body pool is bound to iron-storage proteins in liver, bone marrow, and spleen (Elinder, 1986).

Under normal conditions, the total elimination of iron from the body is limited to 0.6 to 1.0 mg per day, or roughly 0.01 percent of the body stores. Not counting iron not absorbed from the gut, about 0.2 to 0.5 mg elemental iron per day is eliminated through the feces, about 0.1 to 0.3 mg per day in urine, and the remainder through normal dermal losses in sweat, hair, and nails. Based on these elimination rates, the biological half-life of iron in the body is 10 to 20 years (Elinder, 1986).

Environmental sources of iron

Iron concentrations of liver, kidney, beef, ham, egg yolk, and soybeans are about 30 to 150 mg/kg fresh weight. Grains and fruits are low in iron, usually ranging from 1 to 20 mg/kg. The iron concentration of both human and cow's milk is about 0.5 mg/L (Elinder, 1986).

Average daily intakes of iron range from 9 to 35 mg per day (0.1 to 0.5 mg/kg-day) (Elinder, 1986). Approximately 35 percent of dietary iron comes from meat, fish, and eggs, while 50 percent is supplied by cereals, root vegetables, and other foods of plant origin (National Research Council, 1980).

Iron concentrations in water vary greatly. In the United States, the iron concentrations of freshwater and public water supplies range from 0.01 to 1.0 mg/L (Elinder, 1986). Assuming daily consumption of 2 L of water by a 70-kg (body weight) adult, this range would result in an intake of 0.0003 to 0.03 mg/kg-day of iron from drinking water.

The RDA for iron is 10 mg (approximately 0.14 mg/kg-day) for adult males and 18 mg (approximately 0.25 mg/kg-day) for females of reproductive age (National Research Council, 1980).

Toxicity of iron

Iron intoxication is most frequent in children aged 1 to 3 years who eat iron supplements formulated for adults in the form of ferrous sulfate tablets with candy-like coatings. Severe poisoning may occur in children following ingestion of more than 0.5 gram (approximately 22 mg/kg) of iron or about 2.5 grams (110 mg/kg) of ferrous sulfate. This acute iron poisoning has occurred in children who ingested as few as six iron tablets (Whitney et al., 1990). The iron damages the lining of the gastrointestinal tract, producing vomiting as the first symptom. Bleeding of the damaged gastrointestinal tissue frequently results in blood in the vomit and black stools (Casarett and Doull, 1986). Shock and metabolic acidosis can develop. If the patient survives the initial crisis, liver damage with hepatitis and coagulation defects often occur within a couple of days. Renal failure and cirrhosis of the liver may be delayed effects (Elinder, 1986).

Long-term iron intake in a form that is readily absorbed and in doses exceeding 50 to 100 mg of iron per day (0.7 to 1.4 mg/kg-day for a 70-kg adult male) results in an increased body burden of iron because iron is removed from the body at a much slower rate than it is absorbed (Elinder, 1986). As the body burden of iron increases to 20 to 40 grams (roughly 10 times the normal level), production of the iron-binding protein hemosiderin increases and results in a condition known as hemochromatosis. This condition starts with increased pigmentation of the skin and higher iron concentrations in the liver, pancreas, endocrine organs, and heart. This increased tissue iron can produce cirrhosis of the liver, disturbances in endocrine and cardiac function, and diabetes mellitus (Casarett and Doull, 1986) (Figure 5.4).

Chronic iron toxicity in adults can be caused by genetic factors, excess dietary iron, excessive ingestion of iron-containing tonics or medicines, or multiple blood transfusions. The pathologic consequences of iron overload are similar regardless of basic cause (Casarett and Doull, 1986).

5.1.5 Manganese

Absorption

Following ingestion, manganese absorption is homeostatically controlled: the rate of absorption depends on both the amount ingested and tissue levels of manganese. For adult humans, approximately 3 to 4 percent of dietary manganese is absorbed (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). The rate of absorption 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

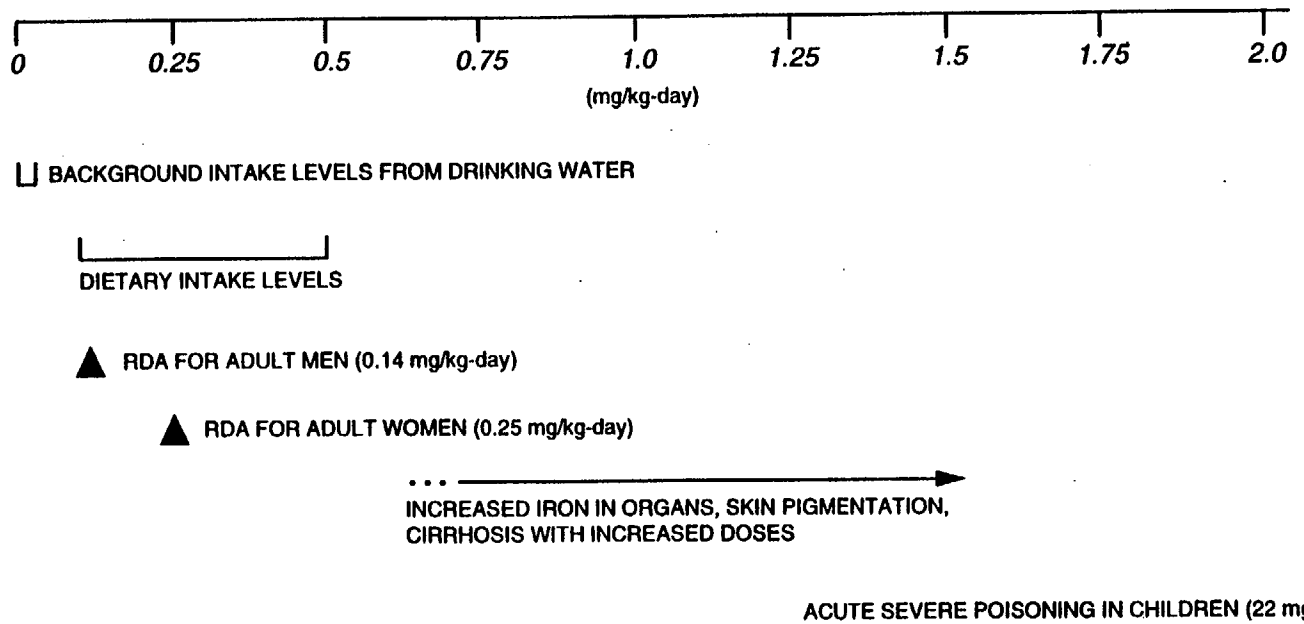


FIGURE 5.4
IRON TOX(' RANGES

phosphorus have been shown to increase the requirements for manganese in several species (Lönnerdal et al., 1987).

Tissue accumulation and clearance

Manganese is widely distributed throughout the body. The highest concentrations are found in the liver and kidney and, to a lesser extent, the hair. The biological half time in humans is 2 to 5 weeks, depending on body stores. Manganese readily crosses the blood-brain barrier and is more slowly cleared from brain than from other tissues (Casarett and Doull, 1986). 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 adult tissues. It is secreted into milk.

Absorbed manganese is almost totally secreted in bile and reabsorbed from the intestine as necessary to maintain body levels. At excessive exposure levels, other gastrointestinal routes may participate. Excess manganese is eliminated in the feces; urinary excretion is negligible (Casarett and Doull, 1986; 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 variation can 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 with cereals and rice as main food sources, the intake will be higher compared to areas where meat and dairy products make up a larger part of the diet. The average daily intake has been estimated as 2.0 to 8.8 mg per 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) have been 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 three-fold (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. Estimated safe and adequate daily dietary intakes for adults range from 0.03 to 0.07 mg/kg-day (Saric, 1986). The EPA NOAEL for drinking water is set at 0.005 mg/kg-day, while the lowest-observed-adverse-effect level (LOAEL) for drinking water sources is 0.06 mg/kg-day. The EPA RfD for drinking water is 0.005 mg/kg-day. The RfD for food ingestion is 0.14 mg/kg-day. There is some indication that manganese in drinking water is potentially more bioavailable (i.e., more readily absorbed) than manganese in dietary food sources. This bioavailability would result in toxic effects at lower ingested doses of manganese in drinking water than in food (EPA, 1994a).

Manganese inhalation in industrial settings has provided the largest source of data on chronic manganese toxicity. These data indicate that excess manganese can result in a central nervous system disorder consisting of 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 may occur when exposure ceases (DHHS, 1992b). Metal-chelating agents are ineffective in treatment, but L-dopa has been effective in treatment (Casarett and Doull, 1986).

Limited information is available on the effects of manganese ingestion. Because the effects from drinking water seem to differ from those from food sources, only studies on water consumption are 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 cases (8 percent) of death were reported among intoxicated people. A Greek study was conducted of more than 4000 individuals who drank water with manganese concentrations varying from 0.081 to 2.3 mg/L (estimated intake at 2 L per day for a 70-kg individual ranges from 0.002 to 0.07 mg/kg-day). Those who drank 0.007 to 0.07 mg/kg-day showed varying degrees of neurological effects but no effects were apparent in individuals drinking less than 0.005 mg/kg-day (Kondakis et al., 1989).

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

Few data are available on manganese toxicity in infants, but it is likely that infants will be more susceptible to toxicity due to greater absorption and greater penetration into the central nervous system (EPA, 1994a; Saric, 1986). Figure 5.5 summarized the toxicity of manganese.

5.1.6 Molybdenum

Absorption

Molybdenum absorption in the gastrointestinal tract depends on the species. Both inorganic and hexavalent forms such as molybdenum trioxide, sodium molybdate, and ammonium molybdate are readily absorbed from both food and water, whereas molybdenite is not. Human absorption rates of 40 to 70 percent have been observed for soluble forms of molybdenum (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. The principal excretion route in humans is the urine. Human studies indicate 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

Natural molybdenum occurs 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 mg/kg to 10 mg/kg), leading to large variations in molybdenum concentrations in plant materials. Natural concentrations in ground water have been reported from 0.00011 mg/L to 0.0062 mg/L. Human dietary intake of molybdenum has been estimated at 0.05 to 0.24 mg per day (0.002 to 0.004 mg/kg-day). The contribution of drinking water is estimated to range from 0 percent to 95 percent. The nutritional range of intake for molybdenum is 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 chronic intake of less than 0.008 mg/kg-day of molybdenum. The primary toxicity of molybdenum is related to its interactions with copper and sulfur, leading to altered excretion patterns for these elements.

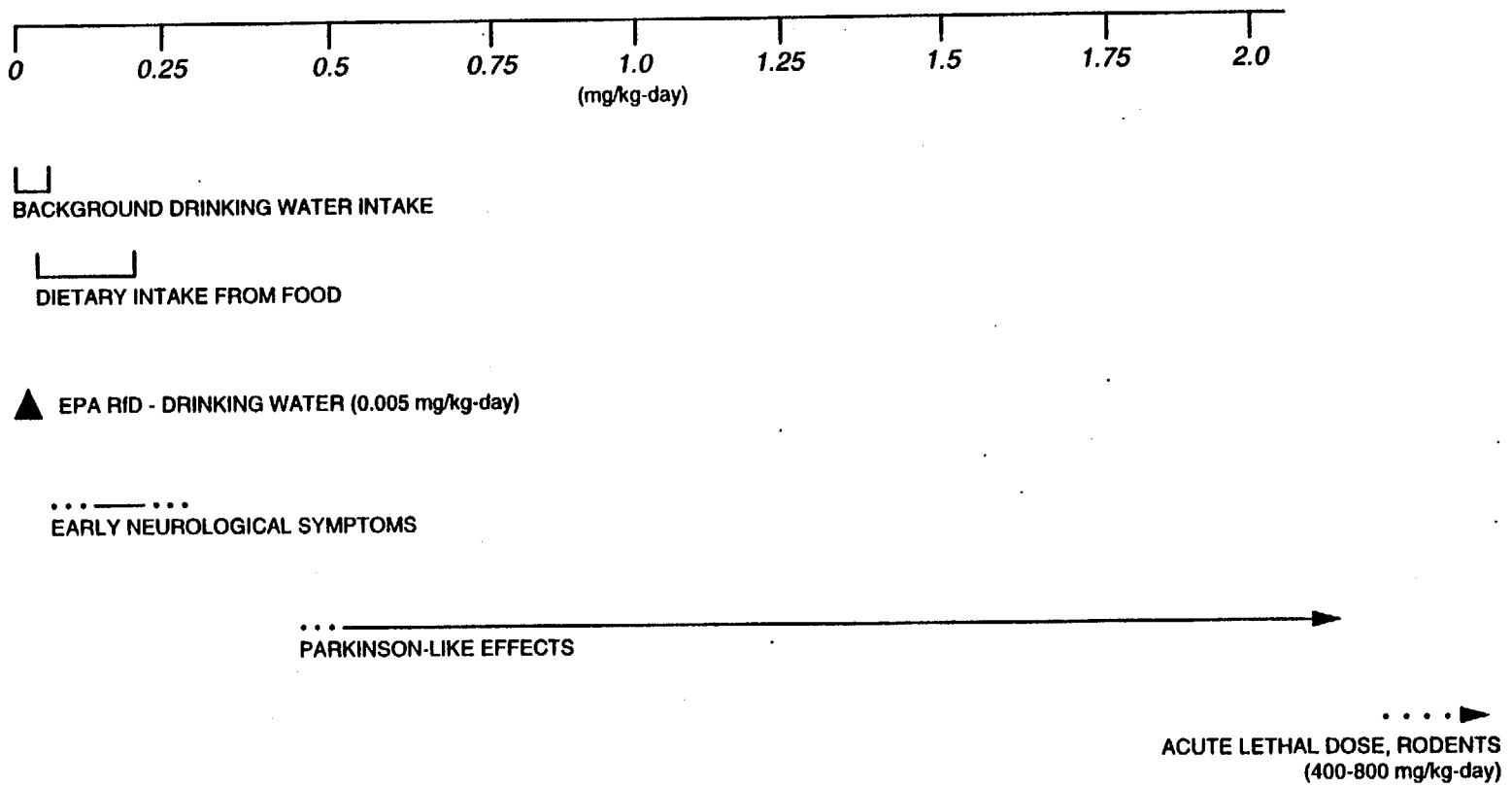


FIGURE 5.5
MANGANESE ' 'ICITY RANGES

MAC: SITE/LKV/BRA/MAN-GEN

Increased levels of molybdenum also increase the levels of xanthine oxidase, which is responsible for the production of uric acid. High levels of uric acid can accumulate in joints and lead to symptoms of gout and other joint disorders.

Intake of 0.008 to 0.022 mg/kg-day of molybdenum can produce mineral imbalance as a result of increased copper excretion. Copper excretion has been reported to double with molybdenum intakes 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 subsequent increased molybdenum concentrations in food would lead to molybdenum intakes in the range of 0.14 to 0.21 mg/kg-day. Figure 5.6 summarizes these health effects as a function of dose.

5.1.7 Nickel

Absorption

Absorption studies in humans report that 27 percent of inorganic nickel (administered as nickel sulfate) was absorbed when it was administered in drinking water, whereas only 0.7 percent was absorbed when it was given in food. In a separate study, the bioavailability of nickel, as measured by serum nickel levels, increased by 80 micrograms per liter (µg/L) after 3 hours in fasted individuals who ingested nickel sulfate in drinking water; levels were not elevated in individuals who ingested nickel in food (DHHS, 1991). Other human studies show that generally less than 10 percent of ingested nickel is absorbed by the gastrointestinal tract. This finding is consistent with studies reporting from 1 to 10 percent oral absorption in several animal species (Friberg et al., 1986). Absorbed nickel is transported in the plasma bound to serum albumin and various organic ligands, amino acids, or polypeptides (Casarett and Doull, 1986). Nickel has been found to affect gastrointestinal absorption of iron, but only when iron was administered as ferric sulfate (Fe^{+3}) (DHHS, 1991).

Tissue accumulation and clearance

In humans, serum nickel levels reportedly peak 2.5 to 3 hours after ingestion of nickel sulfate. In individuals who accidentally drank water contaminated with nickel sulfate and nickel chloride, nickel mean serum half times were 60 hours. No human data were located regarding nickel levels in specific tissues or organs following ingestion of nickel compounds.

In animals, various nickel compounds administered orally distributed primarily to the kidneys, with significant nickel levels also found in the liver, heart, lung, fat, peripheral nervous tissues, and brain. Increased nickel levels also were found in

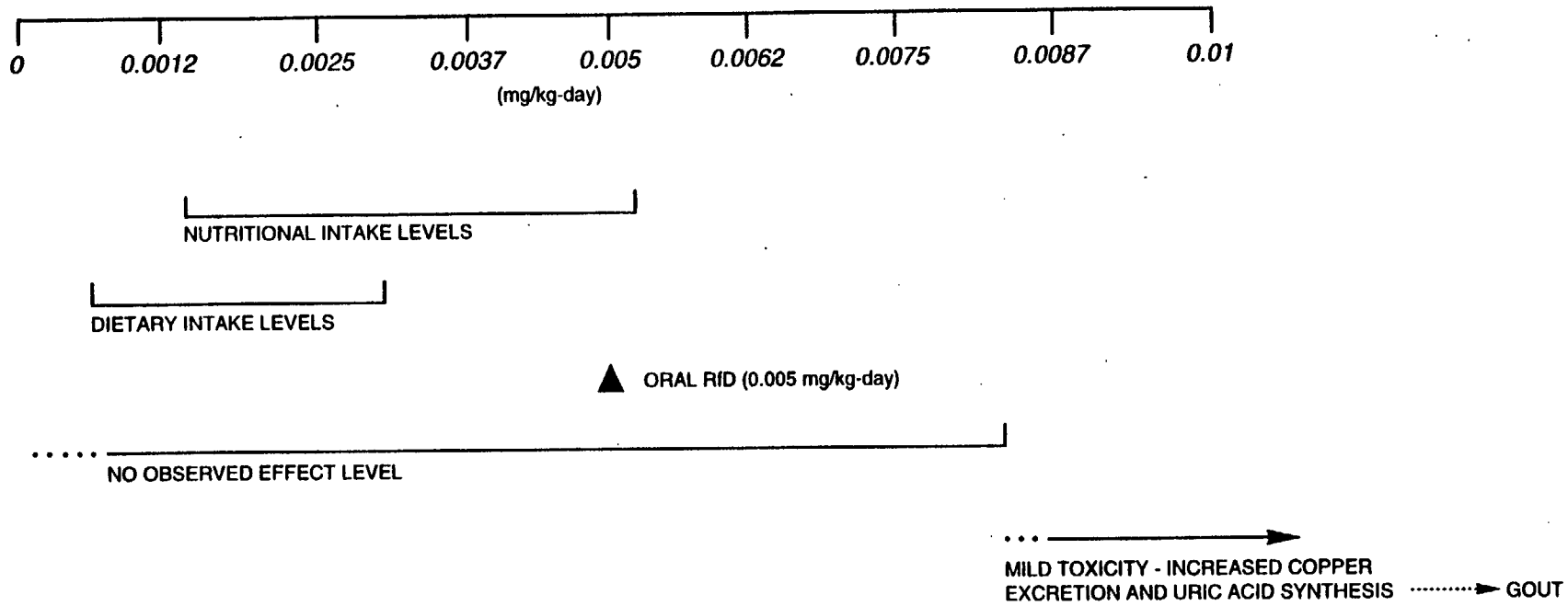


FIGURE 5.6
MOLYBDENUM TOXICITY RANGES

MAC: SITE/LKV/BRA/MOL-GEN

the fetuses of animals exposed orally to nickel compounds, suggesting that nickel crosses the placental barrier (DHHS, 1991).

In humans, most ingested nickel is excreted in the feces, due to limited absorption. Nickel absorbed in the gastrointestinal tract is excreted in the urine. Excretion of a given dose of nickel is nearly complete in 4 or 5 days (Casarett and Doull, 1986), with approximately 26 percent of the dose excreted in the urine and the remainder eliminated in the feces (DHHS, 1991).

Environmental sources of nickel

Exposure to nickel can occur through inhalation of ambient air and tobacco smoke and by ingesting water and food. Most intake occurs through the diet (DHHS, 1991). In grains, fresh weight nickel concentrations reportedly range from 0 to 6.45 µg per gram. In vegetables and fruits, levels range from 0 to 2.59 µg per gram and in seafood from 0.3 to 107 µg per gram. Average daily dietary intake is approximately 165 µg (Friberg et al., 1986).

The drinking water daily intake averages 2 µg (DHHS, 1991). Nickel is not commonly present at harmful levels in ground water. In a nationwide ground water survey, 97 percent of all samples (total of 2053 samples) contained less than 20 µg/L of nickel and 80 percent had less than 10 µg/L, although in areas near nickel mining operations, levels as high as 200 µg/L have been reported (Friberg et al., 1986).

Toxicity of nickel

Acute exposure to high nickel levels in drinking water (1-day duration) reportedly produced symptoms of gastrointestinal distress, including nausea, abdominal cramps, diarrhea, and vomiting. The estimated exposure dose of 7.1 to 35.7 mg/kg also produced transient hematological effects, muscular pain, transient increases in urine albumin, and neurological effects (giddiness and weariness).

The effects of chronic nickel ingestion in humans are not well documented. In laboratory animals (dogs and rats), the primary effects of long-term dietary administration of nickel sulfate were decreases in body weight and changes in organ weights. Low hematocrit and polyuria also were reported for dogs (DHHS, 1991). Rats appear to be the more sensitive of the two species. The lowest nickel dose of 35 mg/kg-day administered to rats in water by gavage resulted in decreased body and internal organ weights, as determined in a subchronic toxicity study (EPA, 1994a).

A susceptible population may exhibit a different or enhanced response to nickel than will most people who may be exposed to the same level of nickel in the environment. Chemical exposure history, genetic makeup, developmental state, health, and nutritional status can affect the detoxification and excretory processes (mainly hepatic and renal). For these reasons, it is expected that the

elderly (with declining function) and the youngest of the population (with immature and developing organs) generally will be more vulnerable to toxic substances than healthy adults.

Exposure to nickel may lead to sensitization. Available data indicate oral exposure to relatively low levels of nickel may elicit allergic dermatitis in sensitized (previously exposed to nickel) individuals (DHHS, 1991). Epidemiologic studies indicate that blacks have a higher sensitivity than whites and that women of either racial group have higher reaction rates (DHHS, 1991). The incidence of allergic reactions may be higher in women because they wear more metal jewelry than men. The suggested threshold for elicitation of the response is approximately 0.007 mg/kg-day following oral challenge. Cross-sensitivity of nickel and other metals (e.g., cobalt) has also been reported (DHHS, 1991).

For the rat, a NOAEL of 100 parts per million (ppm) of nickel in diet (5 mg/kg-day) was reported. The EPA chronic RfD was derived based on this NOAEL for human oral exposure to nickel. Considering the uncertainties with interspecies extrapolation and protection of sensitive populations, an oral RfD of 0.02 mg/kg-day has been developed for nickel (EPA, 1994a). This value represents a chronic daily ingestion dose that would not be expected to produce adverse health effects in humans. Figure 5.7 summarizes these health effects as a function of dose.

5.1.8 Sodium

Absorption

Sodium is rapidly and fully absorbed from the intestinal tract. The skin and lungs also absorb sodium rapidly by simple diffusion and ion exchange. Sodium travels in the blood, where it ultimately passes through the kidneys. The kidneys filter out all the sodium; then the adrenal hormone aldosterone maintains sodium concentration in the bloodstream at the amount needed (National Research Council, 1980).

Tissue accumulation and clearance

Sodium is the major extracellular ion. The sodium ion is essential to regulating 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 the propagation of impulses 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 easy to recover if the blood sodium level drops.

Sodium excretion is mainly urinary, with appreciable amounts also excreted in feces, sweat, and tears (Venugopal and Luckey, 1978). Mammalian renal

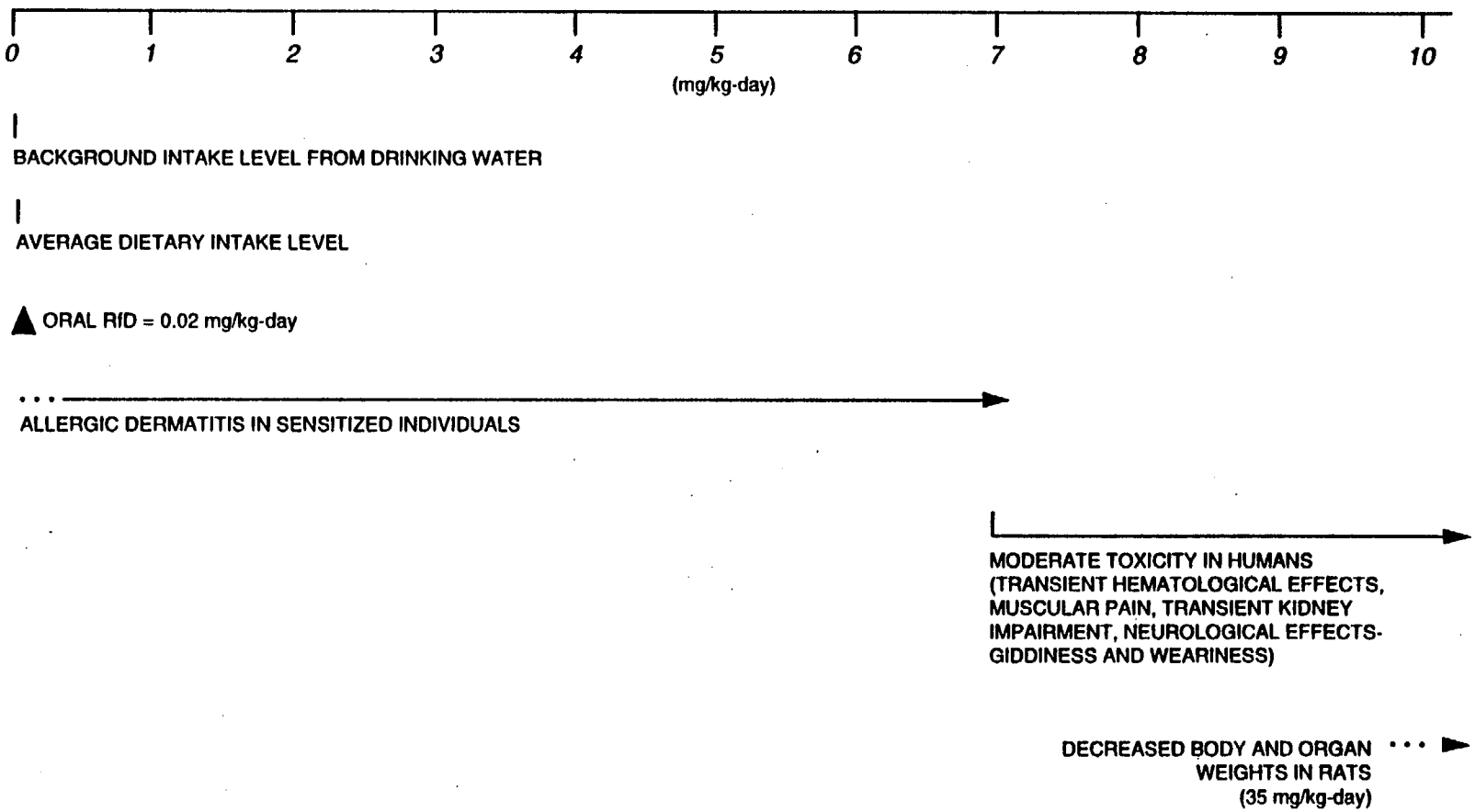


FIGURE 5.7
NICKEL TOXICITY RANGES

MAC: SITE/LKV/BRA/NIC-GEN

excretion of sodium 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 adult humans. A homeostatic mechanism for sodium functions at the renal excretory level.

Environmental sources of sodium

The total intake of sodium is influenced mainly by the extent that salt (sodium chloride) is used as an additive to food, the inherent salt content of the foods consumed, and the intake of other sodium salts in the diet and in medications. Sodium is a natural constituent of both vegetable and animal products in varying concentrations. Other sources of sodium are medications, 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 a day. Human milk contains 161 mg/L and cow's milk contains approximately 483 mg/L (Carson et al., 1986).

No RDA has been set for sodium. The National Research Council recommendations advise limiting daily sodium intake to less than 2400 mg (34 mg/kg-day). 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 intake levels as high as 134 mg/kg-day have been reported (National Research Council, 1980). The American Heart Association recommends limiting sodium intake to 3000 mg daily.

The sodium content of drinking water is extremely variable. The Chemical Analysis of Interstate Carrier Water Supply Systems reports sodium concentrations in 630 systems ranged from less than 1 to 402 mg/L (resulting in drinking water ingestion rates 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

In healthy adult males, acute toxicity symptoms of sodium chloride accompanied by visible edema may occur with an intake as low as 35 to 40 grams of salt per day (20 to 23 mg sodium per kilogram per day, because sodium is 39 percent of the weight of sodium chloride) (Meneely and Battarbee, 1976). Venugopal and Luckey (1978) report the mean lethal dose of sodium for humans is 3230 mg/kg.

Epidemiological studies indicate long-term excessive sodium intake is one of many factors associated with hypertension in humans. A high sodium/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 23 mg/kg-day) (Carson et al., 1986).

Research shows apparently critical levels of sodium ingestion that cause elevated blood pressure with age and hypertension in some people. Freis (1976) reported that with sodium intake below 227 mg per day (3 mg/kg-day for a 70-kg adult), hypertension was absent. In the range of 227 to 1591 mg per day (3 to 23 mg/kg-day for a 70-kg adult), a few cases of hypertension may appear, while in the range of 1590 to 8000 mg per day (23 to 114 mg/kg-day for a 70-kg adult), approximately 15 percent of adults would exhibit hypertension. When sodium intake rises above 8000 mg per day, hypertension may be found in about 30 percent of the population.

Because sodium chloride is present in nearly all processed and packaged foods, it is difficult to limit dietary sodium intake. In the United States, average daily intakes from dietary sources are often within a range where hypertensive effects occur. Drinking water generally contains relatively low levels of sodium; therefore, it does not contribute significantly 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 significant portion of daily sodium from drinking water. Because the kidneys are the major organs involved in regulating sodium balance, individuals with compromised kidney function may be placed on a low sodium diet. In addition, 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 to protect individuals on low sodium diets (Calabrese and Tuthill, 1977). This would limit the additional intake of sodium from drinking water to approximately 0.6 mg/kg-day for a 70-kg adult. Figure 5.8 summarizes the potential sodium health effects as a function of dose.

5.1.9 Sulfate

Absorption

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

Tissue accumulation and retention

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

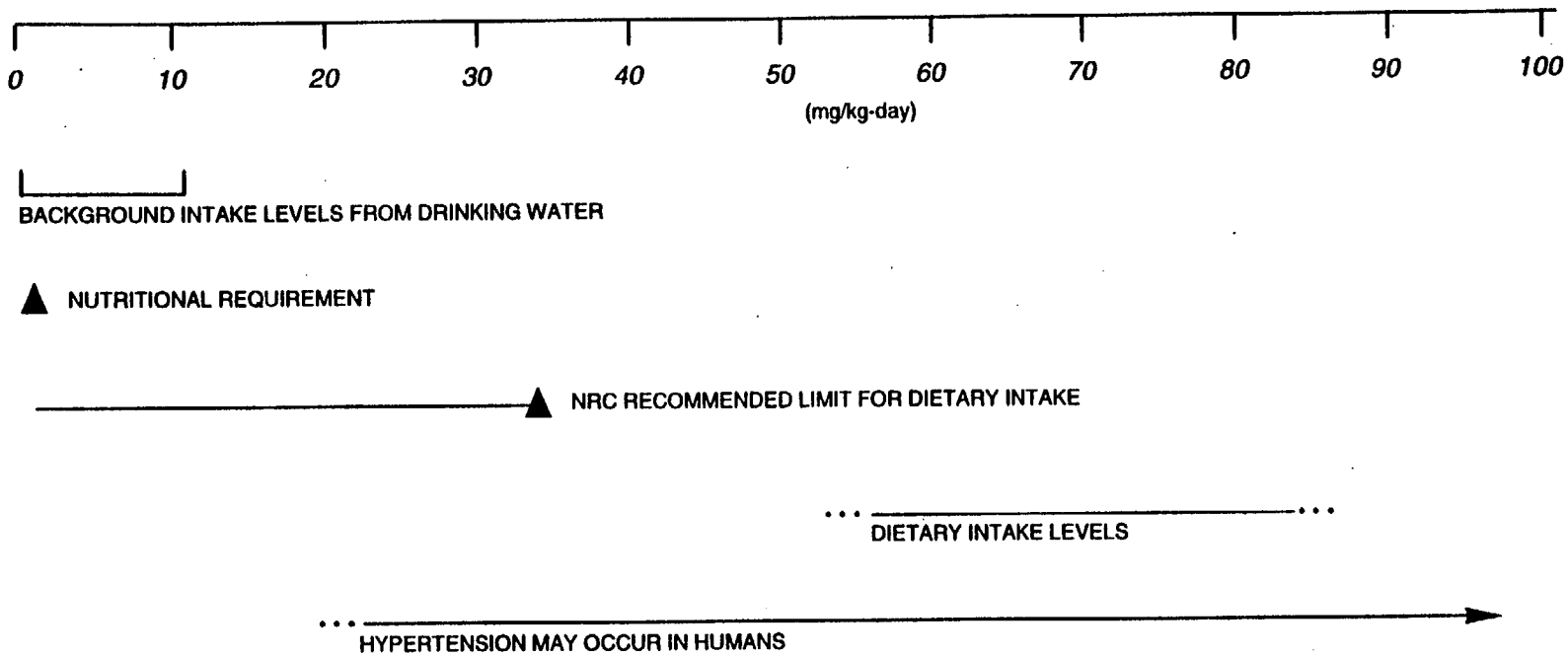


FIGURE 5.8
SODIUM TO[illegible]Y RANGES

MAC: SITE/LKV/BRA/SODITOX

Sulfate is used in the biosynthesis of collagen, cartilage, and dentin and in the formation of 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, which enhances their excretion in the urine. Exposure to high concentrations of compounds that are conjugated with sulfate and excreted can produce a transient decrease in sulfate concentrations in plasma.

Environmental sources of sulfate

Drinking water in the western United States in 1978 showed a range of sulfate concentrations 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 0.000 to 2.9 mg/kg-day from drinking water in the concentration range found in the western United States. No estimates are available on sulfate intake from food sources.

Toxicity of sulfate

The acute and chronic effects of sulfate toxicity differ more in severity than in symptoms or mechanisms. Therefore, this discussion combines acute and chronic toxicities. There are no data to indicate a sulfate bioaccumulates with chronic exposure. Sulfate salts of magnesium and sodium are used medicinally as cathartics. The presence of 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 also is the basis of sulfate toxic effects.

Toxicity in humans primarily manifests as diarrhea; the severity of the diarrhea is dose-dependent. Chronic sulfate ingestion can result in persistent diarrhea, leading to ionic imbalances and dehydration similar to that seen with extremely high acute doses. When drinking water is contaminated with sulfate, the taste of the water may make it unpalatable and reduce consumption. However, this is not always the case. In regions such as Saskatchewan with high sulfate concentrations in the drinking water, 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 seem to be the population most susceptible to sulfate-induced diarrhea. Also, some data indicate diabetic and elderly populations with compromised kidney function may be more sensitive than healthy adults to the effects of sulfates (EPA, 1992a). Figure 5.9 summarizes these health effects as a function of dose.

Data on sulfate toxicity 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 by sampling their drinking water. Therefore, these data do not represent well-controlled studies where dosage ranges can be readily defined.

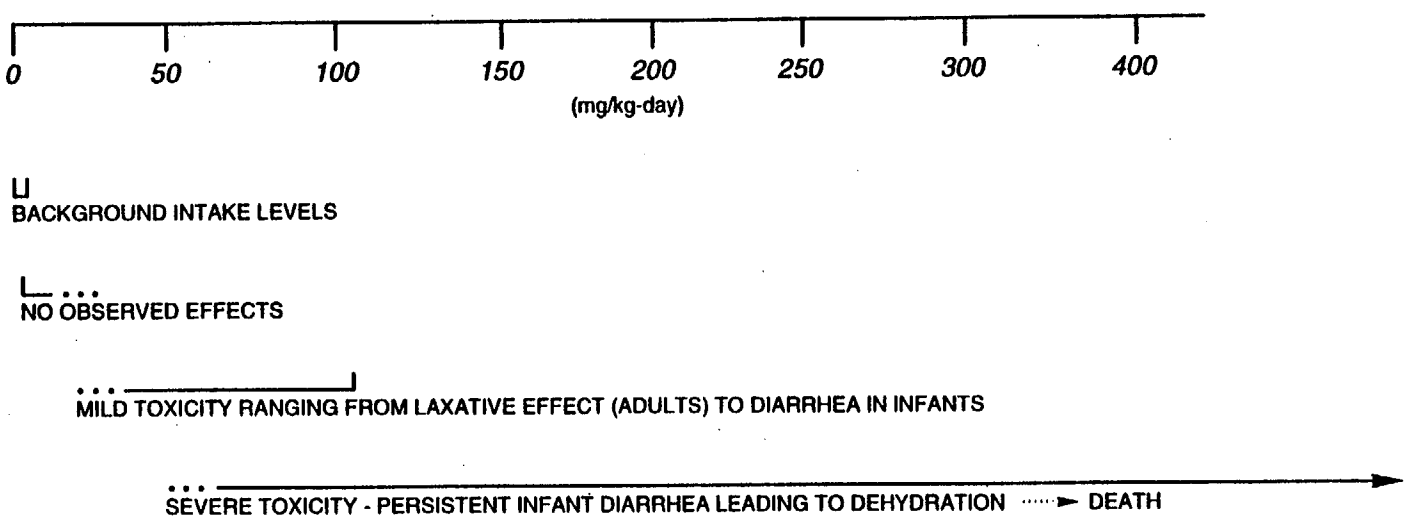


FIGURE 5.9
SULFATE T (ITY RANGES

MAC: SITE/LKV/BRA/SULFTOX

5.1.10 Uranium

Naturally occurring uranium present at UMTRA Project sites consists of three radioactive isotopes: uranium-234, uranium-235, and uranium-238. More than 99 percent of natural uranium occurs as 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, and other radioisotopes. Figure 5.10 summarizes the radioactive decay chain of uranium-238 and uranium-234. As all uranium isotopes in nature are radioactive, the hazards of a high uranium intake are from both its chemical toxicity and potential radiological damage. This section focuses on the chemical toxicity of natural uranium. 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). Even with soluble compounds, only a small fraction is absorbed. Wrenn et al. (1985) have determined human gastrointestinal absorption rates of 0.76 to 7.8 percent.

Tissue accumulation and clearance

In humans exposed to background 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 complexes with low-molecular-weight anions (e.g., bicarbonates, citrates), while the remaining 40 percent binds to the plasma protein transferrin (Stevens et al., 1980). Following oral exposure in humans, more than 90 percent of uranium is excreted in the feces and not absorbed in the gastrointestinal tract. Animal studies indicate that approximately 60 percent of the small amount that is absorbed (typically less than 5 percent) is excreted in the urine within 24 hours and 98 percent 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 averaged 1 pCi/L and 3 pCi/L, respectively (NCRP, 1984). The extent of absorption from

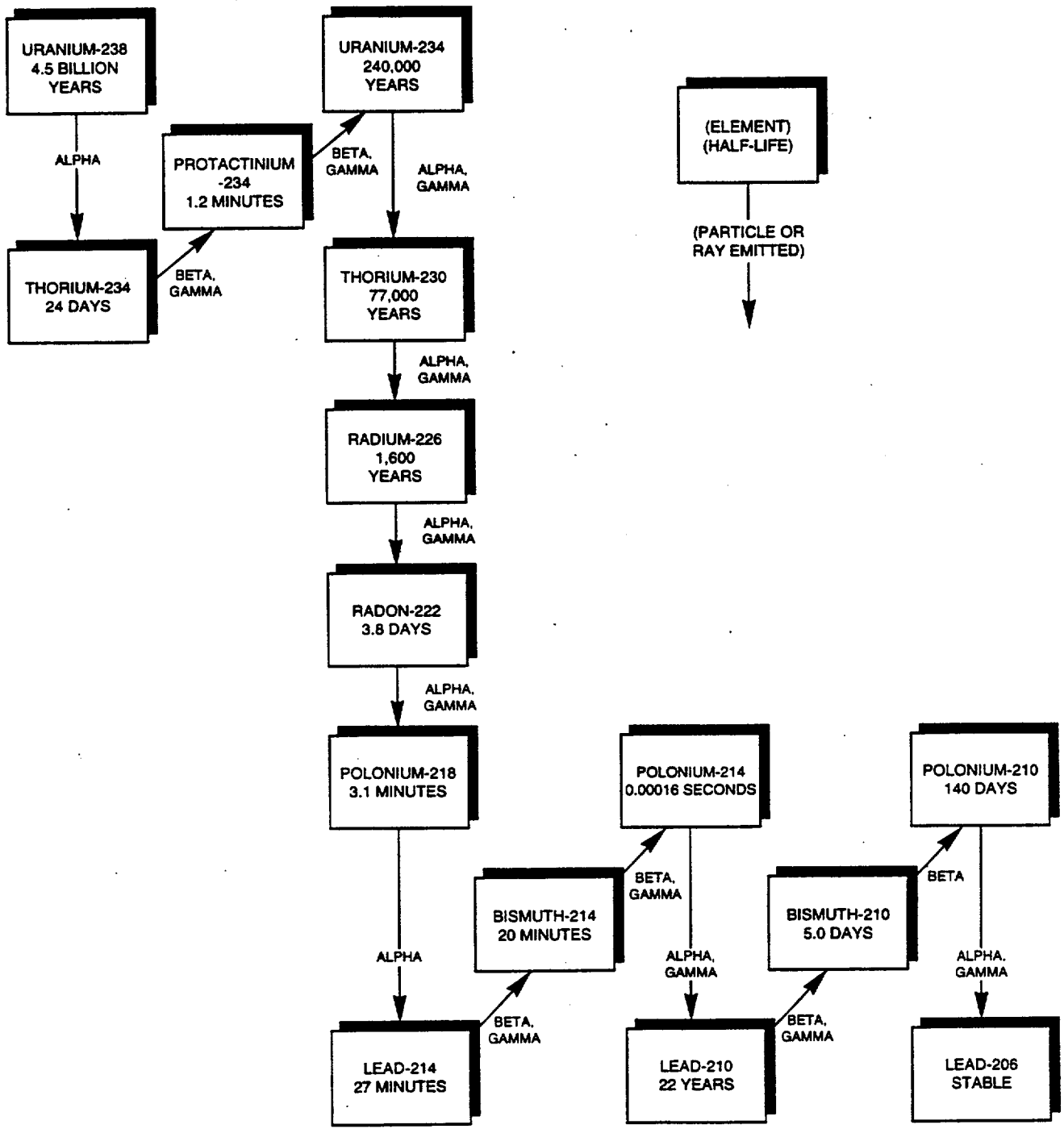


FIGURE 5.10
HALF-LIVES AND EMISSIONS FROM DECAY CHAIN OF URANIUM-238

soil into plant tissues depends on the plant species and the depth of its root system (Berlin and Rudell, 1986). Plant concentrations of uranium averaged 0.075 mg/kg of fresh plant material (Tracy et al., 1983).

The main dietary sources of natural uranium for the general population are food products such as potatoes, grains, meat, and fresh fish, which may contain uranium concentrations between 10 and 100 mg/kg (Prister, 1969). The total dietary uranium intake from the consumption of average foods is approximately 1 mg per day; approximately 20 to 50 percent of that total can come from drinking water. Cereals and vegetables, particularly root crops, are likely to contribute most to the daily uranium intake (Berlin and Rudell, 1986).

Toxicity of uranium

Exposing the general public to natural uranium is unlikely to pose an immediate lethal threat. No human deaths have been reported that are definitely attributable to uranium ingestion; therefore, no lethal dose has been determined for humans. In animals, lethal doses of uranium ($LD_{50,23}$) have been reported as low as 14 mg/kg-day following 23-day oral exposures, depending on the solubility of the uranium compound tested (higher solubility compounds have greater toxicity), route of exposure, and animal species. High doses of uranium cause complete kidney and respiratory failure.

Also, chronic toxic effects have not been reported in humans following oral exposure to uranium. Data available from populations occupationally exposed to high concentrations of uranium compounds through inhalation and data from studies on experimental animals indicate 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 are limited for the toxic effects of uranium on the human kidney.

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). Figure 5.11 summarizes the health effects for uranium as a function of dose.

5.2 CONSTITUENT INTERACTIONS

Some information is available on potential interactions between constituents found at UMTRA Project sites. However, discussions of potential interactions generally can be presented only qualitatively. In addition to individual physiological variables that can affect toxicity, uncertainties in interactions also result from 1) differences between the relative exposure concentrations of the different constituents and the concentrations tested experimentally; and 2) the presence of additional ground water constituents in sufficient quantities to modify predicted toxicities, even though these constituents are not considered constituents of potential concern for human health. Therefore, the interactions described below should be recognized as factors that can influence the

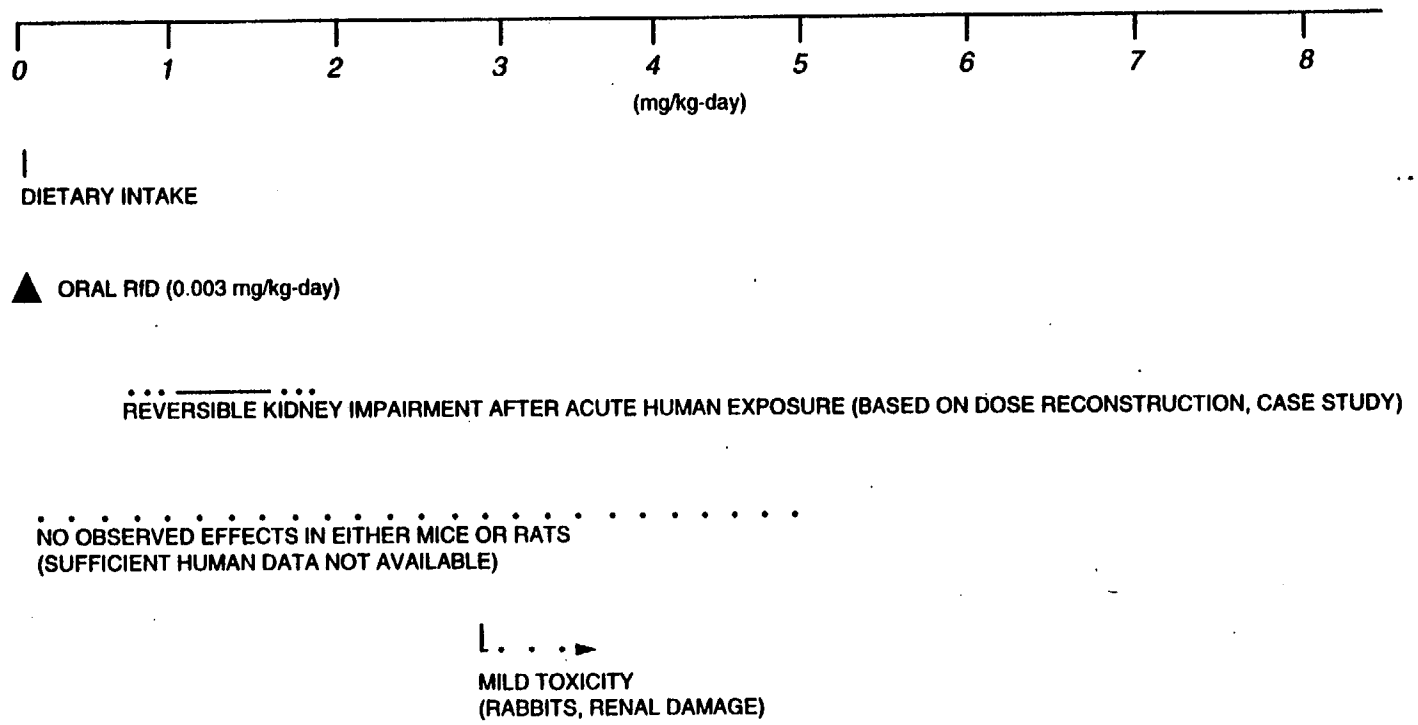


FIGURE 5.11
URANIUM T( )ITY RANGES

predicted toxicity, although the precise nature and magnitude of that influence cannot be determined.

Constituent interactions particularly between manganese and iron, are of the primary concern at the former Lakeview processing site. Excess manganese significantly decreases iron absorption and thereby impairs hemoglobin regeneration in the blood (National Research Council, 1980). However, excess iron inhibits the manganese absorption (Saric, 1986). Even though an excess of either contaminant can inhibit the absorption of the other, the net result of a significant excess of the two in combination is not clear.

Nickel has been found to interact with other heavy metals such as iron, chromium, magnesium, manganese, zinc, and cadmium. A relationship was reported between nickel and cobalt sensitization (DHHS, 1991). It has been suggested that nickel acts as a bioligant cofactor, facilitating the gastrointestinal absorption of iron. This interaction occurs only when the iron is present in the form of a ferric ion (DHHS, 1991). In the Lakeview ground water, most of the detected iron exists in the form of ferric ions (Table 3.7). Therefore, nickel in the soil at this site may affect iron absorption.

In animal studies, iron status affected uranium absorption (EPA, 1989b). No other information on uranium interactions with other metals has been found. However, the common target organ suggests interaction with nickel in the production of kidney toxicity. The carcinogenic effects of the radionuclides and arsenic probably combine at least additively.

5.3 CONSTITUENT RISK FACTORS

Table 5.1 summarizes the most recent oral RfDs for the noncarcinogenic contaminants of concern. RfDs for chloride, iron, polonium-210, sodium, and sulfate have not been determined.

The EPA currently classifies all radionuclides as Group A, or known human carcinogens, based on their property of emitting ionizing radiation and on evidence provided by epidemiological studies of radiation-induced cancer in humans. At sufficiently high doses, ironizing 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 dose and dose rates encountered in the environment. Most of the reliable data were obtained under conditions of high doses delivered acutely. It is not clear if cancer risks at low doses are dose proportional (i.e., the linear dose-response hypothesis) or if risks are greatly reduced at low doses and rates (the threshold hypothesis). A conservative assumption rejects the threshold hypothesis and assumes that any dose and dose rate add to the risk of cancer. Risk factors are published in HEAST and IRIS for correlating lifetime carcinogen intake with the increased excess cancer risk from that exposure. Table 5.2 gives the most recent cancer SFs for arsenic, polonium-210 and the uranium-234/-238 radioactive decay series.

Table 5.1 Toxicity values: potential noncarcinogenic effects

Chemical	Chronic oral RfD (mg/kg-day)	Confidence level	Critical effect/organ	RfD basis/RfD source	Uncertainty factor
Arsenic (inorganic)	3.0E-04	Medium	Keratosis, hyperpigmentation, vascular complications	Water/IRIS	3
Boron	9.0E-02	Medium	Testis	EPA, 1994a	100
Chloride	NA	NA	NA	NA	NA
Iron	NA	NA	NA	NA	NA
Manganese	5.0E-03	Not applicable	Central nervous system	Water/IRIS	30
Molybdenum	5.0E-03	Medium	Increased uric acid levels	Water/IRIS	30
Nickel (soluble salts)	2.0E-02	Medium	Decreased body weight (whole body and major organs)	Diet/IRIS	300
Polonium-210	NA	NA	NA	NA	NA
Sodium	NA	NA	NA	NA	NA
Sulfate	NA	High	Diarrhea	Water/NA	NA
Uranium (soluble salts)	3.0E-03	Medium	Kidney, decreased body weight	Diet/IRIS	1000

NA – not available.

Table 5.2 Toxicity values: potential carcinogenic effects

Parameter	Oral SF $(pCi)^{-1}$	Weight of evidence classification	Type of cancer	SF basis/ SF source
Arsenic[a] (inorganic)	1.8E+0[b]	A	Skin	Water/IRIS
Polonium-210	1.5E-10	A	Liver, kidneys, spleen	Water/HEAST
Uranium-234	4.44E-11	A	Note[c]	Water/HEAST
Uranium-238	6.2E-11	A	Note[c]	Water/HEAST

[a]SF based on oral unit risk of 5×10^{-5} (EPA, 1994a).
[b]In $(mg/kg\text{-}day)^{-1}$.
[c]No human or animal studies have shown a definite association between oral exposure to uranium and development of cancer.

Two potential sources of uncertainty are the following:

- Uncertainties associated with the relationship of an applied dose (used in this assessment) and an absorbed or effective toxic dose.

- Uncertainties associated with differing sensitivities of subpopulations such as individuals with chronic illnesses, which could alter predicted responses to constituents.

6.0 HUMAN RISK EVALUATION

To evaluate human health risks to an individual or population, the results of the exposure assessment are combined with the results of the toxicity assessment. As discussed in Section 5.0, potential adverse health effects are a function of how much of the constituent an individual takes into his or her body. Indeed, at lower levels some of the constituents associated with the mill tailings are beneficial to health, because they are essential nutrients (e.g., calcium and magnesium). At higher levels, these same elements can cause adverse health effects. Exposure doses from using site-related contaminated ground water within the plume as drinking water are evaluated by correlating potential exposure doses to expected adverse health effects (Sections 6.1 and 6.2).

6.1 POTENTIAL NONCARCINOGENIC HEALTH EFFECTS

The results from the exposure assessment showing either the highest intake-to-body-weight ratios (or highest doses) or the toxicologically most sensitive group are used to evaluate potential health effects for noncarcinogens. For the constituents of potential concern at the Lakeview site, the highest intake-per-body-weight group is children 1 to 10 years old. Because infants are the age group most susceptible to sulfate toxicity, infants are used to model potential health risks of sulfate ingestion.

The primary hazard to human health from ingesting contaminated ground water at the Lakeview site is exposure to sulfate, manganese, and to a lesser extent, chloride, iron, and molybdenum.

The potential range of sulfate exposure from drinking contaminated ground water lie in the range expected to produce mild toxicity exhibited by laxative effects in adults and severe persistent diarrhea in infants) (Figure 6.1). Diarrhea resulting from sulfate exposure could alter manganese excretion or reabsorption, although no data are available to evaluate this possibility. The toxic effects of sulfate for adults drinking this water would be less, because adults would be exposed to lower doses (per kilogram of body weight) and would be less sensitive to the effects.

Nearly all simulated exposures for manganese are greater than the EPA oral RfD and are greater than the levels that produce mild neurological symptoms; these symptoms often are similar to early Parkinson's disease. Approximately 85 percent of the distribution falls above levels that could result in more developed Parkinson-like effects with chronic exposure through drinking water (Figure 6.2).

A large portion (approximately 45 percent) of the simulated exposure range for iron is within normal dietary intake levels (Figure 6.3). The upper 40 percent of the simulated exposure range is above the dose that could produce chronic iron toxicity, including skin pigmentation, potential disruption of liver and endocrine

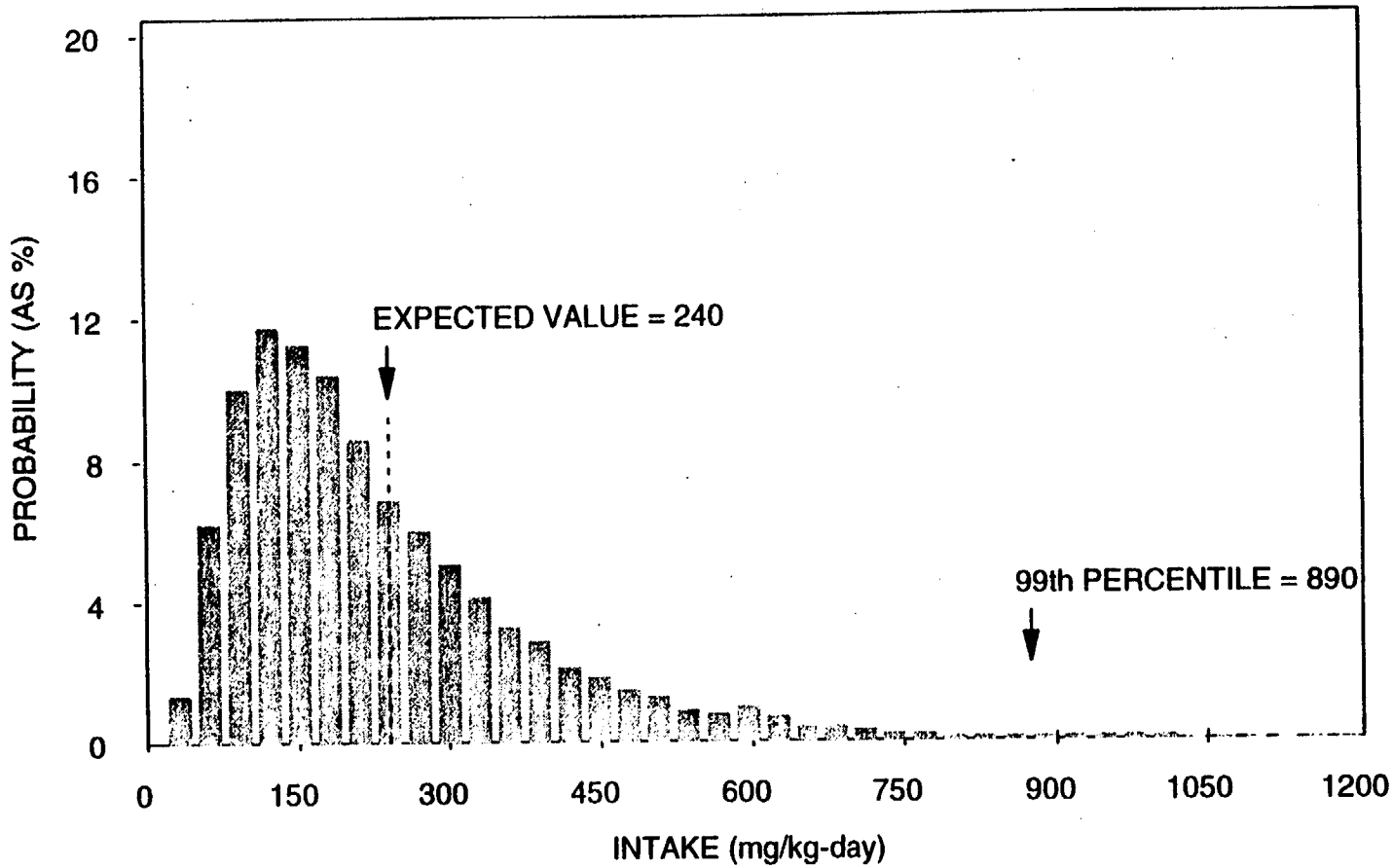


FIGURE 6.1
HEALTH EFFECTS OF POTENTIAL SITE EXPOSURE RANGES FOR INFANTS
LAKEVIEW, OREGON, SITE

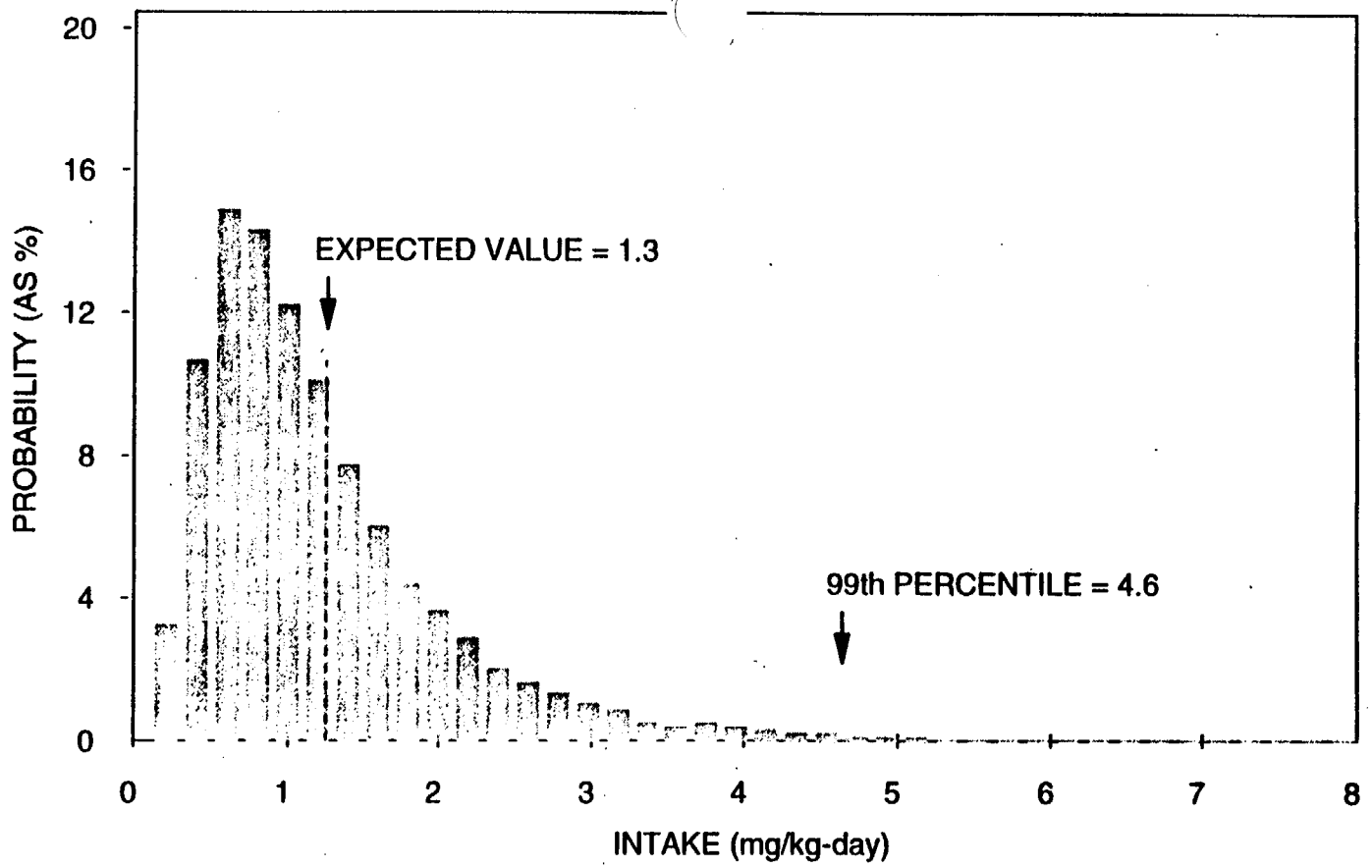


FIGURE 6.2
HEALTH EFFECTS OF POTENTIAL MANGANESE EXPOSURE RANGES FOR CHILDREN
LAKEVIEW, OREGON, SITE

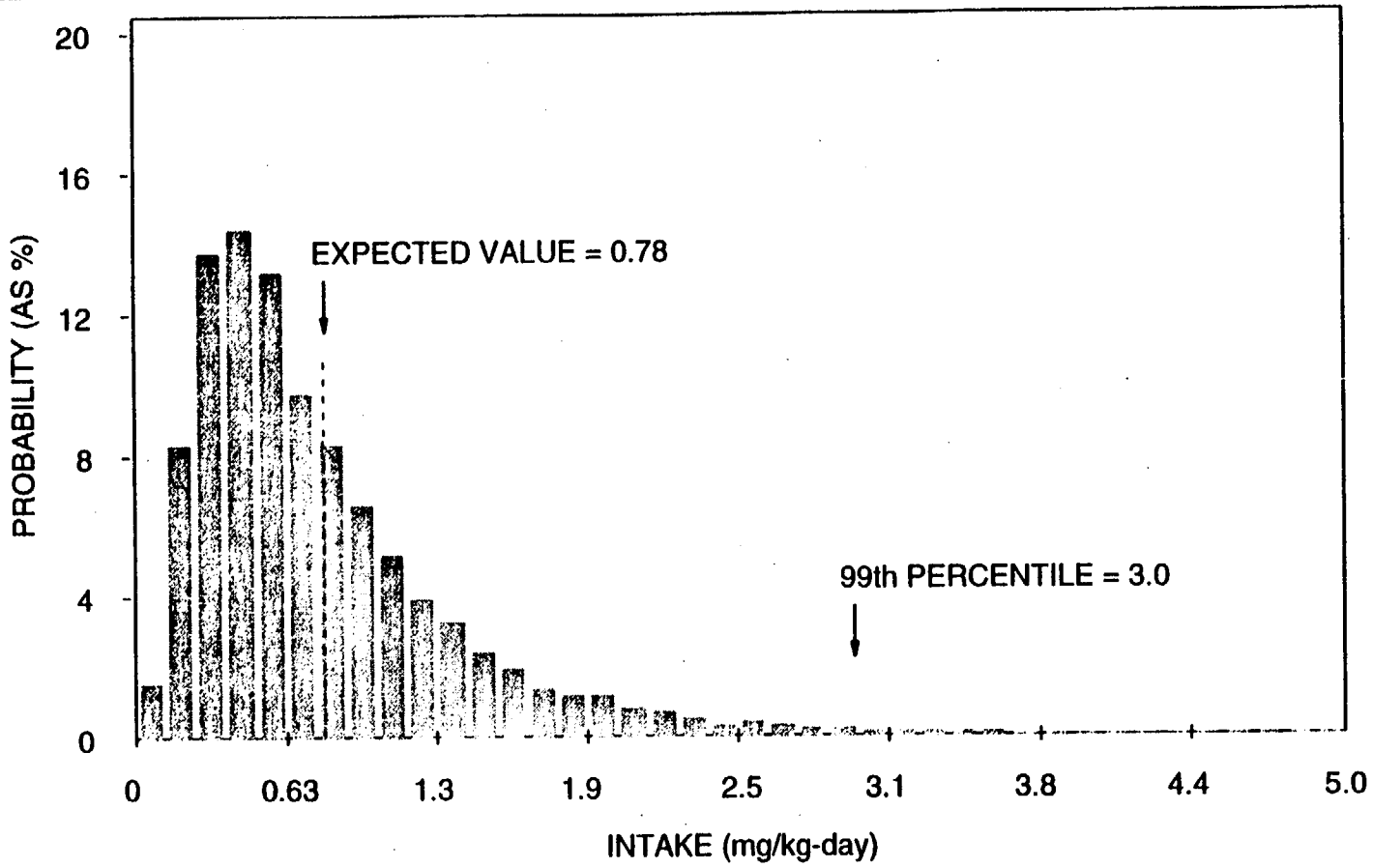


FIGURE 6.3
HEALTH EFFECTS OF POTENTIAL I[illegible] EXPOSURE RANGES FOR CHILDREN
LAKEVIEW, [illegible]EGON, SITE

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function, and, after long-term exposure, cirrhosis of the liver and/or development of diabetes. Based on geochemical modeling for the Lakeview site, almost all of the iron in this ground water is expected to be in the trivalent form, which is less readily absorbed (and therefore less toxic) than the divalent form.

Nearly the entire range (99 percent) of the simulated sodium intake falls above the level reported to cause hypertension and, in some people, kidney impairment (Figure 6.4).

Approximately 75 percent of the simulated molybdenum exposure range falls above the daily intake range that could be associated with mild toxicity manifested primarily by mineral imbalances (increased copper and uric acid excretion) (Figure 6.5). If these exposures increased by a 20 percent contribution from milk ingestion and by a 20 percent contribution from meat ingestion, the doses still would be within the dose range expected to result in mild toxicity. Even with these increased dose contributions, however, the predicted molybdenum intake would be well below the range reported to result in gout-like symptoms.

Most (approximately 90 percent) of the simulated chloride exposure range falls above the level associated with hypertension. However, 80 percent of the exposure range is within normal dietary intake levels (Figure 6.6).

All the simulated exposure range for nickel is below the oral RfD and would not be expected to adversely affect most people. For individuals sensitized to nickel, roughly 85 percent of the potential exposure range has been reported to result in allergic dermatitis, even with oral exposure (Figure 6.7).

For the noncarcinogenic effects of uranium, the entire exposure distribution falls below the oral RfD and below ranges resulting in adverse effects in animal studies (Figure 6.8). Although animal data are not always predictive of human toxicity, the lack of human data to evaluate oral toxicity of uranium at these concentrations should not suggest that toxic effects will not occur. RfDs incorporate safety and uncertainty factors and therefore are generally conservative values designed to protect human health. However, they are based on careful evaluation of existing databases; therefore, exposures that significantly exceed an RfD should be considered potential problems.

For the noncarcinogenic effects of arsenic, nearly all the simulated exposure range (from ingesting contaminated ground water) is within the range associated with normal background intake levels (Figure 6.9). A very small portion (less than 0.5 percent) of the exposure range simulated here has been associated with skin pathology and arterial thickening.

No adverse health effects have been reported for any of the simulated boron intakes, even though a large portion of the intake range exceeds the oral RfD (Figure 6.10).

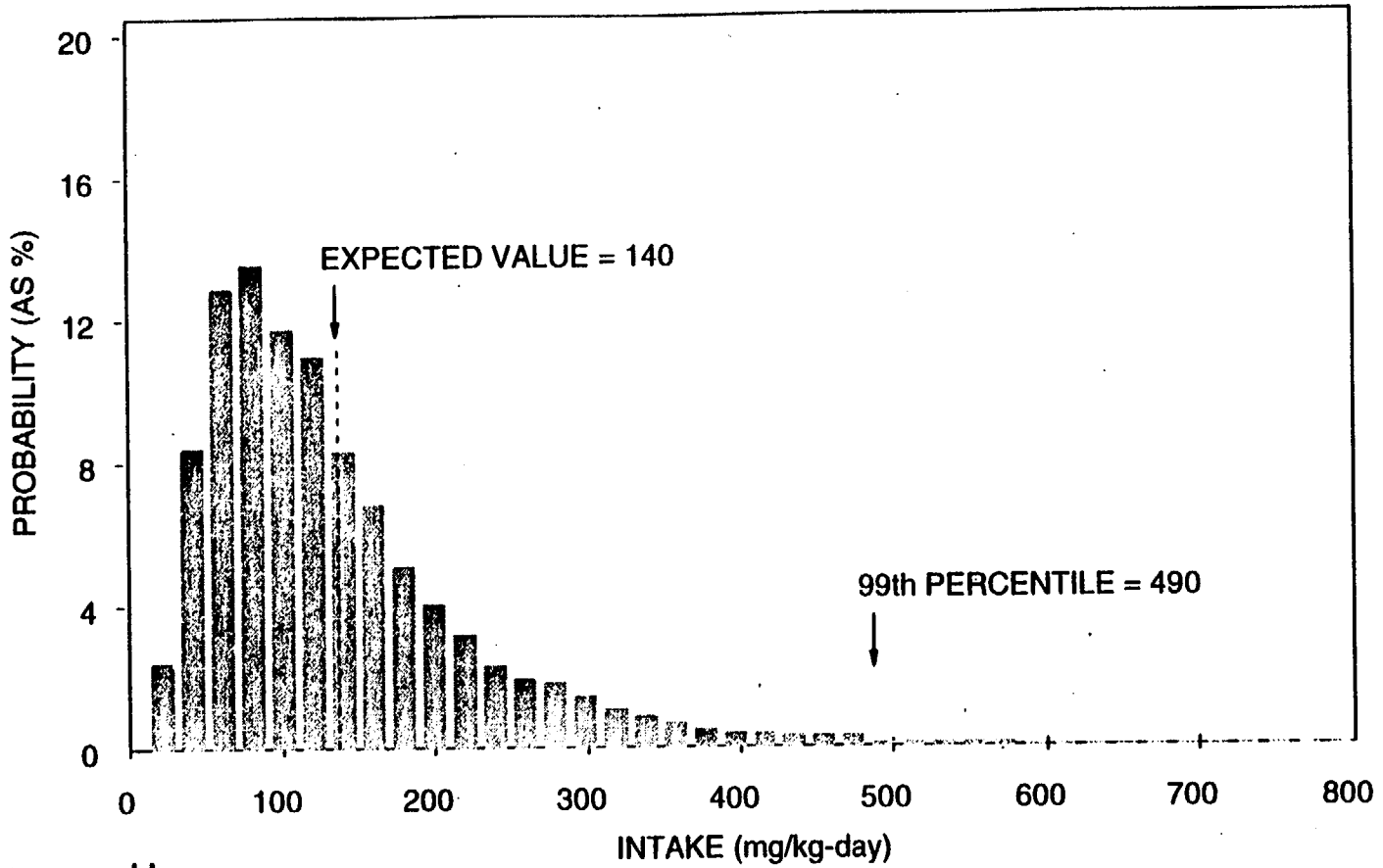


FIGURE 6.4
HEALTH EFFECTS OF POTENTIAL SODIUM EXPOSURE RANGES FOR CHILDREN
LAKEVIEW, EGON, SITE

PATH I:\FL301\LKVBRA

SODIHLT.DRW

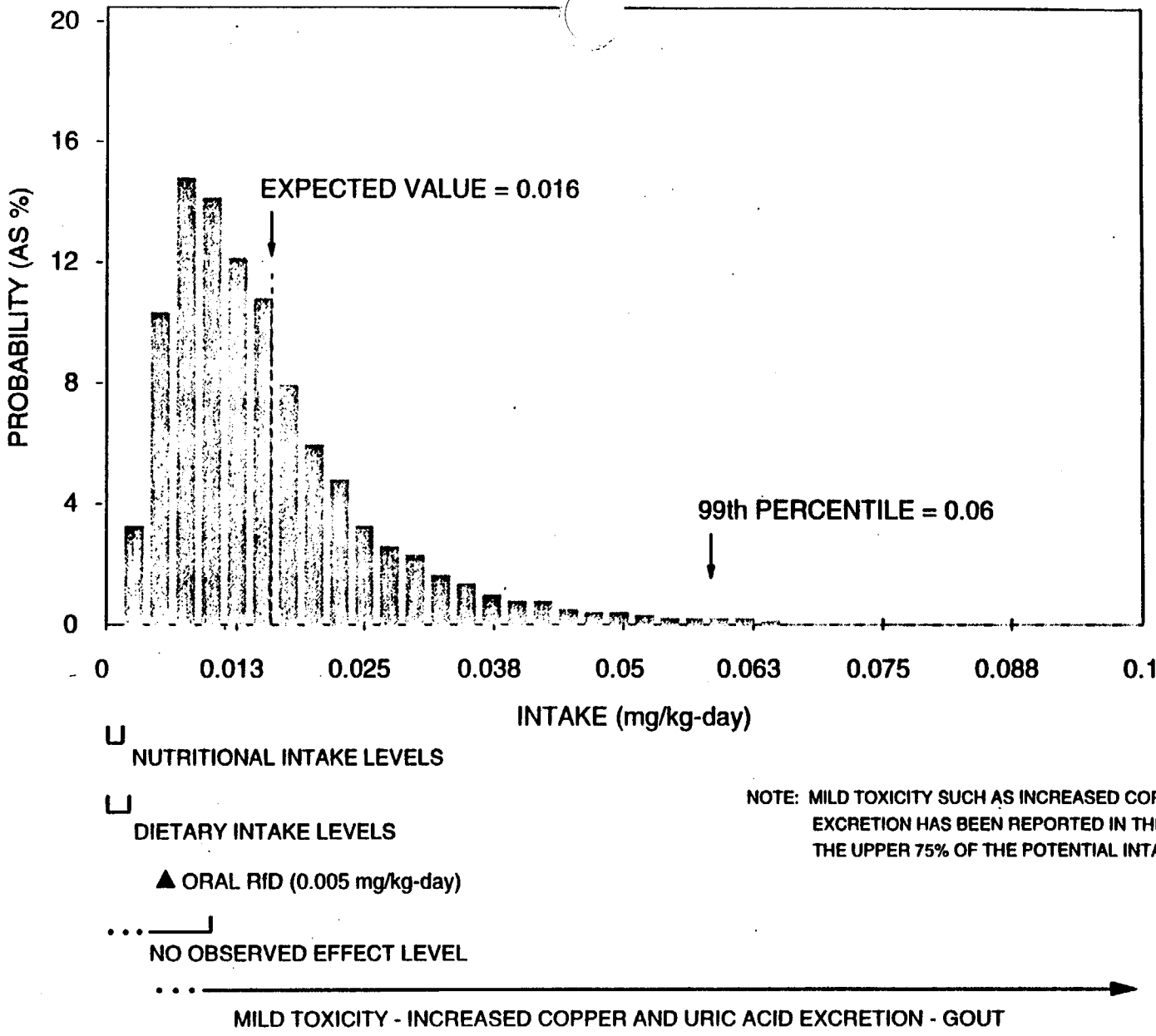
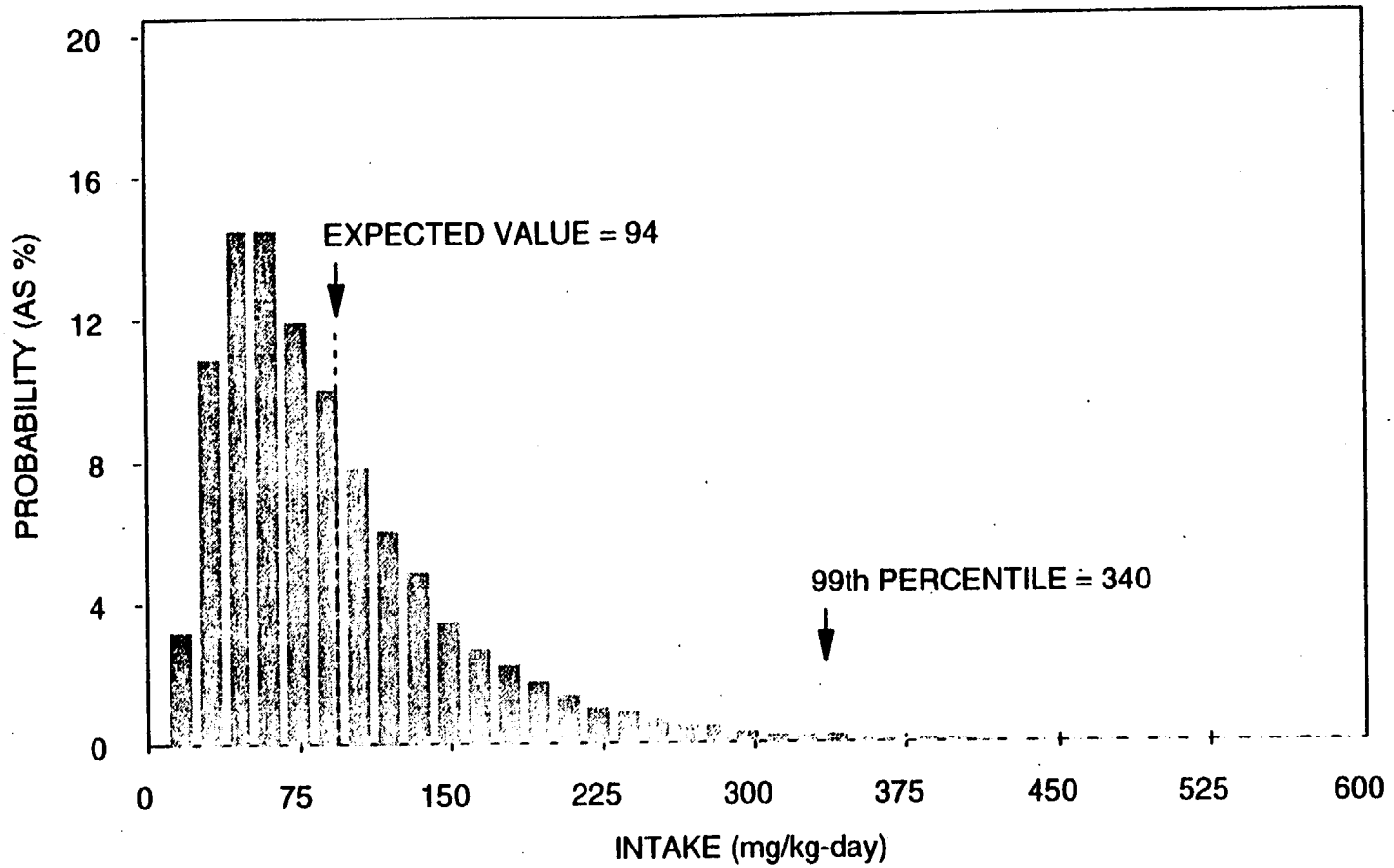


FIGURE 6.5
HEALTH EFFECTS OF POTENTIAL MOLYBDENUM EXPOSURE RANGES FOR CHILDREN
LAKEVIEW, OREGON, SITE

PATH I:\FL3.01\LKVBRA

MOLYHLT.DRW

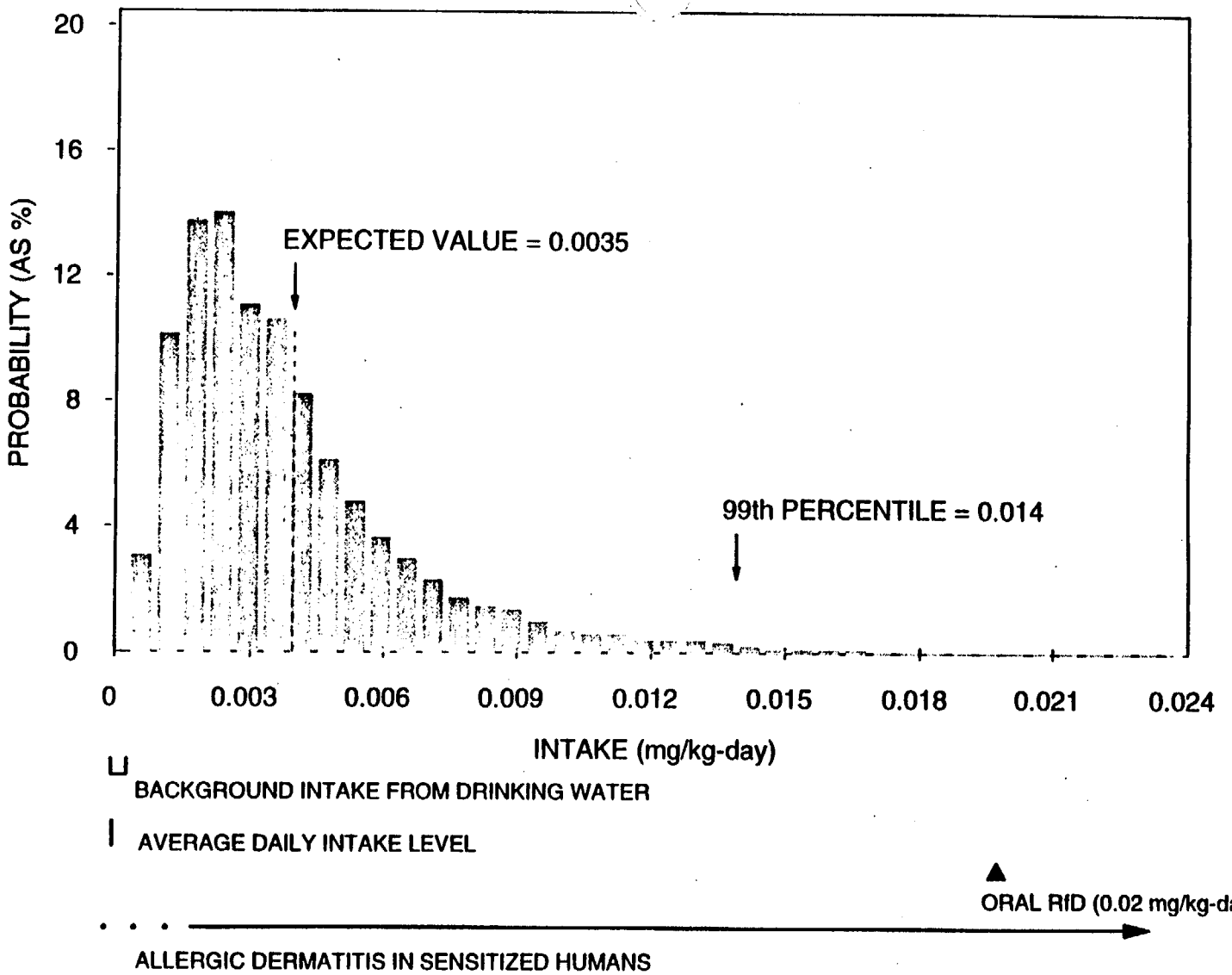


NOTE: ALTHOUGH A LARGE PORTION (APPROXIMATELY 90%) OF THE POTENTIAL INTAKES FALL ABOVE THE LEVEL WHERE HYPERTENSION HAS BEEN REPORTED IN THE LITERATURE, APPROXIMATELY 80% OF THE POTENTIAL INTAKES FALL WITHIN REPORTED DIETARY INTAKE LEVELS.

FIGURE 6.6
HEALTH EFFECTS OF POTENTIAL CHI[illegible]IDE EXPOSURE RANGES FOR CHILDREN
LAKEVIEW[illegible]EGON, SITE

PATH I:\FL3 01\LKVBRA

CHLHLT.DRW



NOTE: THE MAJORITY OF THE POTENTIAL INTAKES IN CHILDREN WOULD NOT BE ASSOCIATED WITH ADVERSE HEALTH EFFECTS IN NONSENSITIZED INDIVIDUALS. HOWEVER, A LARGE PORTION (APPROXIMATELY 85%) OF THE POTENTIAL INTAKES COULD RESULT IN ALLERGIC DERMATITIS IN SENSITIZED INDIVIDUALS.

FIGURE 6.7
HEALTH EFFECTS OF POTENTIAL NICKEL EXPOSURE RANGES FOR CHILDREN
LAKEVIEW, OREGON, SITE

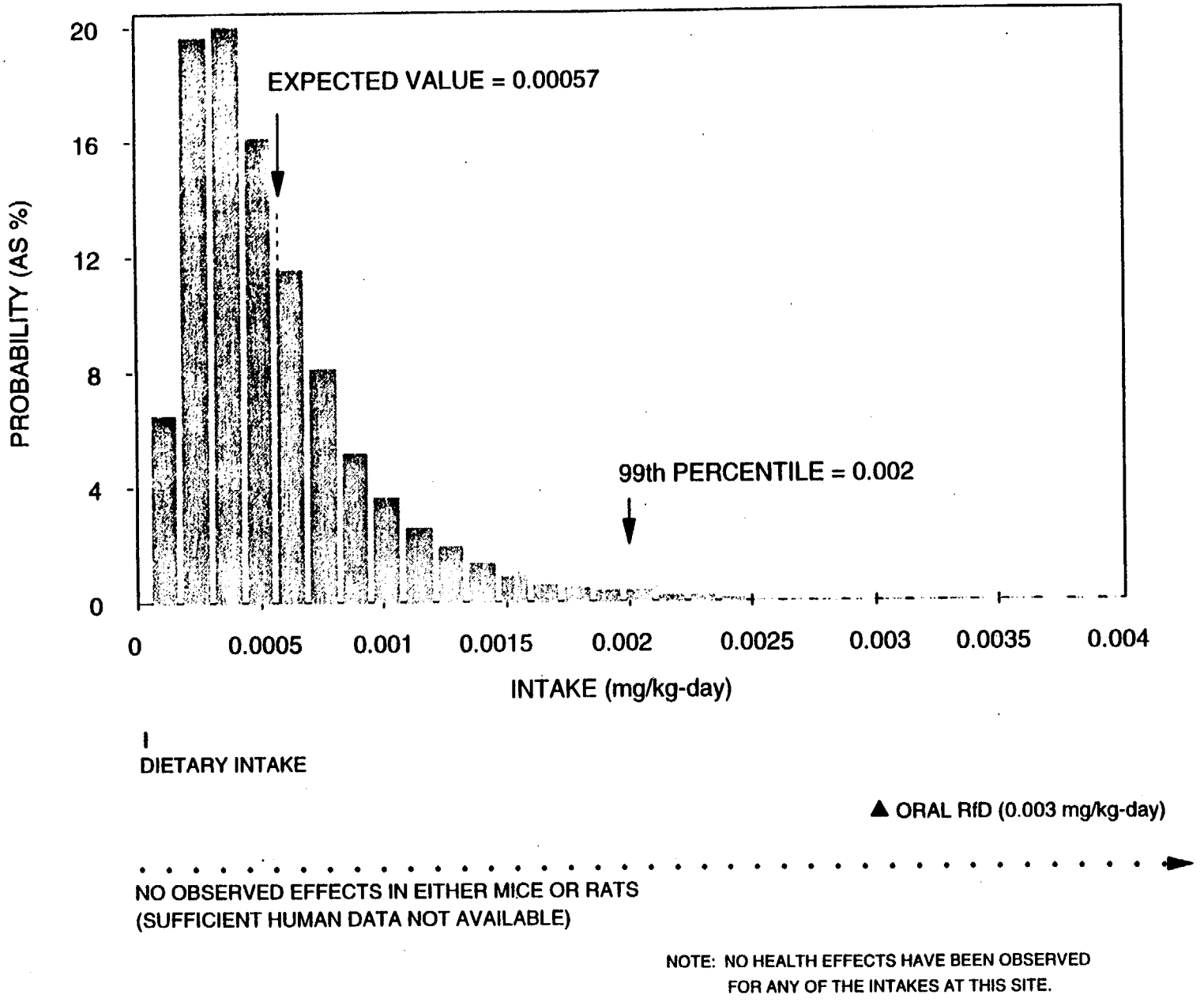
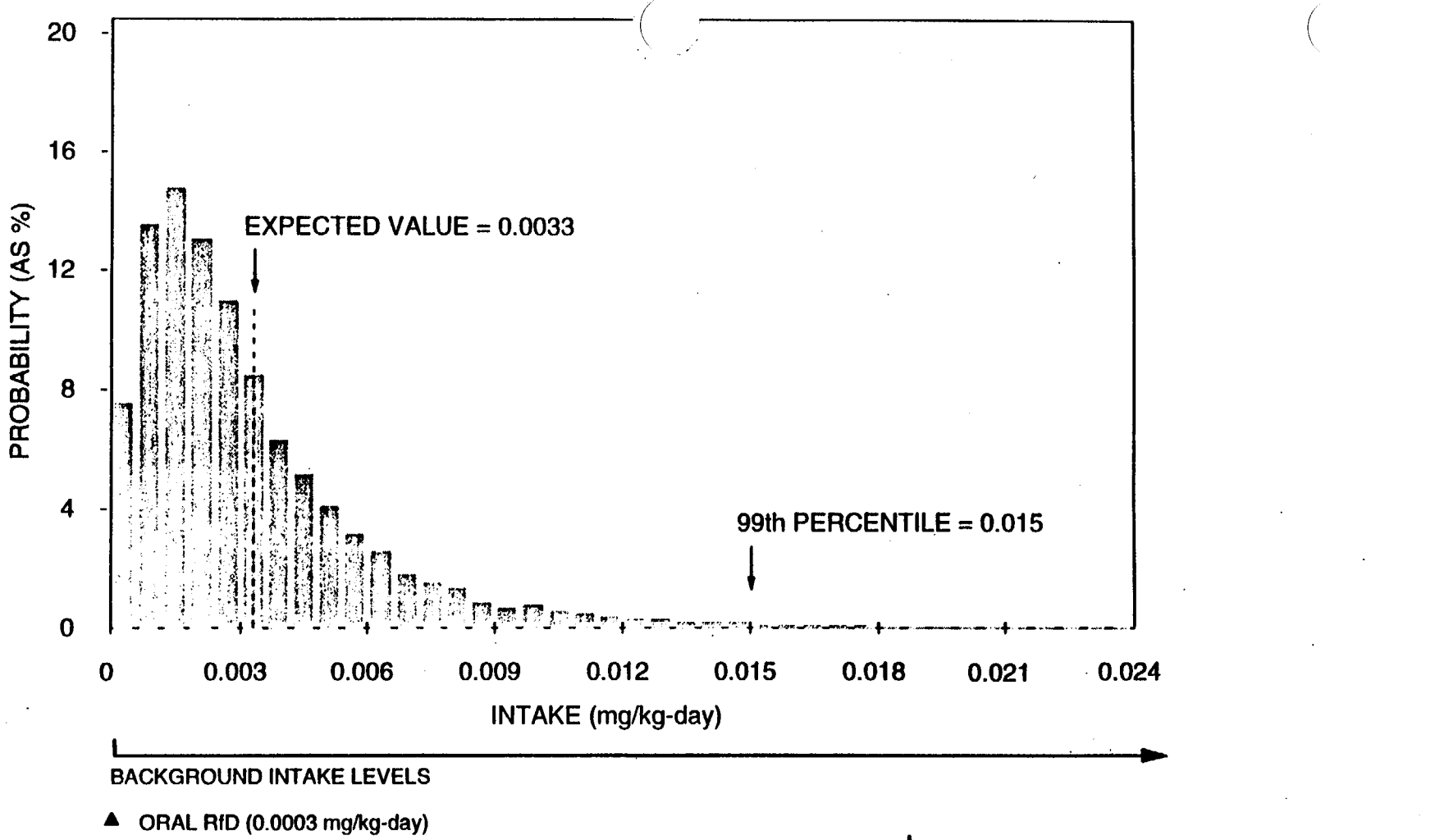


FIGURE 6.8
HEALTH EFFECTS OF POTENTIAL UR' 'M EXPOSURE RANGES FOR CHILDREN
LAKEVIEW EGON, SITE

URANHLT.DRW

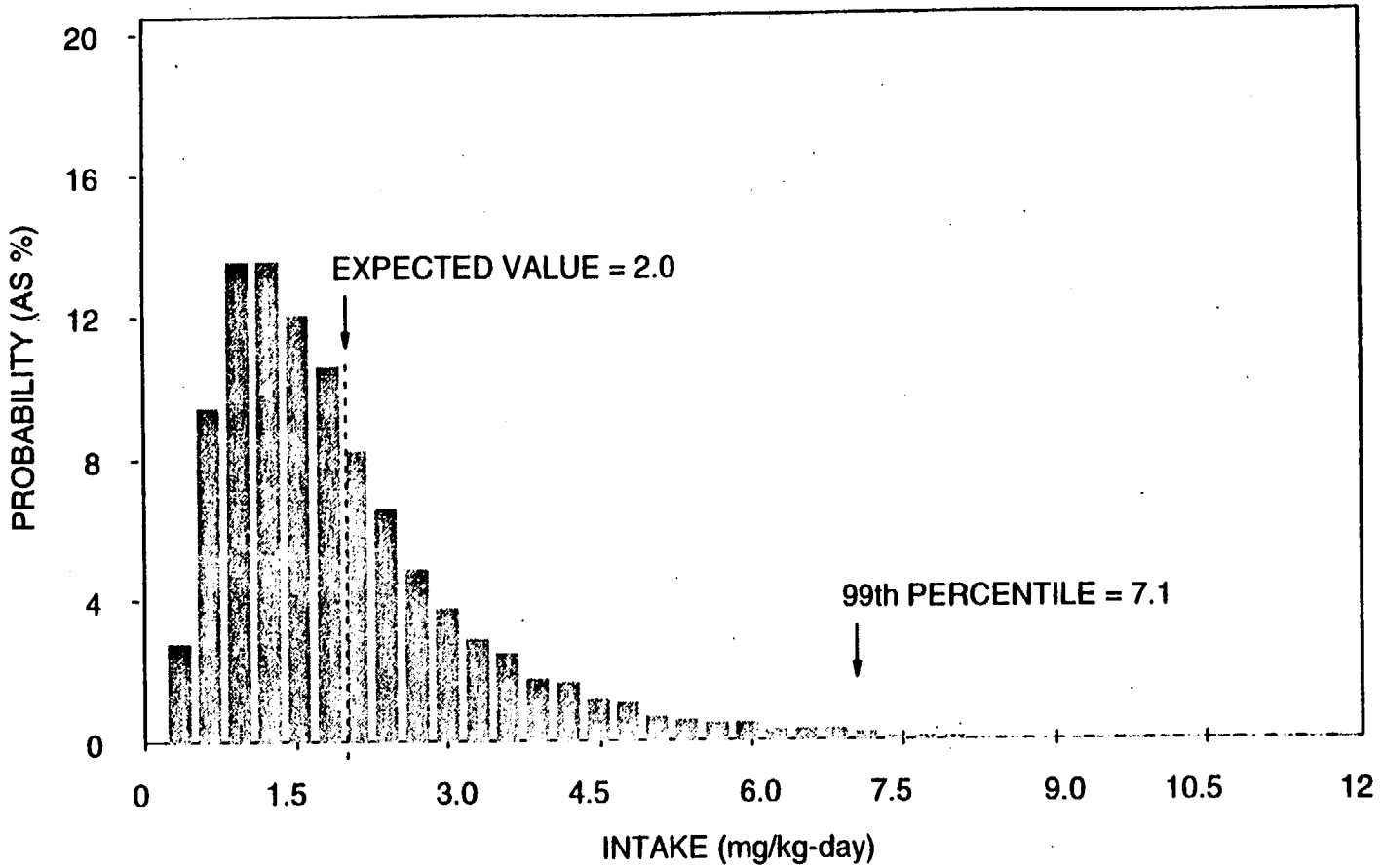


NOTE: ONLY A SMALL AMOUNT (LESS THAN 0.5%) OF THE POTENTIAL INTAKES IN CHILDREN COULD BE ASSOCIATED WITH SKIN PATHOLOGY AND CARDIOVASCULAR SYMPTOMS.

FIGURE 6.9
HEALTH EFFECTS OF POTENTIAL ARSENIC EXPOSURE RANGES FOR CHILDREN
LAKEVIEW, OREGON, SITE

PATH I:\FL3.01\LKVBRA

ARSHLT.DRW



NOTE: ALTHOUGH THE MAJORITY OF THE SIMULATED INTAKES FALL ABOVE THE ORAL RfD, NO ADVERSE HEALTH EFFECTS HAVE BEEN ASSOCIATED WITH THE SIMULATED INTAKES FOR BORON.

FIGURE 6.10
HEALTH EFFECTS OF POTENTIAL BORON EXPOSURE RANGES FOR CHILDREN
LAKEVIEW, OREGON, SITE

For each constituent of potential concern, the exposure contribution from the other pathways (dermal contact with ground water, ingestion of garden produce, and the ingestion of meat and milk from livestock) would be approximately 7 percent or less. The exception is molybdenum, where the exposure doses from the milk and meat pathways would be approximately 20 percent per pathway. These increases in the potential exposure for each constituent of potential concern would not significantly increase the risk over that predicted from the drinking water pathway alone.

As discussed in Section 5.2, physiologic interactions are likely among the numerous metal constituents at this site. These interactions are likely to alter 1) the absorption of some metals in the presence of others, resulting in competition for binding sites once absorbed; 2) the concentrations of binding proteins that often transport metals in the bloodstream and through cell membranes; and 3) the tissue distribution of individual metals. The complexity of these interactions and the number of metal constituents at Lakeview make it impossible to predict an increase or decrease in the toxicity of a given metal with the concurrent exposure to many other metals.

6.2 POTENTIAL CARCINOGENIC HEALTH EFFECTS

All uranium isotopes are radioactive and, as such, are considered potential carcinogens. Arsenic is not radioactive but is carcinogenic due to its chemical properties. Table 6.1 predicts the individual excess lifetime cancer risk from exposure to arsenic and the two radionuclide constituents of potential concern (polonium-210 and uranium) through ingesting contaminated ground water at the Lakeview site. These estimates are based on the cancer SFs developed by the EPA; however, ingesting natural uranium has not been demonstrated to cause cancer in humans or animals. The individual excess lifetime cancer risk estimates for polonium-210 and uranium are within the range recommended by the National Contingency Plan (NCP) of 1E-04 and 1E-06. The individual excess lifetime cancer risk for arsenic is 2E-03, which exceeds the range recommended by the NCP. Summing the risks for the radionuclides calculated in Table 6.1 to one significant figure, the excess cancer risk estimate from ground water ingestion is 1E-04 , which is within the recommended range.

6.3 EVALUATION OF GROUND WATER FROM PRIVATE WELLS

The potential for arsenic, chloride, iron, manganese, molybdenum, sodium, and sulfate to cause adverse health effects is evaluated (except for manganese) by comparing the total exposure doses (Table 4.5) to the toxicity ranges that are presented in Section 5.0.

The results of the evaluation show that manganese would have the greatest potential to cause adverse health effects. The total manganese dose of 0.2 mg/kg-day, from dermal absorption and ingestion of water through cooking, falls in the range where early neurological symptoms such as irritability, speech

Table 6.1 Excess lifetime cancer risk calculations for ground water ingestion by a hypothetical future adult resident, Lakeview, Oregon, site

Constituent of potential concern	Concentration in ground water[a]	Ground water exposure dose[b]	Oral SF	Excess lifetime cancer risk[c]
	UCL	UCL	(mg/kg-day; pCi)$^{-1}$	UCL
Arsenic	0.11	1.0E-03	1.8E+0	2E-03
Polonium-210	8.5	2.9E+05	3.26E-10	9E-05
Uranium	14	4.9E+05	5.32E-11[d]	3E-05
			Total radionuclide risk:	1E-04

[a]Concentrations in milligrams per liter for arsenic and in picocuries per liter for polonium-210 and uranium.
[b]Exposure doses in milligrams per kilogram per day for arsenic and in picocuries per lifetime for polonium-210 and uranium.
[c]Calculated by multiplying the exposure dose by the slope factor (SF). The SF is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen.
[d]Uranium isotopes -234 and -238 are averaged for this calculation.

Notes:
1. UCL is the upper 95 percent confidence limit on the mean.
2. Ingestion rate: 2 L per day.
3. Exposure frequency: 350 days per year.
4. Exposure duration: 30 years.

disturbance, and compulsive behaviors could be expected to occur. The estimated amount of chloride that could be associated with hypertension in sensitive individuals is in the range of 36 to 180 mg/kg-day. Ingesting chloride in water used to cook with (10 mg/kg-day) would not appreciably increase the potential for hypertension in sensitive individuals. However, the effect of chloride doses from sources other than water, e.g., meat and milk, 47 and 36 mg/kg-day, respectively, where the exposure doses are higher than in water, cannot be predicted at this time because of little research data in this area.

Noncarcinogenic adverse health effects would not be expected if all of the exposure doses are combined for arsenic, molybdenum, sodium, and sulfate. Also, the total carcinogenic risk estimate (8E-05) falls within the acceptable risk range of 1E-04 to 1E-06.

As stated in Section 4.2, the evaluation of the private wells is conservative because of the conservative assumptions. It was assumed that the people would get all of their garden produce, meat, and milk from their own garden or livestock and ingest the constituents for 350 days per year for 30 years, concurrently. Using these assumptions likely overestimates the true risks associated with using the ground water from these wells.

6.4 LIMITATIONS OF RISK EVALUATION

The following potential limitations apply to interpretations of this risk evaluation:

- One of the primary limitations associated with this risk assessment is the uncertainty of the actual constituent concentrations underneath the site. Several factors add to this uncertainty. There are no data regarding constituent concentrations underneath the site since 1988. However, downgradient concentrations indicate constituent concentrations have not changed. Therefore, the highest historical levels of site-related constituents statistically above background were used in this risk assessment. If the concentrations beneath the site actually have decreased, this risk assessment potentially overestimates risk of ingesting ground water as drinking water at this site.

- This risk assessment evaluates only risks related to inorganic ground water contamination. Potential contamination with any of the organic constituents used in uranium processing is not addressed here.

- Except for individuals sensitized to nickel by previous nickel exposure and infants exposed to sulfate, subpopulations that might have increased sensitivity to specific constituents are not specifically addressed on the graphs.

- Uncertainties are associated with the derivation of the toxicity values (RfDs and SFs). Derivations for these values intentionally overestimate rather than underestimate risk.

- Data available to interpret potential adverse health effects are not always sufficient to allow accurate determination of all health effects (i.e., lack of testing in humans or testing of dose ranges other than those expected at this site).

- Only the drinking water exposure pathway has been considered in depth, although other pathways were screened to determine their contribution.

This evaluation incorporates these limitations and compensates wherever possible by presenting toxicity ranges rather than point estimates, incorporating as much variability as could be reasonably defined. The impacts of these potential limitations is discussed more fully in Section 8.2.

7.0 LIVESTOCK AND ENVIRONMENTAL EVALUATION

The objective of the environmental portion of this risk assessment is to determine if constituents detected at the Lakeview site have the potential to adversely affect biological communities at or in the area surrounding the site. This section describes the qualitative methodology used to evaluate the ecological risk at the site (EPA, 1989b). 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 consists of four increasingly complex phases: identifying potentially exposed habitats (phase 1); collecting analytical data from potentially affected media such as surface water and sediment (phase 2); collecting biological samples such as plant and animal tissue (phase 3); and toxicity testing (phase 4). If the early phases of the assessment indicate constituents may be adversely affecting the ecological receptors, a higher level of analysis may be warranted. However, if the early phases of the evaluation indicate little or no potential for ecological risk, the assessment likely will be complete.

This ecological evaluation is a screening level assessment of the risks associated with the Lakeview site, using only phases 1 and 2. This approach compares constituent concentrations in environmental media to aquatic life criteria and guidelines for sediment, vegetation, wildlife, livestock watering, and crop irrigation. The comparisons determine if the constituents of potential concern potentially threaten ecological, livestock, and agricultural receptors.

It should be noted that sources of uncertainty in the ecological assessments can arise from limited analyses of media, limited toxicological information, and the inherent complexities of the ecosystem. In addition, methods of predicting nonchemical stresses such as drought, biotic interactions, behavior patterns, biological variability (differences in physical conditions, nutrient availability), and resiliency and recovery capacities are often unavailable. Therefore, it often is difficult to determine if constituents can affect the biological component of an ecosystem and to predict adverse effects to the ecosystem.

7.1 EXPOSURE CHARACTERIZATION

The potential exposure pathways associated with the Lakeview site are discussed below. For risk to exist, a receptor must be exposed to constituents. The evaluation of limited data for surface water and sediment in Section 3.6 suggests surface water has not been discernibly impacted and the levels of constituents detected above background in sediment could reflect the natural variation associated with drainage areas other than the site. However, the limited database creates uncertainly about the impact of site-related contamination on surface water and sediment. Therefore, constituent concentrations detected in these two media are evaluated for potential ecological impacts.

Currently, ground water is the only impacted medium at the site. Because the tailings pile and contaminated soil have been removed from the processing site, some direct exposure pathways (such as incidental soil ingestion, dermal contact

with soil, and inhalation of air containing particulates) do not represent an ecological concern and are not evaluated here. Other direct and indirect exposure pathways are possible at the site. Direct exposure pathways include ingesting surface water and sediments potentially affected by contaminated ground water or by particulate transport and constituent bioconcentration in surface water by aquatic organisms. Indirect exposure pathways include consumption of previously exposed organisms.

Bioconcentration is the net accumulation of a constituent by an organism directly from the surrounding environment. Net accumulation as a result of all routes of exposure, including diet, is known as bioaccumulation. Generally, bioconcentration is measured for chemical uptake from water by aquatic organisms. BCFs for ingestion of (and dermal contact with) soils are too variable and dependent on site conditions to make identification of generic soil BCFs possible.

The main surface water bodies in the site vicinity are Hunters Hot Springs, Warner Creek, Thomas Creek, and Hammersley Creek. These surface water bodies were evaluated in this screening assessment because they are potential exposure points for resident aquatic life and for terrestrial wildlife (including domestic animals) to come in contact with surface water and/or sediments.

Another potential current pathway is plant uptake of constituents in ground water. Due to the shallow depth to ground water in the site area (approximately 10 to 20 ft [3 to 6 m] or less below land surface), plant roots can reach contaminated shallow ground water. To evaluate plant uptake, the roots were assumed to reach soil saturated with ground water containing the mean concentrations of the constituents of potential concern in the most contaminated wells. Plant BCFs from the literature were used in the evaluation.

This screening assessment conservatively assumed a future private well could be placed at a location that intercepts the most contaminated ground water in the plume. The water from this hypothetical well could be used in a livestock watering pond (which could be stocked with fish) or to irrigate agricultural crops.

7.2 ECOLOGICAL RECEPTORS

Ecological resources present at the site and its vicinity that are potentially exposed to site-related constituents are identified below.

The following information on ecological receptors is based primarily on surveys conducted before tailings removal began; it provides an historical perspective (DOE, 1985b). Limited observations of aquatic organisms were conducted at the surface water and sediment sampling locations during the October 1993 qualitative field survey.

7.2.1 Terrestrial plant and animal communities

The Lakeview site is in the ecoregion known as the Intermountain Sagebrush Province. This semiarid region is in the rain shadow of the Cascade Mountains to the west. The natural vegetation type for the region is the ponderosa shrub forest (DOE, 1985b). The site is characterized primarily by introduced grassland vegetation. The site also has been colonized by desert saltgrass (*Distichlis spicata* var. *stricta*). Hammersley Creek is distinguished by a narrow riparian zone that traverses the former processing site.

Wildlife observed or determined to be present (based on habitat availability) are the coyote, red fox, mountain cottontail, and jackrabbit. Mule deer may occur irregularly as vagrants.

Bird species that may be in the site vicinity include the gray partridge, ring-necked pheasant, Canada goose, mallard, great blue heron, and a variety of small waterfowl such as cinnamon teal, blue-winged teal, and green-winged teal along the drainages. Although some nesting by these ducks (as well as mallards and perhaps other species) is possible, most waterfowl use probably occurs during migration. Raptors hunting across the open terrain of the site probably include red-tailed hawks, northern harriers, and short-eared owls as year-round residents, with rough-legged hawks and ferruginous hawks present in winter and several other species present as migrants or vagrants.

Reptiles at the mill tailings site probably are limited due to the small number of habitat types represented. A few amphibian species would be expected to breed along Hammersley Creek.

A complete list of the plant and animal species that have been observed or are characteristic of the Lakeview area is presented in Appendix F of the environmental assessment (DOE, 1985b).

7.2.2 Threatened and endangered species

Two species of plants in the state of Oregon are on the Fish and Wildlife Service (FWS) list of endangered and threatened plants. One plant is proposed for protected status, and 113 plants are under review for protected status (50 CFR Part 17; 45 FR 82480; 48 FR 53640). The Oregon Natural Heritage database, maintained for the state by the Oregon Chapter of the Nature Conservancy, indicates neither the two plant species listed as endangered nor the one plant species proposed for protected status occurs in or near the Lakeview site (Wolfin, 1985).

The only wildlife species listed by the FWS that are potentially present at the site are the American peregrine falcon (*Falco peregrinus anatum*) (endangered) and the bald eagle (*Haliaeetus leucocephalus*) (currently proposed as a threatened species) (50 CFR Part 17). Both species could occur as vagrants or

migrants because of the proximity to suitable habitat along nearby lakes and rimrocks.

7.2.3 Aquatic organisms

Quantitative surveys of aquatic organisms in the water bodies near the site were not conducted for this baseline risk assessment. A brief qualitative survey of the aquatic organisms was conducted near historic surface water sampling locations 605 through 609 and a new location, 613, which is in a pond near the former mill buildings. The following organisms were observed using a fine-mesh dip net at all water sampling locations: dragonfly and damselfly nymphs (*Odonata*), water striders (*Gerridae*), backswimmers (*Notonectidae*), midge larvae (*Chironomidae*), and unidentified water fleas (*Cladocera*). Fish were not observed at any location, due to the limited stream habitat. All the streams except the open water marshy areas in Hunters Hot Springs were shallow (less than 4 inches [10 cm] deep) and were channelized with no riffle/run areas or undercut banks.

7.3 CONSTITUENTS OF ECOLOGICAL CONCERN

The complete list of ground water constituent levels that exceed background levels was considered in assessing constituents of potential concern for ecological receptors potentially exposed to ground water (Table 3.6). Potential receptors and pathways include plants by uptake, livestock by watering, and fish stocked in a ground water-fed pond.

As discussed in Section 3.6, available data suggest that the surface water is not discernibly impacted by site-related contaminated ground water (Table 3.5). Therefore, no constituents were identified as ecological contaminants of potential concern for surface water. Also as discussed in Section 3.6, data indicate that sediments adjacent to and downstream of the site have higher levels of iron, manganese, and uranium than samples collected from Hunters Creek upstream of the site (Table 3.9). Therefore, these three constituents are identified as ecological constituents of potential concern for sediment.

7.4 POTENTIAL IMPACTS TO WILDLIFE AND PLANTS

7.4.1 Ground water

Concentrations of the constituents of potential concern in plant tissue were estimated using soil-to-plant BCFs. Soil concentrations in the saturated zone were estimated by multiplying the ground water concentration by the soil-water distribution coefficient (Kd). Table 7.1 presents the methodology and parameters used to estimate root uptake and plant tissue concentrations at harvestable maturity for the constituents of potential concern. This methodology is described in detail elsewhere in the literature (Baes et al., 1984) and therefore will not be presented here.

Table 7.1 Comparison of estimated plant concentrations to phytotoxic concentrations, Lakeview, Oregon, site

Constituent of potential concern	UCL concentration in ground water (mg/L)	Kd (L/kg)	Estimated soil concentration (mg/kg DW)	Soil-to-plant concentration factor		Estimated concentration in vegetative growth[a] (mg/kg DW)	Estimated concentration in fruits/tubers[b] (mg/kg DW)	Approximate concentration in mature leaf tissue that is toxic[c] (mg/kg DW)
				Bv	Br			
Arsenic	0.11	19	2.0	0.04	0.006	0.084	0.013	5-20
Boron	58	1.3	75	4	2	300	150	50-200
Chloride	3,000	0.25	750	70	70	52,500	52,500	NA
Iron	27	15	400	0.004	0.001	1.6	0.41	NA
Manganese	40	25	1,000	0.25	0.05	250	50	200[d]-1000
Molybdenum	0.46	120	55	0.25	0.06	14	3.3	10-50
Nickel	0.13	59	7.7	0.06	0.06	0.46	0.46	10-100
Sodium	3970	0.2	790	0.075	0.055	60	60	NA
Sulfate[e]	6860	0	NC	0.5	0.5	NC	NC	NA
Uranium	0.02	50	1.0	0.008	0.004	0.0085	0.004	NA
Radionuclide								
Polonium-210[f]	1.9E-12	15	2.9E-11	0.015	0.0015	7.1E-14	1.1E-14	NA

[a]Estimated concentration in vegetative portions, calculated as estimated soil concentration multiplied by Bv.

[b]Estimated concentration in nonvegetative portions, calculated as estimated soil concentration multiplied by Br.

[c]Concentrations are not presented for very sensitive or for highly tolerant plant species due to a general lack of data for these species (Kabata-Pendias and Pendias, 1992).

[d]The value of 200 mg/kg is a recommended criterion of the Illinois Institute of Environmental Quality (Saric, 1986).

[e]Bv and Br factors available for elemental sulfur only; thus, these factors were reduced by a factor of 3 for sulfate.

[f]The ground water concentration in picocuries per liter was converted to milligrams per liter.

Kd – soil-water distribution coefficient; from PNL (1989).
Bv – soil-to-plant elemental transfer factor for vegetative portions of food crops and feed plants (Baes et al., 1984).
Br – soil-to-plant elemental transfer factor for nonvegetative portions (e.g., fruits, tubers), of food crops and feed plants (Baes et al., 1984).
DW – dry weight.
NC – value cannot be calculated because Kd is zero.
L/kg – liters per kilogram.
A – not available.

No Kd, Bv, or Br values available for ammonium.

The estimated tissue concentrations for the constituents of potential concern in the vegetative portions (e.g., stems and leaves) and in the nonvegetative portions (e.g., fruits and tubers) of plants at harvestable maturity were compared to approximate concentrations in mature leaf tissue that were toxic to plants (phytotoxic) (Table 7.1). Data on phytotoxic soil concentrations of metals are available in the literature. However, for the metals of concern at this site, more data are available for phytotoxic tissue concentrations than for phytotoxic soil concentrations. As illustrated in Table 7.1, few available data relate tissue concentrations to phytotoxicity. The reported phytotoxic concentrations are not representative of very sensitive or highly tolerant plant species because most of the data are for agronomic crops (Kabata-Pendias and Pendias, 1992). The estimated tissue concentrations for boron in plants that may reach soil saturated with contaminated ground water exceed the available phytotoxicity data, while the estimated concentrations of manganese and molybdenum fall within the range reported to be phytotoxic. The estimated plant tissue concentrations for arsenic and nickel are below phytotoxic levels. For constituents without comparison data (chloride, iron, polonium-210, sodium, sulfate, and uranium) it is not possible to determine if the estimated tissue concentrations could adversely affect plants.

Bioaccumulation in terrestrial organisms as a function of constituents of potential concern in ingested plants or animals (for example, birds eating fish) is a potential exposure pathway at the site. Birds and other vertebrates consuming these plants and animals can bioaccumulate some constituents of potential concern if the amount of contamination ingested exceeds the amount eliminated. Bioaccumulation often is a function of the areal extent of contamination compared to the areal extent of an animal's feeding range. When the contaminated area is small, the amount of food in the diet usually exceeds the impacted food, and bioaccumulation is not a concern. Therefore, while exposure through diet is possible for all food chain species in certain areas (e.g., wetlands), the potential for bioaccumulation is not always a concern.

Biomagnification is more severe: the constituent concentration increases in higher levels of the food chain because the constituent concentrations accumulate through each successive trophic level. Biomagnification effects are of particular concern for the top predators, especially carnivorous birds and mammals. Only a limited number of metals (e.g., mercury and selenium) have the potential to magnify in the food chain (EPA, 1989b; EPA, 1991). None of the metals detected in media at this site represent a significant biomagnification concern. Available data suggest low potential for the constituents of potential concern to represent a concern via food chain transfer.

To evaluate the potential impact on wildlife of using contaminated ground water in a livestock pond (i.e., animals drinking from the pond or fish stocked in the pond), the UCL ground water concentrations for the constituents of potential concern were compared to available comparison water quality criteria (Table 7.2). Neither federal nor state criteria or standards have been established to protect terrestrial wildlife from exposure to contaminated water. Therefore, it is

Table 7.2 Comparison of constituents of potential concern in ground water with available water quality values, Lakeview, Oregon, site

Constituent of potential concern	UCL concentration in ground water	Aquatic life water quality value[a]	Concentration in irrigation water protective of plants[b]	Water concentration protective of livestock[b]
Arsenic	0.11	0.048	0.10	0.20
Boron	58	1.0[c]	0.75	5.0
Chloride	3000	230[d]	NA	NA
Iron	27	1.0	5.0	NA
Manganese	40	NA	0.20	NA
Molybdenum	0.46	50 (0.79)[e]	0.010	NA
Nickel	0.13	1.6[f]	0.20	NA
Polonium-210	8.5 pCi/L	NA	NA	NA
Sodium	3960	NA	NA	NA
Sulfate	6860	NA	NA	1000[g]
Uranium	0.02	31[h]	NA	NA

[a]From ODEQ (1992), unless specified otherwise. These values are standards protective of aquatic life via chronic exposure.
[b]From EPA (1972), unless specified otherwise. Values shown are for water used continuously on all soils.
[c]No state or federal water quality value available. Value presented is the current boron criterion recommended by the FWS for the protection of aquatic life (Eisler, 1990).
[d]No state water quality value available. Value presented is the Federal Water Quality Criterion for the protection of freshwater aquatic life via chronic exposure (EPA, 1992b).
[e]No state or federal water quality value available. Value presented is the current molybdenum criterion recommended by the FWS for the protection of aquatic organisms, with the exception of newly fertilized eggs of rainbow trout, which are sensitive to molybdenum concentrations above 0.79 mg/L (Eisler, 1989).
[f]Water-hardness-related state standard (ODEQ, 1992). Criterion presented was calculated using the median hardness (milligrams per liter) determined from concentrations of calcium and magnesium in the plume wells (Table 3.2).
[g]From National Research Council (1971).
[h]No state or federal water quality value available. Value presented is the state of Colorado's chronic water quality standard for uranium (CDH, 1991). This is a hardness-dependent standard.

Concentrations reported in milligrams per liter unless otherwise noted.
NA – not available.

difficult to evaluate the potential hazards to terrestrial receptors. However, surface water quality values for the protection of freshwater aquatic life are available and include state of Oregon standards (ODEQ, 1992).

UCL ground water concentrations for arsenic, boron, chloride, and iron exceeded the comparison aquatic life water quality values (Table 7.2), indicating this water would be unacceptable for aquatic organisms. Ground water concentrations for molybdenum, nickel, and uranium were below the comparison values. No comparison water quality values are available for manganese, polonium-210, sodium, and sulfate.

Another future hypothetical use of contaminated ground water in the area is crop irrigation. Table 7.2 compares the approximate concentrations in irrigation water that should be protective of plants (EPA, 1972). The EPA developed these approximate irrigation water concentrations to protect agricultural crops from toxicity associated with constituent buildup in the soil. Six constituents of potential concern (arsenic, boron, iron, manganese, molybdenum, and nickel) have comparison values. The UCL ground water concentrations for all these inorganics exceed the comparison values, with the exception of nickel. No comparison values are available for the remaining constituents of potential concern. Thus, it is not possible to evaluate the potential for these compounds to adversely affect plants through irrigation water.

Based on the available information, using contaminated alluvial ground water near the site (containing the UCL concentrations) as a continuous source of irrigation water could adversely affect crops, primarily because of the elevated concentrations of arsenic, boron, iron, manganese, and molybdenum.

However, the DOE is sponsoring an irrigation and plant growth study at the University of Arizona to determine the uptake of manganese, molybdenum, uranium, and selenium by three plants (sudan grass, carrots, and squash). The measurement of uptake can be used to assess potential exposure doses of inorganics from animal or human consumption of plants. In addition, to study the toxicity of these inorganics to the plants themselves (phytotoxicity), changes in dry-weight biomass is measured.

Preliminary results are available (Baumgartner, 1995). No effect was observed in sudan grass and carrots up to a manganese concentration in irrigation water of 31 mg/L (the highest treatment level). The squash biomass is reduced slightly at the highest level of exposure of 31 mg/L, indicating a small degree of phytotoxicity. Phytotoxicity was not observed for molybdenum in any of the plant species up to the highest treatment level of 2.56 mg/L. Additionally, phytotoxicity was not observed for uranium in any of the three plant species up to the highest treatment level of 5 mg/L. These results suggest that the EPA guidance values used for the preceding evaluation of manganese and molybdenum may be overprotective. However, the UCL concentration for manganese at this site is 40 mg/L, where some phytotoxic response could be observed.

The sodium hazard is a basic criterion in evaluating irrigation water quality. Sodium concentrations can contribute to the total salinity of an irrigation water and may be directly toxic to sensitive crops. However, the primary concern with elevated sodium concentrations is the adverse effect on soil characteristics (e.g., increase in colloidally absorbed sodium, resulting in hard compact soil). The sodium hazard of water is expressed as the sodium adsorption ratio (SAR), which is calculated as the proportion of sodium to the total of calcium and magnesium in the water. Using the 95 percent UCL ground water concentrations for sodium, calcium, and magnesium, an SAR of 50 was calculated. This SAR is well above the upper SAR limit of 10 (Follett and Soltanpour, 1985). Water with a SAR value greater than 10 should not be used as the sole source of irrigation water for long periods of time.

7.4.2 Sediments

There are no established state or federal sediment quality criteria (SQC) for the protection of aquatic life for the constituents of potential concern (iron, manganese, and uranium) at this site (EPA, 1988; NOAA, 1990). There are no guidelines for iron, manganese, and uranium.

Many of the constituents that exceed background ground water quality have not been monitored in sediments from water bodies in the site vicinity. Thus, their potential threat to the ecological environment cannot be evaluated at this time.

7.5 POTENTIAL IMPACTS TO LIVESTOCK

Ingestion of vegetation that may have bioconcentrated constituents from alluvial ground water is a potential exposure route for livestock. However, without actual plant tissue concentrations or exposure and toxicity information for livestock, this potential exposure route cannot be evaluated.

It is possible that contaminated ground water could be used in the future to provide water for livestock. To evaluate the potential impact to livestock in this future scenario, the UCL ground water concentrations for the constituents of potential concern were compared to drinking water concentrations considered protective of livestock (Table 7.2). The UCL ground water concentrations exceed the comparison water quality guidelines for boron and sulfate, while the arsenic UCL concentration is below the guideline. The boron ground water concentration (58 mg/L) is more than 10 times the livestock drinking water value (5 mg/L). Sulfate was detected in ground water at the UCL concentration of 6860 mg/L. This level is above the value (1000 mg/L) that can cause diarrhea in cattle (National Research Council, 1971; Church, 1984).

No livestock drinking water guidelines have been reported for the remaining constituents of potential concern. However, the available information suggests that the use of ground water as a source of drinking water for livestock would be hazardous due to elevated levels of boron and sulfate.

7.6 LIMITATIONS OF THE ECOLOGICAL RISK ASSESSMENT

This qualitative evaluation of potential ecological risks is a screening level assessment of the risks associated with potential exposure of plants and animals to contaminated ground water at the Lakeview site. Sources of uncertainty in any ecological assessment arise from the monitoring data, exposure assessments, toxicological information, and inherent complexities of the ecosystem. In addition, methods of predicting nonchemical stresses such as drought, biotic interactions, behavior patterns, biological variability in physical conditions and nutrient availability, and resiliency and recovery capacities are often unavailable. In general, limitations for the Lakeview ecological risk assessment include the following:

- Only a small amount of ecological data were collected during this screening.
- Many of the constituents that exceed background ground water quality levels have not been measured in surface water or sediments from the water bodies in the site vicinity.
- Land adjacent to the site is used for pasture. Due to the shallow depth to ground water at and downgradient of the site, plant roots might access contaminated ground water. However, because little is known about uptake rates of plant site-specific constituents, this potential exposure pathway was not evaluated. Additionally, because of the lack of plant tissue data, the potential effect on livestock could not be evaluated.
- Only limited ecotoxicological reference data are available.
- Site-specific biota tissue analysis has not been conducted.

7.7 SUMMARY

Recent surface water data from the water bodies near the site indicate the constituent concentrations detected at adjacent locations from the Lakeview site were not elevated relative to the background location. This suggests that site-related constituents have not adversely affected the quality of the surface water bodies in the site vicinity.

Three constituents (iron, manganese, and uranium) detected in the sediments exceed background concentrations. However, no state or federal sediment quality guidelines for the protection of aquatic life are available to evaluate these constituents.

Available data and criteria indicate potential hazards to plants at harvestable maturity that may have roots in contact with soil saturated with the most contaminated ground water in the alluvial/lacustrine aquifer. The concentrations

of boron, and possibly of manganese and molybdenum, could cause phytotoxicity following accumulation in plant tissue. Additionally, this ground water would not be suitable for continuous long-term use as irrigation water for crops due to the elevated levels of arsenic, boron, iron, manganese, molybdenum, and sodium.

This ground water would also not be suitable as a long-term source of drinking water for livestock due to the adverse effects associated with elevated levels of boron and sulfate. Water from the most contaminated wells in this aquifer would not be suitable as a source of water (e.g., a pond) for fish to live in.

Available surface water, sediment, and ground water data indicate that the constituents of concern detected in media at the site have a low potential to threaten the food chain of terrestrial and aquatic wildlife (via bioaccumulation and biomagnification). However, tissue from biota (e.g., invertebrates and plants) has not been analyzed.

Insufficient water quality and sediment quality values were available to allow a comprehensive and statistical evaluation of the impact of surface water, sediment, and contaminated ground water on ecological receptors. However, available data show no compelling evidence that the surface water and sediment of the drainage features near the site are affected by former milling activities at the Lakeview site.

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 Lakeview site to evaluate the potential occurrence of these hazards.

Currently, no uses of site-related contaminated ground water by human receptors have been identified at the Lakeview site. However, shallow ground water is used in the Lakeview area for domestic purposes such as drinking, bathing, and cooking. Additionally, ground water in this area is used for agricultural purposes such as forage crop irrigation and livestock watering, although the current use of contaminated ground water for these purposes has not been identified. Surface water is used primarily for irrigation in the former site area. Access to site-related contaminated ground water at and downgradient of the site is possible, thereby providing potential future exposure routes to site-related contaminated ground water.

This risk assessment is a conservative estimate of risk to human health at the Lakeview site because ground water data from the most contaminated part of the shallow on-site zone were used. Additionally, with the uranium mill tailings (the source of the contamination) removed, contaminated ground water at this site will tend to disperse and dilute (although slowly), thereby reducing exposure concentrations over time.

8.1.1 Human health

If the site-related contaminated ground water in the shallow zone is used for drinking water in the future, potential adverse human health effects could occur.

Serious adverse health effects could result from nearly the entire range of potential exposures to sulfate, manganese, and sodium, as well as from the upper range of potential exposures to iron. The individual excess lifetime cancer risk of arsenic (2 in 1000) is at a level that exceeds the NCP's upper-bound criterion of 1 increased chance in 10,000 of developing cancer. However, the total carcinogenic risk from the radionuclides uranium and polonium-210 fall at the NCP criterion of 1 increased chance in 10,000 of developing cancer.

8.1.2 Ecological

The ground water would not be suitable as a long-term source of drinking water for livestock, due to the adverse effects of sulfate and boron. In addition, the site-related contaminated ground water would not be acceptable as a water source for fish habitat (e.g., a ground water-fed pond) or as a source of continuous irrigation water for agricultural forage crops and other plants.

Available surface water data from water bodies in the site vicinity suggest contaminated ground water from the site has not adversely affected surface water. Three constituents (iron, manganese, and uranium) detected in the sediments exceed background concentrations. However, no state or federal sediment quality guidelines for the protection of aquatic life are available to evaluate these constituents.

8.2 LIMITATIONS OF THIS RISK ASSESSMENT

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

- One of the primary limitations associated with this risk assessment is the uncertainty of the actual constituent concentrations underneath the site. Several factors add to this uncertainty. There are no data regarding constituent concentrations underneath the site since 1988. However, downgradient concentrations indicate constituent concentrations have not changed. Therefore, the highest historical levels of site-related constituents statistically above background were used in this risk assessment. If the concentrations beneath the site actually have decreased, this risk assessment potentially overestimates risk of ingesting ground water as drinking water at this site.

- This document evaluates risks associated with exposures only to inorganic constituents of ground water at the UMTRA Project site near Lakeview. Potential organic constituents (those few related to uranium processing) have not been considered.

- In general, the results presented in this document are based on filtered (0.45-micron) water samples. Unfiltered data were used for arsenic. Filtration effects vary with different elements; filtered samples can have somewhat lower or equal concentrations than unfiltered samples for some constituents. Constituents in suspension may be lost with filtration but still can produce toxic effects if ingested and broken down in the acidic environment of the stomach.

- Constituent toxicity varies from person to person. Normal variability in biochemical factors among individuals, differences in medical history, previous exposure to toxicants, and dietary and exercise habits all affect susceptibility to chemical toxicity. Chemicals also exert different toxic effects at different exposure levels. Because it is not possible to account for all sources of variability and still present useful and meaningful analyses, specific subpopulations of individuals known to be more sensitive to toxic effects of given constituents have been noted.

To assess toxicity, standardized reference values developed by agencies such as the EPA are used to determine plant uptake, tissue concentrations in livestock,

and toxic effects in humans. These reference values themselves have limitations, including the following:

- Toxicity, uptake, and bioconcentration data are not available for all constituents elevated above background levels at the site.

- In some cases, 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.

- Data used to determine toxicity generally are based on exposure only to the constituent of concern. In reality, exposures generally occur simultaneously to several chemicals. The interactive effects of multiple constituents and the toxicological impacts of these interactions generally cannot be accurately assessed from existing data.

- Considerable effort has been directed at determining plume movement and placing monitor wells in locations that capture maximal contamination. Nevertheless, physical systems and models used to determine contaminant plume migration vary widely and may result in well placements that do not measure the highest constituent concentrations or determine the fullest extent of plume impact.

- 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. The use of multiple samples should introduce high confidence in the reliability and validity of the collected data.

- The drinking water pathway is considered the major determinant of exposure in this assessment. Although other pathways were screened and determined not to contribute significantly to the total exposure, the additivity of exposure from these pathways should be kept in mind.

By presenting ranges of toxic effects, summaries of available data on health effects and interactions, and outlines of potential limitations, this document provides a reasonable interpretation of potential health risks associated with ground water contamination at this site. This assessment presents both contamination and risk as accurately as possible, based on available data, and conveys areas of uncertainty.

8.3 GROUND WATER CRITERIA

In 1983, the EPA established health and environmental protection standards for the UMTRA Project (40 CFR Part 192); the EPA final rule ground water standards for the UMTRA Project were published on 11 January 1995 (60 FR

2854). These standards consist of ground water protection standards to evaluate disposal cell performance and ground water cleanup standards for existing contamination at processing sites. The constituents that have MCLs are summarized in Table 8.1. While the standards apply only to the UMTRA Project, the EPA also has published drinking water health advisory levels for both long- and short-term exposures. These advisories are also shown in Table 8.1.

8.4 RISK MITIGATION MEASURES/INSTITUTIONAL CONTROLS

In the preamble to the final ground water standards for the UMTRA Project, institutional controls are defined as mechanisms that can be effectively used to protect human health and the environment by controlling access to contaminated ground water (60 FR 2854). Although the preamble refers to institutional controls for long periods of time (e.g., up to 100 years during natural flushing), this concept also can be applied to short-term restrictions of access to ground water. Because all 24 UMTRA Project sites cannot be evaluated simultaneously, institutional controls may be needed pending Ground Water Project compliance decisions or during the implementation of the selected ground water compliance strategy at individual sites.

The Oregon Water Resources Department (formerly the State Engineer's Office) administers certain Oregon water laws that allow the Oregon Water Resources Department to curtail use of any ground water wells, including privately owned wells, that are known to be contaminated (Oregon Water Resources Department, 1994). In accordance with this law, the Water Resources Department could potentially prohibit further use of a well determined to be contaminated (Carter, 1994).

The Oregon Department of Environmental Quality (ODEQ) policy is to notify owners of private ground water wells that they are required to restrict the use of a well that presents a major contamination problem to other wells in the vicinity. ODEQ rules can be implemented if ground water well contamination is proved a major source of contamination. The ODEQ also sends written notification to any private well owner of a known contamination problem (Bailey, 1994).

8.5 RECOMMENDATIONS

Currently, human health is not at risk from the use of site-related contaminated shallow zone ground water. However, using ground water from the shallow zone as drinking water in the future could result in potential adverse effects to human health. Therefore, it is recommended that no one drink the site-related contaminated ground water from the shallow zone.

This risk assessment was performed without complete site characterization of the contaminated ground water at the Lakeview site. Therefore, the following limitations associated with this site are recommended for consideration in future site investigations.

Table 8.1 Constituent maximum concentration limits and health advisories of constituents

Constituent	UMTRCA MCL (mg/L)	Health advisories 10-kg child, 10-day (mg/L)	Health advisories 70-kg adult lifetime (mg/L)
Chemicals (inorganic)			
Antimony	-	0.01	0.003
Arsenic	0.05[b]	-	-
Barium	1.0	-	2
Boron	-	0.9[b]	0.6[b]
Cadmium	0.01[b]	0.04	0.005
Chromium	0.05	1	0.1
Cobalt	-	-	-
Copper	-	-	-
Fluoride	-	-	-
Iron	-	-	-
Lead	0.05	-	-
Manganese	-	-	-
Mercury	0.002	-	0.002
Molybdenum	0.1[b]	0.04	0.04
Nickel	-	1	0.1
Nitrate	44[b,c]	10[d]	-
Selenium	0.01	-	-
Silver	0.05	0.2	0.1
Strontium	-	25	17
Sulfate	-	-	-
Thallium	-	0.007	0.0004
Vanadium	-	-	-
Zinc	-	6	2
Radionuclides			
Lead-210	-	-	-
Polonium-210	-	-	-
Radium-226/-228	5 pCi/L	-	-
Thorium-230	-	-	-
Uranium (U-234/-238)	30 pCi/L (0.044 mg/L)	-	-

[a]From 40 CFR §192.02.
[b]Exceeded in plume wells.
[c]Equal 10 mg/L nitrate as nitrogen.
[d]Under review, 10 mg/L as nitrogen.

Dash indicates not available.

- The farthest southern extent of the contaminant plume has not been characterized.

- Substantiation of the conceptual model of saline ground water should be considered.

- Dilution and dispersion in conjunction with ground water flow is identified as a major control on the fate and transport of constituents at the Lakeview site. The present rates of ground water transport of site-related constituents, indicated by little or no change in constituent concentrations over the last 12 years, appear to be too slow to explain the known extent of contamination. The apparent contradiction between the extent of contamination and the lack of change in constituent concentrations in individual wells is not understood.

- Three constituents (iron, manganese, and uranium) are identified as above background in the sediments adjacent to the site. These observed constituents could reflect natural variation associated with a different drainage area, such as Warner Creek, rather than site-related constituents. Additionally, surface water data suggest the surface water is not impacted by site-related contaminated ground water. However, the limited database precludes definitive conclusions about the origins of any constituents detected in these media.

- Although the use of organic chemicals has not been identified at the Lakeview site, organics (e.g., kerosene used as a carrier) are known to have been used at other UMTRA Project sites. Consequently, this is an area of uncertainty at this site.

- Depth to ground water in the area of the Lakeview site is 10 to 20 ft (3 to 6 m) or less in some areas. In addition to areas containing indigenous plantlife, much of the land downgradient from the site is agricultural or pastureland. Some plants such as alfalfa have deep root systems that could reach contaminated ground water in the downgradient plume where access to ground water is not restricted. Therefore, consideration of this exposure pathway may be warranted.

9.0 LIST OF CONTRIBUTORS

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40 CFR Part 264, *Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities*, U.S. Environmental Protection Agency. Administration, Washington, D.C.

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UNITED STATES CODE

42 USC §7901 *et seq.*, *Uranium Mill Tailings Radiation Control Act*, 8 November 1978.

Remedial Action Plan and Site Design for Stabilization of the Inactive Uranium Mill Tailings Site at Lakeview, Oregon: Volume 1, Text and Appendices A through D. Final Report: Revision 1
July 1992

The Remedial Action Plan (RAP) assesses the risk for performing surface remedial action and discusses the proposed design for relocating the millsite materials to the Collins Ranch approximately 7 miles north of Lakeview. The RAP provides information to support a ground water compliance strategy at the former millsite but defers defining a specific strategy until after proposed EPA ground water standards are final. However, the report suggests that restoration of the aquifer beneath the site would not be warranted because

Except for arsenic, contaminants originating at the raffinate ponds and tailings pile are nontoxic. However, arsenic concentrations in the background geothermal ground water are greater than concentrations in the contaminant plume.
Ground water contamination is limited to a distance of about 800 feet downgradient of the site and to a depth of about 25 feet below ground surface.
Ground water within the contaminant plume is not used for any purpose.
Concentrations of site-related contaminants are expected to decrease over time because the tailings and other contaminated materials have been relocated.

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DATE: 6/12/92

*NOTE: NRC concurrence is conditional until DOE adequately addresses groundwater cleanup in accordance with EPA standards.

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EXECUTIVE SUMMARY
REMEDIAL ACTION PLAN
LAKEVIEW, OREGON, SITE

Background

The Lakeview inactive uranium processing site is in Lake County, Oregon, approximately one mile northwest of the town of Lakeview, sixteen miles north of the California-Oregon border, and 96 miles east of Klamath Falls. The total designated site covers an area of 258 acres consisting of a tailings pile (30 acres), seven evaporation ponds (69 acres), the mill buildings, and related structures. The mill buildings and other structures have been decontaminated and are currently being used by Goose Lake Lumber Company.

Remedial action

The tailings pile at the processing site was originally stabilized by Atlantic Richfield (ARCO) with an earthen cover 18-24 inches thick. The average depth of the tailings, including the cover, varied from six to eight feet. There were estimated to be 662,000 cubic yards of tailings, windblown contaminated materials, and vicinity property materials. During remedial action under the Uranium Mill Tailings Remedial Action (UMTRA) Project, approximately 264,000 cubic yards of additional contaminated materials were identified from excavations required to remove thorium- and arsenic-contaminated soils.

The remedial action for the Lakeview site consisted of the cleanup, relocation, consolidation, and stabilization of all residual radioactive materials and thorium- and arsenic-contaminated materials in a partially below-grade disposal cell at a location approximately seven miles northwest of the tailings site, identified as the Collins Ranch site. A cover, including a radon/infiltration barrier and rock layer for protection from erosion, was placed on top of the tailings. A rock-soil matrix covers the topslope and provides a growth medium for vegetation. The U.S. Department of Energy (DOE) will retain the license and surveillance and maintenance responsibilities for the final restricted site of 13 acres.

EPA standards compliance summary

Pursuant to the requirements of the Uranium Mill Tailings Radiation Control Act (UMTRCA), the remedial action will satisfy the U.S. Environmental Protection Agency (EPA) standards (40 CFR 192) for cleanup, stabilization, and control of the residual radioactive materials (hereafter referred to as tailings) at the Lakeview site. The requirement for control of the tailings (Subpart A) was satisfied by the construction of the engineered disposal cell. The bottom of the cell is approximately 40 feet below the original grade at its lowest point. The cell is covered with a 1.5-foot-thick, fine-grained layer of silt and clay to form a low-permeability layer that reduces radon

releases to well below the standard of 20 picocuries per square meter per second. The radon/infiltration barrier also limits infiltration through the tailings. The average saturated hydraulic conductivity is 7×10^{-8} centimeter per second (cm/s). A coarse-grained, six-inch-thick, highly conductive sand filter/drainage layer placed above the radon/infiltration layer on the topslope encourages runoff of precipitation. This layer has a hydraulic conductivity of 1.0 cm/s or greater. A one-foot-thick rock riprap cover covers the entire cell. The topslope has additional rock-soil matrix to encourage plant growth. These design features operate together to provide a stabilized cover system that withstands erosion and biointrusion, and at the same time sheds water downslope off the pile.

Compliance with the proposed EPA groundwater standards requirements in 40 CFR 192, Subpart A, will be through meeting maximum concentration limits (MCLs) for three constituents (arsenic, cadmium, and uranium) at the downgradient edge of the waste management unit, which is the proposed point of compliance (POC). All groundwater quality data by location collected up to February 1991 are included as Attachment A to Appendix F. The water quality data show that the concentrations for each parameter have remained relatively constant over time. Groundwater statistical data are included in Attachment B to Appendix F. The statistics were generated from groundwater quality data collected between October 1984 and March 1988. These statistical data were also used in the February 1989 version of the RAP. The data have not been updated because the water quality in 1991 is essentially the same.

With the exception of the relic groundwater plume, the standards for cleanup of the Lakeview processing site under Subpart B of 40 CFR 192 are satisfied by the remedial action. Cleanup of the tailings pile, mill buildings, contaminated wood chips, windblown tailings, and vicinity properties was accomplished by consolidating the material into the disposal cell. The DOE has verified that cleanup to standards was accomplished. Cleanup of the relic groundwater plume will be addressed in a separate process after the proposed EPA groundwater standards have been finalized.

Design changes from final remedial action plan

There have been no significant changes in the design of the disposal cell since issuance of the final remedial action plan (RAP) in February 1989. Remedial action at the Lakeview site was completed in October 1989. Since completion of the remedial action, activities at the processing and disposal sites have been limited to drilling of monitor wells at the processing site, drilling of point of compliance wells at the disposal site, and corrective action to remedy erosion which had occurred in the cell vicinity. These efforts were conducted in the spring and fall of 1990.

Text changes from the preliminary final remedial action plan

In response to comments on the preliminary final RAP provided by the State of Oregon Department of Energy (ODOE), the following text changes have been incorporated into this document:

1. Inconsistencies in tense have been eliminated.

2. Radon and groundwater monitoring data presentations and discussions have been expanded to include data collected during remedial action.

   The water quality data show that the concentrations have remained relatively constant over time, for each parameter. Groundwater quality statistics data have not been updated since the water quality is essentially the same in 1991 as it has been in the past.

3. Appendix E, Final Plans and Specifications, has been updated to include the most current version of the specifications.

4. Text was inserted to specifically describe the alternate site selection process conducted for the Lakeview site.

5. The figure showing the proposed construction schedule was deleted.

6. The discussion on the problems associated with the rock borrow sources was revised for clarity. Although not specifically requested by DOE, the discussion was transferred from Section 5.0 of the text and inserted in this Executive Summary for clarity.

7. A number of minor changes and corrections regarding cleanup levels, ranges of contaminants, location of the access road, directions of flow in ditches, and distances between sites were also incorporated.

8. Section 8.0, Responsibilities of Project Participants, has been expanded to present a brief overview of disposal site licensing and the long-term surveillance plan.

9. Due to the additional groundwater data the document has been divided into three volumes: Volume I, Text and Appendices A through D; Volume II, Appendices E through G; and Volume III, Attachments A and B to Appendix F.

As previously mentioned, during the pre-construction investigation in December 1985, the DOE identified the Matchett Quarry as an acceptable rock source for erosion protection materials. Specifications based on limited sampling of the area established criteria for specific gravity, absorption, sodium sulfate soundness, and L.A. abrasion limits. The contract specifications were written allowing the use of other rock sources, as long as the source met the original requirements.

In June 1986, the remedial action subcontractor elected to use the Pepperling Quarry for erosion protection materials. Based on test results from pre-production sample analysis, use of the Pepperling Quarry was approved. Production samples gathered in March 1987 on the stockpiled riprap and bedding materials showed some failing tests due to geological variation in the ore body not revealed during pre-production testing.

During this time period, an erosion protection working group was established to examine the rock issue for erosion protection for all UMTRA Project

sites. Composed of representatives from the NRC, DOE, and their major subcontractors, this working group established a scoring system and procedure for oversizing and overthickening of the rock to insure the stability of the UMTRA Project tailings piles in areas with marginally suitable rock and provide an alternative to meeting the project design criteria of 1000 years.

As a result of the problems with the stockpiled Pepperling Quarry materials, the DOE, Oregon Department of Energy, and NRC met to evaluate the produced rock. Following a thorough sampling and testing program, and in consideration of the NUREG guidelines, all parties agreed to a one-time modification to the rock specifications for Lakeview for the stockpiled rock. This included oversizing, overthickening, and modifying the durability of certain riprap types. Specifically, Type "D" riprap was oversized and overthickened, Type "C" was overthickened, Type "B" changed in gradation, and there was no change in Type "A" sizing. Durability specifications were modified for absorption, sodium sulfate soundness, and L.A. abrasion tests.

Further efforts by the subcontractor to produce good quality rock from the Pepperling Quarry in June 1988 also failed in attempts to meet the original specifications. Investigations into identifying rock sources that could meet the original specifications showed that the nearest location for such a source was the Choate Quarry, near Bend, Oregon, 145 miles northwest of Lakeview. Following extensive discussions between the DOE, Oregon Department of Energy, and the NRC, rock from the Choate Quarry was determined to be not "reasonably available." Additional rock meeting the scoring criteria outlined below, found in a nearby source, Sheer Quarry, was also used as erosion protection on the cell.

The final agreement reached was to permit utilization of the rock scoring criteria presented in the NRC NUREG guidelines. This allowed the rock to be scored qualitatively for riprap types B, C, and D. The minimum score was set at 75. Additional oversizing is not necessary. Further details may be found in Appendix E, Final Plans and Specifications.

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1.0 INTRODUCTION

1.1 PURPOSE

This remedial action plan (RAP) was developed to serve a twofold purpose. It presents the series of activities which the U.S. Department of Energy (DOE) used to accomplish long-term stabilization and control of radioactive materials at the inactive uranium processing site located in Lakeview, Oregon. It also serves to document the concurrence of both the State of Oregon and the U.S. Nuclear Regulatory Commission (NRC) in the remedial action. This agreement, upon execution by DOE and the State and concurrence by NRC, becomes Appendix B of the Cooperative Agreement.

1.2 RESPONSIBILITIES

In 1978, Congress passed Public Law 95-604, the Uranium Mill Tailings Radiation Control Act (UMTRCA), expressly finding that uranium mill tailings located at inactive (and active) processing sites may pose a health hazard to the public. Title I to the UMTRCA identified 24 inactive sites to be designated for remedial action. On November 9, 1979, Lakeview was designated as one of the sites.

The UMTRCA charged the U.S. Environmental Protection Agency (EPA) with the responsibility for promulgating remedial action standards for inactive processing sites. The purpose of these standards is to protect the public health and safety and the environment from radiological and non-radiological hazards associated with radioactive materials at the sites. The final standards were promulgated with an effective date of March 7, 1983.

The DOE shall select and execute remedial action plans that will satisfy the EPA standards and other applicable Federal and state laws. The DOE funds 90 percent and the affected state funds 10 percent of allowable costs. Under the UMTRCA, the DOE and the State of Oregon entered into a cooperative agreement effective in June 1984 for remedial action at the Lakeview site.

All remedial actions must be selected and performed with the concurrence of the NRC. In conformance with the UMTRCA, the required NRC concurrence with the selection and performance of proposed remedial actions and the licensing of long-term maintenance and surveillance of disposal sites will be for the purpose of ensuring compliance with the standards established by the EPA. Therefore, the RAP constitutes the initial document in the licensing process. A detailed listing of the responsibilities of the project participants is included in Section 8.0 of this report.

1.3 SCOPE AND CONTENT

This document has been structured to provide a comprehensive understanding of the remedial action at the Lakeview site. It includes the detailed design of the remedial action. An extensive amount of data and supporting information have been generated for this remedial action plan and cannot all be incorporated into this single document. Pertinent information and data are included with reference given to the supporting documents.

Section 2.0 presents the EPA standards, including a discussion of their objectives. Section 3.0 traces the history of operations at the Lakeview site with a description of the present site characteristics. Section 4.0 provides a definition of site-specific problems. Section 5.0 is the site design for the remedial action. Section 6.0 describes the water resources protection strategy. Section 7.0 summarizes the plan for ensuring health and safety protection for the surrounding community and the on-site workers. Section 8.0 presents a detailed listing of the responsibilities of the project participants. Section 9.0 describes the features of the long-term surveillance and maintenance plan. Section 10.0 presents the quality assurance procedures required to ensure that all work conformed with project standards. Section 11.0 documents the activities that kept the public informed and participating in the project.

Attached as part of the RAP are appendices that describe various aspects of the remedial action in more detail.

Appendix A, Regulatory Compliance, describes in detail the permits that were required for the remedial action activities.

Appendix B, Calculation Summaries, presents a summary of the rationale and calculations that supported the design.

Appendix C, Radiological Support Plan, describes the procedures used to characterize the radiological condition of the processing site and to control and verify the results of remedial action activities.

Appendix D, Environmental, Health, and Safety Plan, describes the procedures used to protect the health and safety of workers and the general public during remedial action activities.

Appendix E, Final Plans and Specifications, is the design that was constructed at the Lakeview site.

Appendix F, Compliance Strategy for the Proposed EPA Groundwater Standards, details the design features incorporated to ensure compliance with the EPA standards.

Appendix G, Comment and Response Document, provides the comments and responses for the remedial action plan.

1.4 COLLATERAL DOCUMENTS

The Processing Site Characterization Report (PSCR) (DOE, 1985a), the Environmental Assessment (EA) (DOE, 1985b), and the Disposal Site Characterization Report (DSCR), (DOE, 1985c) describe the former conditions at the Lakeview site and the results of the remedial action. These documents include details that are not reported in the RAP.

The PSCR contains all of the geotechnical, hydrological, radiological, meteorological, and physical data necessary to describe the former conditions at the Lakeview site.

The DSCR contains all of the geotechnical, hydrological, and physical data necessary to describe the conditions at the Collins Ranch disposal site prior to remedial action.

The EA describes the remedial action, proposed alternatives, and the environmental impacts of the actions.

An additional supporting document is the Site Design Criteria (DOE, 1984a), which addresses general guidance on the operating procedures, formats for drawings, specifications, calculations, schedules and cost estimates, and minimum design constraints incorporated in the final design documents.

This general guidance was used in conjunction with the RAP as the basis for preparation of the final design. It is further intended to provide sufficient criteria for the reader to understand the constraints, procedures, codes, and standards used during the design and the performance of the remedial actions at the Lakeview site.

Copies of all these documents, as well as supporting data and calculations, are on file in the Uranium Mill Tailings Remedial Action (UMTRA) Project Office in Albuquerque, New Mexico.

2.0 EPA STANDARDS

The requirements and considerations for long-term isolation and stabilization of tailings, radon control, cleanup of land and buildings, and protection of water quality were published in the Plan for Implementing EPA Standards for UMTRA Sites (DOE, 1984c). That document was used as a guide for the development of the RAP and Site Design. The following EPA standards section has been extracted from the above-referenced document.

2.1 GENERAL

Pursuant to the requirements of the UMTRCA, the EPA has promulgated health and environmental standards to govern cleanup, stabilization, and control of residual radioactive materials at inactive uranium mill tailings sites. The promulgated standards establish requirements for long-term stability and radiation protection and provide procedures for ensuring the protection of groundwater quality.

In developing the standards, the EPA determined "that the primary objective for control of tailings should be isolation and stabilization to prevent their misuse by man and dispersal by natural forces such as wind, rain, and flood waters" and that "a secondary objective should be to reduce radon emissions from tailings piles." A third objective should be "the elimination of significant exposure to gamma radiation from tailings piles." (Ref. preamble to Standards for Remedial Actions at Inactive Uranium Processing Sites, 40 CFR Part 192.) These conclusions were based on a determination that the most significant public health risks associated with inactive tailings were posed by exposure to people living and working in structures contaminated by relocated tailings. The EPA further concluded that the potential for contamination of groundwater and surface water should be evaluated on a site-specific basis.

The EPA standards are discussed in the following paragraphs and are summarized in Table 2.1.

2.2 LONG-TERM STABILITY

Isolation and stabilization of tailings in order to prevent misuse by man and dispersion by natural forces is the primary objective of the EPA standards. Accordingly, long-term stability was emphasized in the development and promulgation of the standards. This is consistent with the guidelines provided by the legislative history of the UMTRCA, which stresses the importance of avoiding remedial actions that would be effective only for a short period of time and that would require future Congressional consideration.

The EPA standard-setting process distinguished "passive controls" such as thick earthen covers, below-ground disposal, rock covers, and massive earth and rock dikes, from "active controls" such as semi-permanent covers, fences, warning signs, and restrictions on land use.

PART 192 - HEALTH AND ENVIRONMENTAL PROTECTION STANDARDS FOR URANIUM MILL TAILINGS

SUBPART A - Standards for the Control of Residual Radioactive Materials from Inactive Processing Sites

192.02 Standards

Control shall be designed to:

(a) Be effective for up to one thousand years, to the extent reasonably achievable, and, in any case, for at least 200 years, and,

(b) Provide reasonable assurance that releases of radon-222 from residual radioactive material to the atmosphere will not:

(1) Exceed an average release rate of 20 picocuries per square meter per second, or
(2) Increase the annual average concentration of radon-222 in air at or above any location outside the disposal site by more than one-half picocurie per liter.

SUBPART B - Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites

192.12 Standards

Remedial actions shall be conducted so as to provide reasonable assurance that, as a result of residual radioactive materials from any designated processing site:

(a) The concentration of radium-226 in land averaged over any area of 100 square meters shall not exceed the background level by more than -

(1) 5 pCi/g, averaged over the first 15 cm of soil below the surface, and
(2) 15 pCi/g, averaged over 15 cm thick layers of soil more than 15 cm below the surface.

(b) In any occupied or habitable building -

(1) The objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL. In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL, and
(2) The level of gamma radiation shall not exceed the background level by more than 20 microroentgens per hour.

SUBPART C - Implementation (condensed)

192.20 Guidance for Implementation

Remedial action will be performed with the "concurrence of the Nuclear Regulatory Commission and the full participation of any state that pays part of the cost" and in consultation as appropriate with other government agencies and affected Indian tribes.

192.21 Criteria for Applying Supplemental Standards

The implementing agencies may apply standards in lieu of the standards of Subparts A or B if certain circumstances exist, as defined in 192.21.

192.22 Supplemental Standards

"Federal agencies implementing Subparts A and B may in lieu thereof proceed pursuant to this section with respect to generic or individual situations meeting the eligibility requirements of 192.21."

(a) ". . .the implementing agencies shall select and perform remedial actions that come as close to meeting the otherwise applicable standards as is reasonable under the circumstances."

(b) ". . .remedial actions shall, in addition to satisfying the standards of Subparts A and B, reduce other residual radioactivity to levels that are as low as is reasonably achievable."

(c) "The implementing agencies may make general determinations concerning remedial actions under this Section that will apply to all locations with specified characteristics, or they may make a determination for a specific location. When remedial actions are proposed under this Section for a specific location, the Department of Energy shall inform any private owners and occupants of the affected location and solicit their comments. The Department of Energy shall provide any such comments to the other implementing agencies [and] shall also periodically inform the Environmental Protection Agency of both general and individual determinations under the provisions of this section."

Ref: Federal Register, Volume 48, No. 3, January 5, 1983, 40 CFR Part 192.

TABLE 2.1 EPA STANDARDS

Active control covers could be expected to need frequent replacement or other major repairs requiring the appropriation and expenditure of public funds. In setting the standards, the EPA called for designs which rely primarily on passive controls.

The standards are framed as a longevity requirement that recognizes the difficulty in predicting very long-term performance with a very high degree of confidence. In establishing the longevity requirements, the EPA concluded that existing knowledge permits the design of control systems that have a good expectation of lasting at least 1000 years. Therefore, a design objective of 1000 years was established to be satisfied whenever reasonably achievable, but in any case, a minimum performance period of 200 years must be achieved.

The standards recognize the need for institutional controls such as custodial maintenance, monitoring, and contingency response measures. In its preamble to the standards, the EPA calls for such controls to be provided as an essential backup to the primary, passive controls.

2.3 RADON EMISSIONS CONTROL

The EPA identified a reduction of radon emission from tailings piles as the second objective in its standards for the control of tailings. In developing the standards, the EPA considered several approaches and selected an emission limitation as the primary form of the standard. In addition, a concentration limit was established by the EPA as an alternative form of the standards for use in cases where the DOE determined that the alternative was appropriate.

In establishing the emission limitation for tailings piles, the EPA sought to reduce both the maximum risk to individuals living very near to the sites and the risk to the population as a whole. With regard to individuals very near to disposal sites, the EPA estimates that exposure to radon emissions will be reduced by more than 96 percent. The radon standard limits the increase in radon concentration attributable to a pile to a small increase above the background radon level near the disposal site. Both radon standards are design standards, with compliance to be determined on the basis of predicted rather than measured emission rates and concentrations. The EPA states that "post-remediation monitoring will not be required to show compliance, but may serve a useful role in determining whether the anticipated performance of the control system is achieved."

In establishing the radon standard, the EPA determined that the emission limitation could be achieved by well-designed thick earthen covers and that such control techniques would be compatible with the requirements of the EPA longevity standard.

2.4 WATER QUALITY PROTECTION

The EPA reviewed available water quality data at inactive tailings sites and determined that there was little evidence of recent movement of contaminants into groundwater. They also determined that any degradation of groundwater quality should be evaluated in the context of potential beneficial uses of the groundwater as determined by background water quality and the available quantity of groundwater.

Rather than establish specific numerical limitations for contaminant discharges or groundwater quality, the EPA determined that the most appropriate course of action would be to require site-specific analyses of potential future contaminant discharge and a case-by-case evaluation of the significance of such a discharge. The implementation guidelines for the EPA standards call for adequate hydrological and geochemical surveys at each site as a basis for determining whether specific water-protection measures should be applied.

Specific site assessments must include monitoring programs sufficient to establish background water quality through one or more upgradient wells, and to identify the present movement and extent of contaminant plumes associated with the tailings piles. The site assessments further call for judgments of the need for restoration or prevention, or both, to be guided by the EPA's hazardous waste management system and relevant state and Federal water quality criteria. Decisions on specific actions to protect or restore water quality are guided by such factors as the technical feasibility of improving the aquifer, the cost of applicable restorative or protective programs, the present and future value of the aquifer as a water source, the availability of alternate water supplies, and the degree to which human exposure is likely to occur.

The UMTRCA requires that the standards promulgated by the EPA "to the maximum extent practicable, be consistent with the requirements of the Solid Waste Disposal Act, as amended." In setting the standards, the EPA determined that the statutory requirement for the NRC to concur with the selection and performance of remedial actions and to issue licenses encompassing "monitoring, maintenance, or emergency measures necessary to protect public health and safety" was consistent with the EPA regulations implementing the Solid Waste Disposal Act (47 FR 32274). Accordingly, the EPA established the implementation procedures requiring case-by-case evaluations of potential contamination at sites. Decisions regarding monitoring or remedial actions are guided by relevant considerations in the hazardous waste management systems.

On September 3, 1985, the U.S. Tenth Circuit Court of Appeals set aside the EPA standards applicable to the protection of waterways and groundwater, 40 CFR Part 192.20(a)(2)-(3). The water protection standard was remanded to the EPA for further consideration in light of the Court's opinion that the water standard promulgated by the EPA on March 7, 1983, was site-specific rather than of general application as required by the legislation. The EPA has issued draft revised standards but has not issued final standards. The DOE will implement the remedial action plan, with the concurrence of the NRC and after the revised EPA standards have

been finalized. When the EPA re-promulgates final groundwater protection standards, Subpart C 40 CFR Part 192, the DOE will evaluate the groundwater contamination at the Lakeview site and take the appropriate action to comply with such standards. All measures proposed by the DOE to meet the water-quality goals of the re-promulgated EPA standards will be submitted to the NRC for review and concurrence.

2.5 CLEANUP OF LANDS AND BUILDINGS

The EPA evaluated the risk associated with the dispersion of tailings off the site and concluded that the primary concern was the risk to man from exposure to radon daughter products inside buildings. The EPA therefore stated that the objective of the cleanup of tailings from around existing structures was to achieve an indoor radon daughter concentration (RDC) of less than 0.02 working level (WL). For open lands, the purpose of removing the contamination is to remove the potential for excessive indoor radon daughter concentrations that might arise from new construction on contaminated land. The 5.0 picocuries per gram (pCi/g) and 15 pCi/g radium-226 (Ra-226) concentration limits for 15 centimeters (cm) thick surface and subsurface layers were considered adequate to limit indoor RDCs to below 0.02 WL. A secondary concern was to limit exposure to people from gamma radiation.

The standard requires that residual radioactive materials be removed from buildings with concentrations exceeding 0.03 WL. In cases where levels are between 0.02 and 0.03 WL, the Federal government has the flexibility to use measures such as sealants, filtration devices, or ventilation devices to reduce concentrations to below 0.02 WL.

3.0 SITE CHARACTERIZATION

Site characterization describes the pre-remedial action conditions at the Lakeview site and the disposal site at Collins Ranch. Emphasis was given to the three major concerns of stability, radiation, and groundwater. The data to support the characterization may be found in the PSCR (DOE, 1985a) and the DSCR (DOE, 1985c).

3.1 HISTORY

The Lakeview uranium mill was built and operated by the Lakeview Mining Company in 1958. The owners of this firm were also the owners of the Gunnison Mining Company, who operated the mill at Gunnison, Colorado. Both companies were acquired in 1961 by Kerr-McGee Oil Industries through its subsidiary, Kermac Nuclear Fuels Corporation. Between 1960 and 1968 the property had five owners.

In 1968 the Lakeview site was acquired by Atlantic Richfield Company, who initiated in 1974, and subsequently performed, a cleanup operation on the site under a plan approved by the Oregon State Health Division. By 1977 the mill buildings and their immediate surroundings had been decontaminated to meet the then-existing requirements of the Oregon Regulations for the Control of Radiation. The property was sold on March 8, 1978, to Precision Pine Lumber Company which used the site and structures as a lumber mill and stockpile for sawdust and scrap waste. The property containing the mill buildings, office area, and acreage for timber storage was sold to Goose Lake Lumber Company in 1987. Precision Pine Lumber Company still retains title to the former tailings pile area.

During the 1958 to 1961 period of operations, 130,000 tons of ore were treated at the mill site. The mill operated at a rated capacity of 210 tons of ore per day and used a sodium chlorate and sulfuric acid leach process. The ore came from the White King and Lucky Lass mines, located approximately 16 road miles northwest of Lakeview.

3.2 PHYSICAL DESCRIPTION

Regional geology

The Lakeview area is located in the Basin and Range physiographic province, which is characterized by north to northwest mountains and ridges (horsts) separated by oblong narrow valleys (grabens). Both the processing site and the Collins Ranch alternate disposal site are located within the Goose Lake graben.

The regional topography has been influenced by normal faulting with upthrust sides typically steeper than downthrust sides. Intermittently during the Pleistocene Epoch (10,000 to 1,000,000 years ago) lakes filled the valley to varying depths, depositing lacustrine sediments to depths in excess of 5000 feet.

The oldest rocks in the area are Miocene and Pliocene volcanic deposits. These rocks are exposed in the Fremont and Warner Mountain horstblocks and underlie the sediments of the Goose Lake Valley. The valley fluvial terrace, lacustrine, and diatomaceous sediments range from silts and clays to conglomerates.

Surface features of the Lakeview site

The Lakeview site and tailings are located in south-central Oregon, in Lake County. The closest town is Lakeview, one mile to the southeast. Klamath Falls is approximately 96 miles west of the site. The site is approximately 16 miles north of the California-Oregon border (Figure 3.1).

The total designated site covers an area of 258 acres. This included the tailings (30 acres) and the evaporation ponds (approximately 69 acres). The tailings were stabilized with an earthen cover 18 to 24 inches thick. The pile was almost square with a very flat surface, although the cover had depressions that trap moisture. The cover supported a vigorous growth of vegetation. The average depth of the tailings, including the cover, varied from six to eight feet. An earthen dike was constructed around the tailings area before the tailings were emplaced. The tailings were fenced with a hog-wire type of fence, and radiation signs were posted. There was also a barbed-wire fence around the entire site. The mill and tailings site before remedial action are shown in Figure 3.2.

The mill buildings and other structures have been decontaminated, and the machinery and other salvageable items have been removed and decontaminated by the owners. Materials from the final decontamination of the mill buildings and surroundings areas were placed on the southeastern portion of the tailings pile and stabilized in the same manner as the remainder of the tailings.

The areas to the north and west of the site are generally swampy during much of the year due to the high water table. To the east of the site, the land is swampy during the spring and early summer but dries out later in the summer and remains dry until winter.

Precision Pine Lumber Company stored bark, wood chips, and sawdust on the northwest evaporation pond. Precision Pine Lumber Company built an addition onto the northern end of the lumber mill building. Two new buildings also have been constructed on the mill site near the old mill building; one of these is located directly over the former ore storage area.

Subsurface features of the Lakeview site

Soils immediately underlying the processing site consist of a complex series of interbedded silts, sands, and clays. These deposits are lacustrine and alluvial in origin. Groundwater is encountered at depths ranging from one to 25 feet below the land surface.

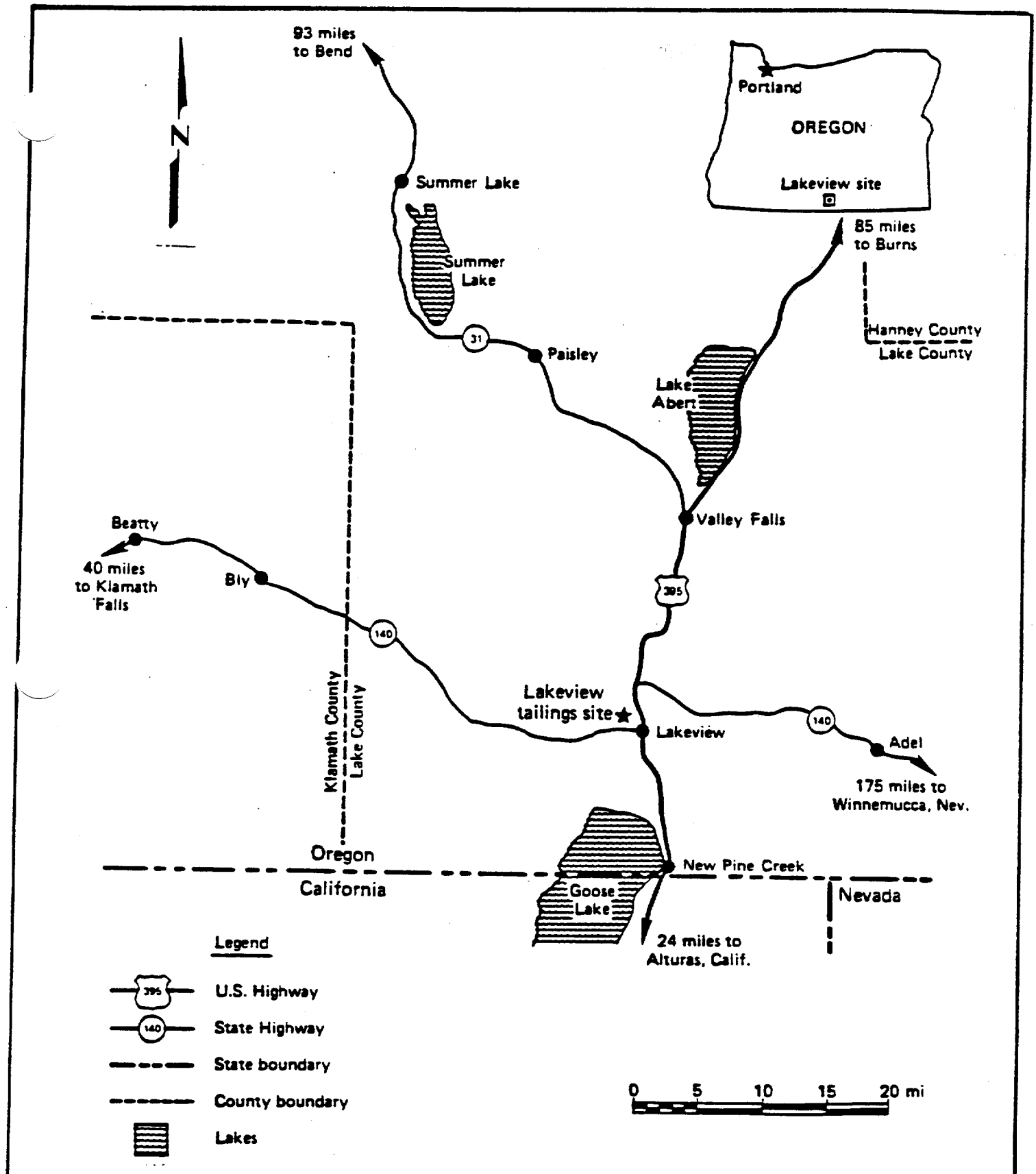

FIGURE 3.1
LAKEVIEW SITE LOCATION

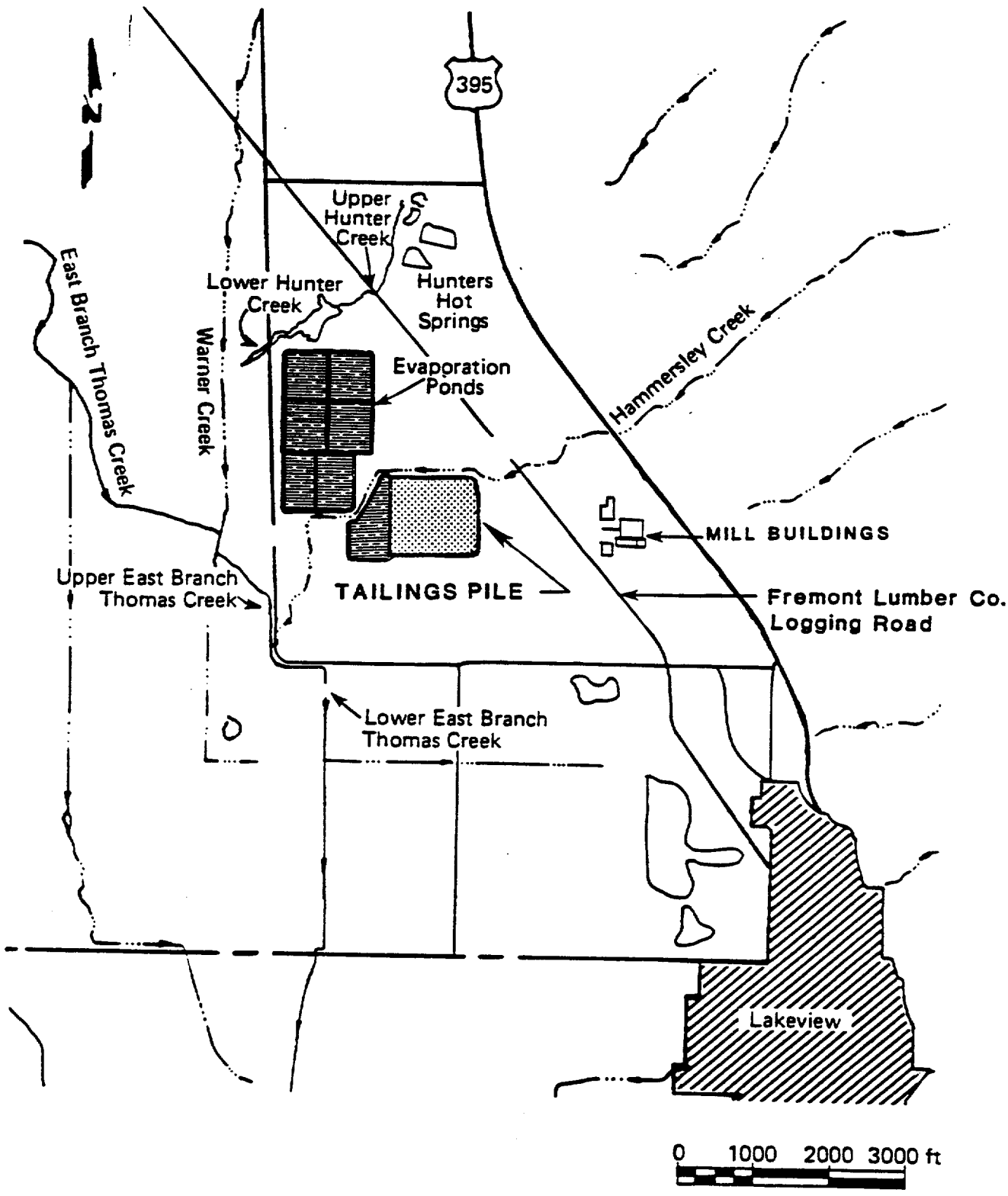

FIGURE 3.2
LAKEVIEW MILL SITE

The former processing site is located in a Known Geothermal Resource Area (KGRA). The geothermal activity is associated with the seismotectonic setting of the area. Geothermal anomalies have been observed in the form of geysers, the closest of which is Hunters Hot Springs, located 0.4 mile north of the site. Water temperatures of 60°C and 41°C encountered in two monitor wells immediately north of the evaporation ponds and a four-inch blowhole opening through snow on the southeast evaporation pond (observed on January 27, 1984) also are indications of geothermal activities in the area.

Further details of the subsurface features of the processing site may be found in the PSCR (DOE, 1985c).

Surface features of the Collins Ranch disposal site

The Collins Ranch disposal site is approximately seven road miles northwest of the Lakeview tailings site and consists of a 40-acre area in Section 12, Range 19 East, Township 38 South, Lake County, Oregon (Figure 3.3). A private logging road owned by Fremont Lumber Company connects the Lakeview tailings site with a National Forest Development Road that passes within 0.75 mile east and north of the Collins Ranch disposal site.

The site is part of a larger area of a ranch owned by John and Bridgette Collins. Prior to a range fire that occurred in August 1984, the site was leased for grazing. The area used for disposal is isolated and visible only from a distant, seldom-used National Forest Development Road. The few inhabited residences in the area are over one mile away.

Subsurface soil features of the Collins Ranch disposal site

The Collins Ranch site is located on a remnant terrace deposit east of the Fremont Mountains. This pediment has been separated from the mountain flank by erosional processes. The eastern portion of the site rests upon this pediment, which is typified by surface slopes of five to 20 percent. The western portion of the site rests upon outwash deposits of the Fremont Mountains.

Soils underlying Collins Ranch consist of interfingered and layered silty sands, sandy silts, and surficial lenses of high plasticity clays. These materials, encountered to a depth of 127 feet, form the slopes of Augur Hill, and represent a remnant pediment of outwash deposits from the nearby Fremont Mountains. Groundwater was encountered in seven of the 10 boreholes completed as monitor wells. The four remaining on-site observation well borings did not encounter groundwater within the stratigraphic interval penetrated. Four shallow wells (22 to 27 feet) in the valley, just west of the site boundary, show water-table conditions with depths to groundwater from seven to 18 feet (December 1984). One 78-foot well drilled on the disposal site near the course of a broad drainage channel on the southwest slope of Augur Hill showed groundwater at 76 feet below ground surface. A minimal depth to groundwater beneath the proposed

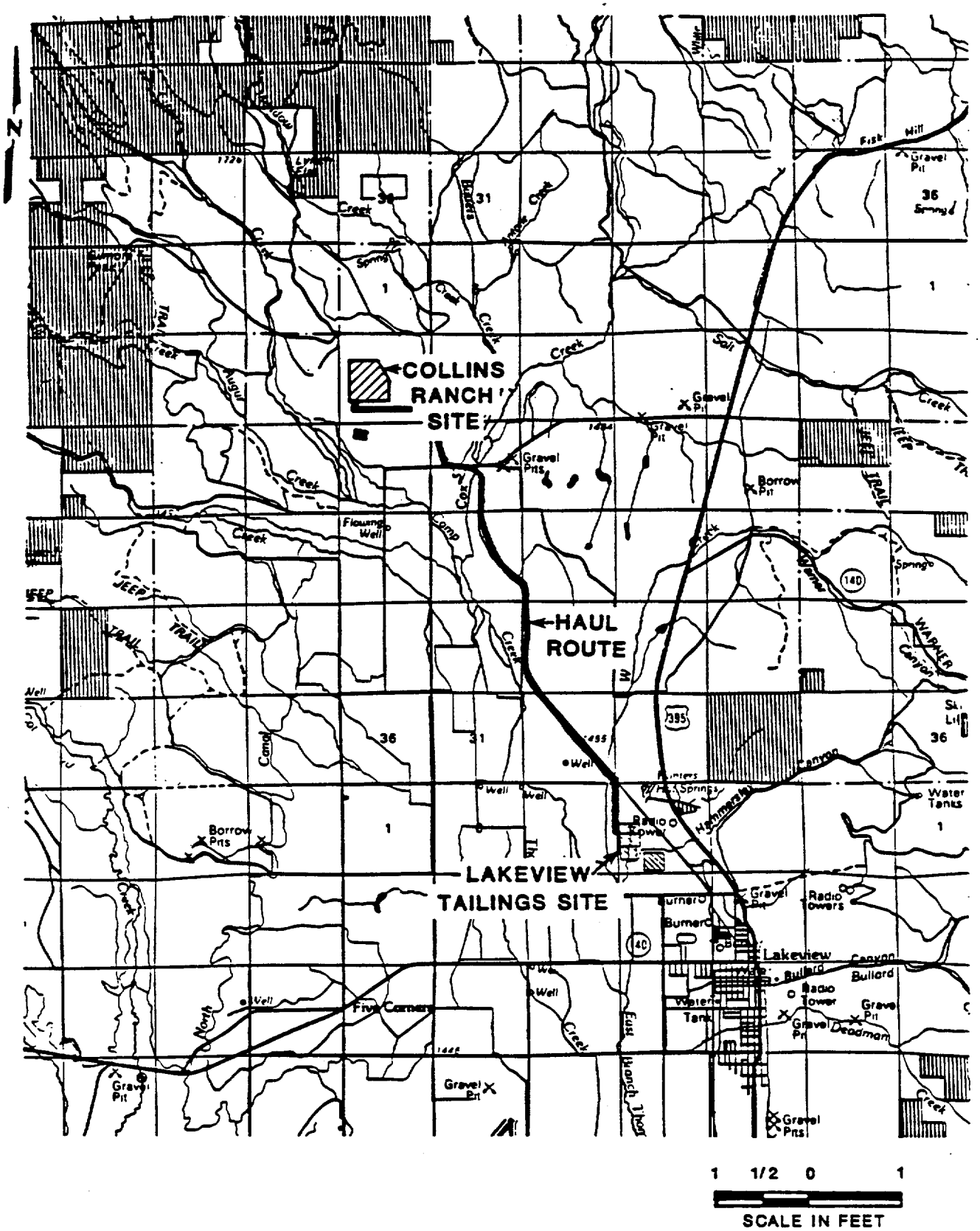

FIGURE 3.3
DISPOSAL SITE LOCATION
COLLINS RANCH SITE

boundary of the disposal site is presently about 30 feet. This depth increases moving up the slope of Augur Hill. Groundwater beneath the site moves from northwest to south-southeast under a hydraulic gradient of approximately 0.018. The groundwater flow direction is opposite the topographic slope, indicating most recharge is from the Fremont Mountains to the west, rather than from the soils at the proposed disposal site.

In the spring of 1987, two seeps were identified along the exposed surface of the north wall of the disposal cell. The maximum potential flow from seep No. 1 was estimated to be 0.7 gallon per minute (gpm). The maximum potential flow from seep No. 2 was estimated to be 0.1 gpm. Figure 3.4 shows the approximate locations of the two seeps.

Details of subsurface features of the Collins Ranch disposal site are in the DSCR (DOE, 1985c).

Groundwater conditions at the Collins Ranch disposal site are discussed in Section 3.5.

3.3 STABILITY

South-central Oregon is in an area of moderate to high seismic risk. Historical seismicity in the region is characterized by moderate-sized earthquakes associated with normal faulting within the region. There are five faults within a 65-km (40-mile) site radius that are considered to be capable faults. The seismic design for the disposal site at Collins Ranch is based on a 7.4 magnitude earthquake occurring on the east side of the Goose Lake graben fault zone located 6.5 km (4.0 miles) from the site with a potential peak horizontal acceleration of 0.50 g.

In addition to the ground motion experienced from a seismic event, a potential for surface rupture exists directly under the processing site due to the short distance (less than 0.5 mile) from the Fremont Mountain fault zone. This potential is not present at the Collins Ranch disposal site.

Geothermal activity at the processing site is associated with the seismotectonic setting of the area. There exists potential for solutioning of the silicious caprock or alteration by seismic events to produce venting directly beneath the tailings pile at the processing site (DOE, 1985a). This potential does not exist at the Collins Ranch site.

The geomorphic setting of both sites is relatively stable. Hammersley Creek at the processing site has a small potential to flood and meander. The slopes of the Collins Ranch site may require some protection from erosion, but are generally well protected by a natural gravel and cobble armoring.

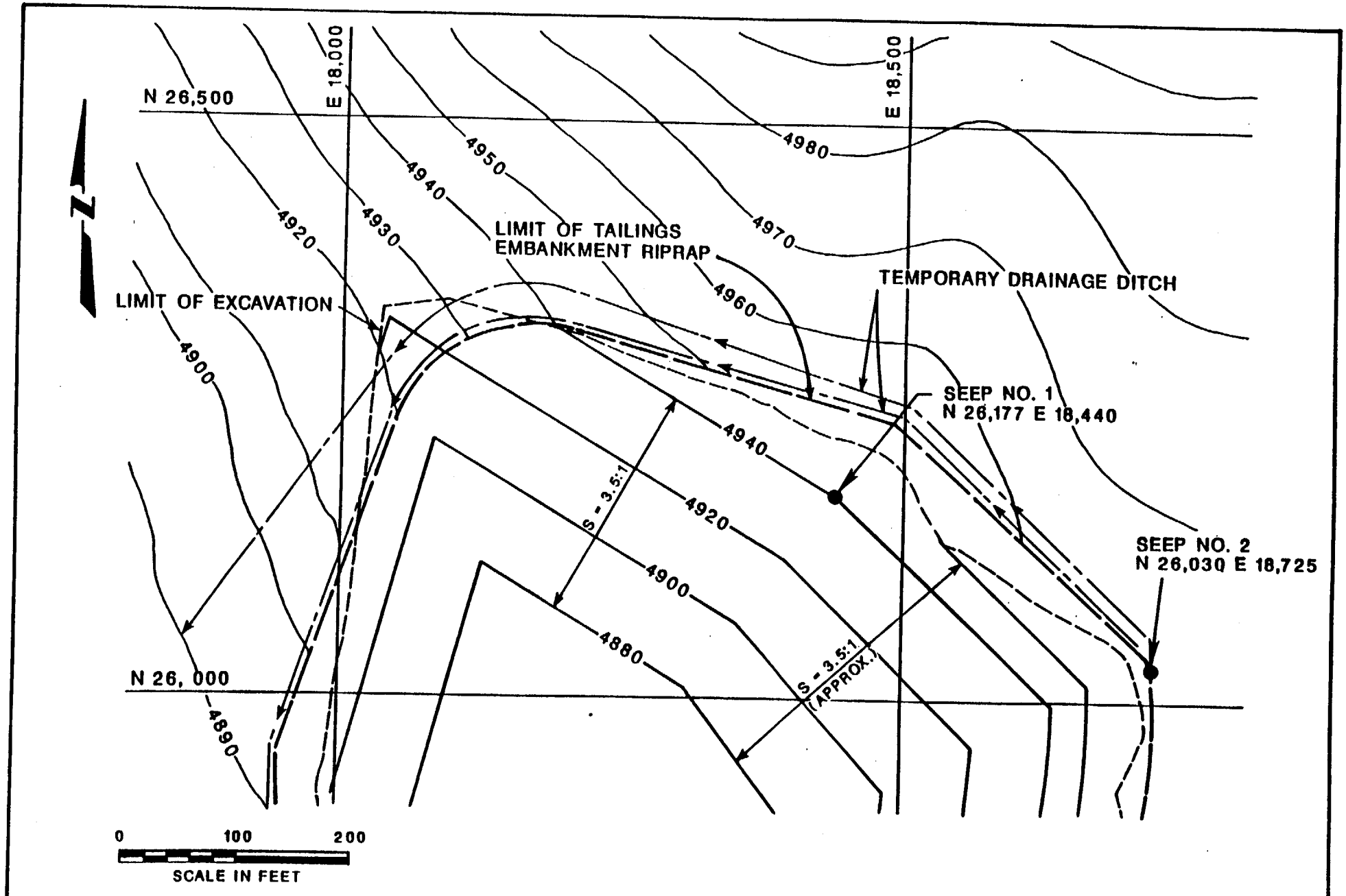

FIGURE 3.4
LOCATION OF SEEPS, COLLINS RANCH SITE

3.4 RADIATION

Background radiation levels

Radioactive elements occur naturally throughout the earth's air, water, and soil. The concentration of these elements varies greatly throughout the United States. Background soil radioactivity levels typical of the Lakeview area and not influenced by the tailings pile have been established as 0.8 pCi/g for Ra-226 (ORNL, 1980).

The average background gamma radiation exposure rate in the Lakeview region from both terrestrial and cosmic sources measured at three feet above the ground is 11 microroentgens per hour (microR/hr) with a range of eight to 19 microR/hr (ORNL, 1980). Cosmic rays (radiation from the sun and other sources external to the earth) contribute approximately 5.3 microR/hr (48 percent) to the 11 microR/hr background gamma exposure rate in the Lakeview area (EG&G, 1981).

The average outdoor background radon concentration in the Lakeview area was 0.2 picocuries per liter (pCi/l). This is the annual average background radon concentration as determined from three monitoring locations in the vicinity of Lakeview (TAC, 1987).

Lakeview tailings site

Previous remedial action activities were conducted from 1974 to 1977 at the Lakeview tailings site. These included the cleanup and stabilization of the former mill area, partial excavation of material in the evaporation ponds, and application of cover material over the tailings pile.

Samples from 21 drill holes on the former tailings pile were analyzed by gamma spectroscopy, and computer modeling was used to profile the pile contaminant distribution and the average Ra-226 concentration. The resulting average Ra-226 concentration of the tailings was 160 pCi/g; this included the tailings, the existing two foot thick cover, and a two foot layer of contaminated material underlying the tailings (BFEC, 1984; JEG, 1984). Radium concentrations ranged from a minimum of background to a maximum of 739 pCi/g.

The soil beneath the tailings pile exceeded the EPA standard of 15 pCi/g Ra-226 to an average depth of approximately one foot. Elevated arsenic levels were also present beneath the tailings, approximately 600 parts per million (ppm) from the surface to two feet beneath the tailings pile interface. Actual site excavation showed considerably more arsenic contamination than originally expected. Site-related arsenic concentrations are described in detail in the Lakeview Site Completion Report (DOE, 1990).

Using Shiager's (1974) estimate of 2.5 (microR/hr)/(pCi/g), the base tailings gamma exposure rate would be 400 microR/hr based on the average tailings pile Ra-226 concentration of 160 pCi/g. The former cover on the tailings pile reduced the pile surface gamma exposure rate to an average of less than 25 microR/hr (EG&G, 1981).

The radon flux source term from the tailings pile was calculated using the RAECOM model (NRC, 1984), which resulted in an annual average radon flux of 59 picocuries per square meter per second (pCi/m^2s) for no-action conditions.

Results of field data from the evaporation ponds (69 acres) on the tailings site indicated elevated thorium-230 concentrations, averaging 65 pCi/g in the surface six-inch layer, 35 pCi/g in the six- to 12-inch layer, and 12 pCi/g in the 12- to 18-inch layer. Since Ra-226 activity in-growth in 1000 years would be above or borderline to EPA standards, excavation was planned to a depth of 18 inches.

Field data (ORNL, 1980; BFEC, 1984) showed that minimal spread of gamma-emitting contamination had occurred by wind or water erosion into areas beyond the tailings pile or evaporation ponds. Approximately 17.4 acres immediately adjacent to the tailings pile and in isolated areas in the mill yard that were not cleaned during previous remedial action indicated elevated Ra-226 concentrations. The concentrations ranged from five to 170 pCi/g Ra-226.

Collins Ranch site

Background soil Ra-226 concentration and gamma exposure rate levels, measured in the Lakeview region, indicated average levels of 0.8 pCi/g Ra-226 and 11 microR/hr for gamma exposure rate (ONRL, 1980). Background radiation levels were measured at five locations in the Lakeview area. Results indicated an average Ra-226 concentration of less than one pCi/g, and gamma exposure rate measurements ranged from nine to 13 microR/hr (BFEC, 1984).

Background radiation measurements have also been made on the Collins Ranch site (DOE, 1985a). The mean and one standard deviation from four pressurized ionization chamber measurements were 12.1 plus or minus 0.5 microR/hr. A subsequent gamma exposure rate traverse survey indicated no readings beyond the range of 10 to 14 microR/hr. Surface soil samples were collected at the four pressurized ionization chamber measurement locations and analyzed for Ra-226, Th-230, and natural uranium. The average concentrations found were: Ra-226, 0.9 pCi/g; Th-230, 1.1 pCi/g; and natural uranium, 3.5 ppm.

Pre-remedial-action radon monitoring was conducted at the Collins Ranch site. Monitoring was performed prior to the movement of the tailings to the site. The annual average radon concentration at the Collins Ranch disposal site, prior to remedial action, was 0.17 pCi/l (TAC, 1987).

3.5 GROUNDWATER

Lakeview processing site

Groundwater in the valley fill deposits at the Lakeview processing site occurs under unconfined to semi-confined conditions. The below ground field characterization concentrated on the zone from the surface to a depth of 100 feet, the predictable limits of vertical contaminant migration. Within this zone, groundwater occurs under unconfined to semi-confined conditions within sequences of discontinuous lenses of silty to sandy clays and silty sands with minor amounts of fine gravel. More details on location and depth of site monitoring wells and on the lithology are contained in the PSCR and draft EA (DOE, 1985a,b).

The groundwater flow direction is from the northeast to southwest with an apparent hydraulic gradient of 0.01. Recharge in the site area is from local precipitation and snowmelt and groundwater flow from the Warner Mountains. There appears to be upward movement of groundwater in the geothermal area north of the site. Groundwater discharges to surface drainages, springs, and wells in the area.

Differences in water levels of two to 12 feet between monitor well pairs indicate a small downward vertical hydraulic potential that decreases from northeast to southwest across the site. A survey of domestic wells within one mile of the site showed only small differences in water level between shallow (100 feet deep) and 450 foot deep wells. Therefore, strong vertical flow gradients outside the geothermal system are unlikely, and the entire sequence of sediments behaves as a single leaky system. Two aquifer tests were performed and indicated that restricted hydraulic interconnection exists between shallow (20 to 25 feet) and deeper (70 to 75 feet) screened zones.

There are two chemically distinct types of upgradient water quality. The low temperature groundwater exhibits a calcium bicarbonate chemistry with total dissolved solids (TDS) of approximately 200 milligrams per liter (mg/l), whereas the geothermal groundwater exhibits a sodium sulfate chemistry with TDS of approximately 800 mg/l. All groundwater quality data by location collected up to February 1991 are included as Attachment A to Appendix F. The water quality data show that the concentrations for each parameter have remained relatively constant over time. Groundwater statistical data are included in Attachment B to Appendix F. The statistics were generated from groundwater quality data collected between October 1984 and March 1988. These statistical data were also used in the February 1989 version of the RAP. The data have not been updated because the water quality in 1991 is essentially the same.

Two contaminant plumes are migrating from the processing site. The main plume emanates from the southeast evaporation ponds area. A lesser plume is migrating from the tailings pile area. Extent of the plumes has been determined from sulfate or TDS concentrations. Elevated concentrations of radionuclides and most heavy metals are not appearing in the groundwater, and are apparently attenuated in the subsoils beneath source areas of contamination. Differences in concentrations of elements between

shallow and deep well pairs show that most of the contaminant migration has occurred in the shallow groundwater, above 30 feet, and further attenuation of soluble species occurs as seepage moves downward into the deeper 75-foot zone.

Groundwater use downgradient of the site is generally sustained by pumping from zones deeper than 75 feet. Available well records do not indicate any water usage from the shallow zone downgradient from the processing site.

Collins Ranch disposal site

Groundwater at the Collins Ranch disposal site occurs within sequences of layered silty sands, sandy silts, and surficial lenses of high plasticity clays. These layers are stratified and interfingered in a complex manner, similar to the processing site lithology, with a larger percentage of finer-grained soils (DOE, 1985a,b). Hydrochemical data from wells indicate that the shallow strata at the processing site have a high attenuative capacity. Boreholes at the Collins Ranch site indicate an even larger attenuative capacity because the strata there are finer grained and thus have larger dispersivity and larger particle surface areas for sorption processes. These materials, encountered to a depth of 127 feet, form the slopes of Augur Hill upon which the partially below-grade disposal site was be located.

Groundwater in the valley just west of the site boundary is found at depths from seven to 18 feet beneath the ground surface. The depth to groundwater beneath the site increases approaching the eastern edge of the disposal site. Six monitor wells were installed within the boundary of the disposal site at depths ranging from 47 feet to 127 feet. Three wells encountered groundwater at depths of 65 to 76 feet below the ground surface. Other wells at the site did not encounter water within the stratigraphic section penetrated.

Groundwater moves from northwest to southeast beneath the site, counter to the topographic slope, with an apparent hydraulic gradient of 0.018. The primary source of recharge is the Fremont Mountains to the west. Minimal recharge occurs along the small drainage divide immediately above the disposal site. Discharge occurs to a small drainage south of the site and ultimately into drainages that drain to Goose Lake, 15 miles southeast of the site. Groundwater level fluctuations due to spring snowmelt and runoff in the Fremont Mountains were monitored and were less than two feet between the autumn of 1984 and the summer of 1985.

The chemistry of the shallow groundwater in the Collins Ranch area exhibits low TDS, high pH, and high silica (DOE, 1985b, Appendix D). All groundwater quality data collected up to February 1991 are included as Attachment A to Appendix F.

4.0 PROBLEM DESCRIPTION

4.1 GENERAL

The tailings (without the cover) emitted an estimated radon flux of 160 pCi/m^2s, which was in excess of the EPA standard of 20 pCi/m^2s.

4.2 LONG-TERM STABILITY

The tailings and contaminated rubble were not secure from physical removal off the Lakeview site. In addition, the potential for ground surface rupture and geothermal activity at the processing site precluded the long-term stabilization of the tailings at that location. By moving the tailings and contaminated material to the Collins Ranch site these risks were avoided and EPA longevity requirements were met.

4.3 RADIATION

Radon emissions from the tailings exceeded the EPA standard of 20 pCi/m^2s by approximately eight times; however, the two-foot-thick earthen cover decreased the radon emissions by half. The radiation standards for buildings and open lands were exceeded in approximately six vicinity properties and 86.4 acres of evaporation pond or windblown contaminated areas on and around the Lakeview site. Additional vicinity properties were identified during remedial action.

4.4 WATER QUALITY

Lakeview processing site

An unconfined to semi-confined groundwater system exists at depths greater than one to 25 feet below the ground surface. Contaminants associated with the tailings pile and evaporation ponds have moved into this aquifer and have migrated 800 feet downgradient to the southwest in the shallow groundwater zone above 30 feet. Mobile species include sulfate, manganese, and sodium. Radionuclides and most heavy metals from leachate are attenuated in the subsoils beneath the ponds and former pile area. Monitor wells screened in a deeper zone at 70 to 75 feet showed sulfate and TDS concentrations increasing downgradient from the evaporation ponds. Stable isotope analyses indicated that the increasing trend in sulfate and TDS in the deeper zone was due to the influence of the geothermal system in the region (see Appendix B, Calculation Summaries).

There is no water use from the shallow zone, above 30 feet, downgradient of the site. Most domestic wells are screened at depths from 100 to 300 feet. Data showed that contaminants associated with the site have not endangered any downgradient water uses. Due to the chemical nature of the contaminant plume compared to local background water quality, the limited extent of contaminants, the non-toxic nature of contamination,

and the lack of uses and potential uses, aquifer restoration is not warranted.

As additional water quality data become available for the processing site, the possible long-term need for aquifer restoration will be re-examined. A separate process during a later phase of the UMTRA Project will examine the need for, and feasibility of, aquifer restoration at every UMTRA site.

Collins Ranch site

The potential for groundwater contamination at the Collins Ranch site appears to be insignificant. For every constituent of concern, the disposal site design allows proposed EPA concentration limits to be met in shallow groundwater within 50 feet of the downgradient edge of the tailings cell (see Appendix F).

4.5 ALTERNATIVES CONSIDERED

4.5.1 Selection of disposal site

After determination was made that a fault zone in combination with seismic and geothermal activity would preclude stabilizing the tailings at the processing site, a structured alternate disposal site selection process was followed to find a suitable disposal site.

The process consisted of a four-phase approach: Phase I designated the limits of the search region; Phase II provided for a preliminary screening of the designated search region; Phase III began the preliminary screening and evaluation of the potential disposal areas; and Phase IV identified and evaluated each of the candidate sites.

The search region designated by Phase I encompassed a 15-mile radius from the existing tailings pile. Phase II consisted of the development of regional screening guidelines, and application of those guidelines resulted in elimination of all land except 70 square miles of the search region. Under Phase III, evaluation of those 70 square miles by a technically diversified team of specialists identified six one-square-mile desirable areas. Evaluation and ranking of the six areas under Phase IV identified the two highest ranking sites for subsequent field data collection and inclusion in the EA.

The final design contained in this document was developed around the "preferred alternative," the Collins Ranch site. Other specific sites evaluated but found less desirable included the Flynn Ranch site and the Mines site. Comparison of these three sites along with stabilization in place was the subject of a discussion paper (DOE, 1985d). A detailed description of the site

selection process and a comparison of alternatives is contained in the EA (DOE, 1985b).

4.5.2 Design concept

Upon selection of the preferred alternative, relocation of the tailings to the Collins Ranch site, extensive engineering studies were performed in the development of the design in Section 5.0. Major areas of evaluation included minimizing the surface water shed area to protect against flooding, locating the site approximately 50 feet above the floodplain to protect against the Probable Maximum Flood (PMF), groundwater occurrence and protection, embankment configuration, erosion protection, foundation settlement, and slope stability. Other design components that were included in the site selection process are listed in the remaining portion of this section.

The hydrogeologic field program revealed that an unconfined to semi-confined groundwater system exists below the Collins Ranch site. Continued monitoring of groundwater levels at the site has defined seasonal water level fluctuations in this system. Details are included in Appendix B, Calculation Summaries.

Because of the abundance of silt and clay soils in the Collins Ranch area, below-grade disposal was considered a viable option. The final, partially below-grade embankment was designed to use the soils available on the site and the natural topography of the site in the best way, as well as to avoid the local unconfined groundwater system. The contaminated materials would be isolated from the shallow groundwater system by limiting infiltration through a low-permeability cover and a highly conductive sand filter/drainage layer, and by geochemical retardation and flow reduction through a two-foot clay-enhanced geochemical/flow barrier liner to assist in compliance with EPA's groundwater standards. In order to reduce the amount of radon barrier that was previously required the highly contaminated materials were placed at the bottom of the cell overlain with lesser contaminated materials, thus reducing possible radon emanation through the top layer. A French drain system was installed along the northern edge of the disposal cell beneath the geochemical flow-barrier liner to intercept water from the two seeps prior to it coming into contact with the cell.

The deepest excavation at the processing site was accomplished in late summer when groundwater levels were low, thus minimizing the dewatering effort. Details are provided in Section 5.0. Wastewater treatment for runoff water and decontamination water was necessary at the Collins Ranch site during construction.

The Goose Lake Basin is an area of extensive seismic activity. The disposal embankment was designed to withstand the occurrence of a MCE. The design slopes (1 vertical to 5 horizontal) provide the necessary factor of safety against embankment slope failure

and settlement under both static and seismic loading conditions. The embankment slopes blend into the surrounding terrain and reduce the potential effects of erosion due to surface water flows. Final design calculations on slope stability, settlement, and erosion protection are contained in Section 5.0 and Appendix B, Calculation Summaries.

5.0 SITE DESIGN

5.1 INTRODUCTION

This section provides the maps, drawings, and other information necessary to understand the design used for relocating the tailings to the Collins Ranch disposal site. A three-dimensional isometric drawing of the original Collins Ranch site is shown in Figure 5.1. The site design is described to provide sufficient detail for the reader to evaluate the feasibility and effectiveness of the basic design concepts. The final design provides a basis for the schedule and cost estimate to be used in obtaining concurrences and funding at Federal and state levels (Appendix E, Final Plans and Specifications).

The site design demonstrates remedial action that meets the requirements of PL95-604. Although the as-built design varied to a limited extent from the final design, the basic concepts presented in this document represent final remedial action.

5.2 SUMMARY OF PROPOSED REMEDIAL ACTION

The principal feature of the design concept was the relocation of approximately 925,810 cubic yards of tailings and contaminated materials to the Collins Ranch disposal site located about seven miles from the former mill site. The contaminated materials were consolidated into an embankment constructed partially below grade, and enclosed with protective layers. These protective layers consist of the following:

- A two-foot-thick compacted clay layer beneath the tailings (the "geochemical/flow barrier liner") to attenuate migration of contaminants.
- A compacted soil layer above the contaminated materials (the "radon barrier") to reduce emission of radon gas to acceptable levels and inhibit infiltration.
- A highly conductive sand filter/drainage layer to prevent runoff from eroding the radon barrier through the rock layer.
- A combination of rock and a rock-soil matrix on the topslope to provide erosion protection and support vegetation.
- A rock layer on the steeper sideslopes for erosion protection.

Construction of the embankment comprised several major elements. Material for the radon and infiltration barrier was excavated from the embankment area. Approximately 279,000 cubic yards of soil from the disposal site excavation was used for processing site backfill. A compacted geochemical/flow barrier liner two feet in thickness was constructed. The liner was constructed from select materials also excavated from the embankment area. The tailings and highly contaminated material

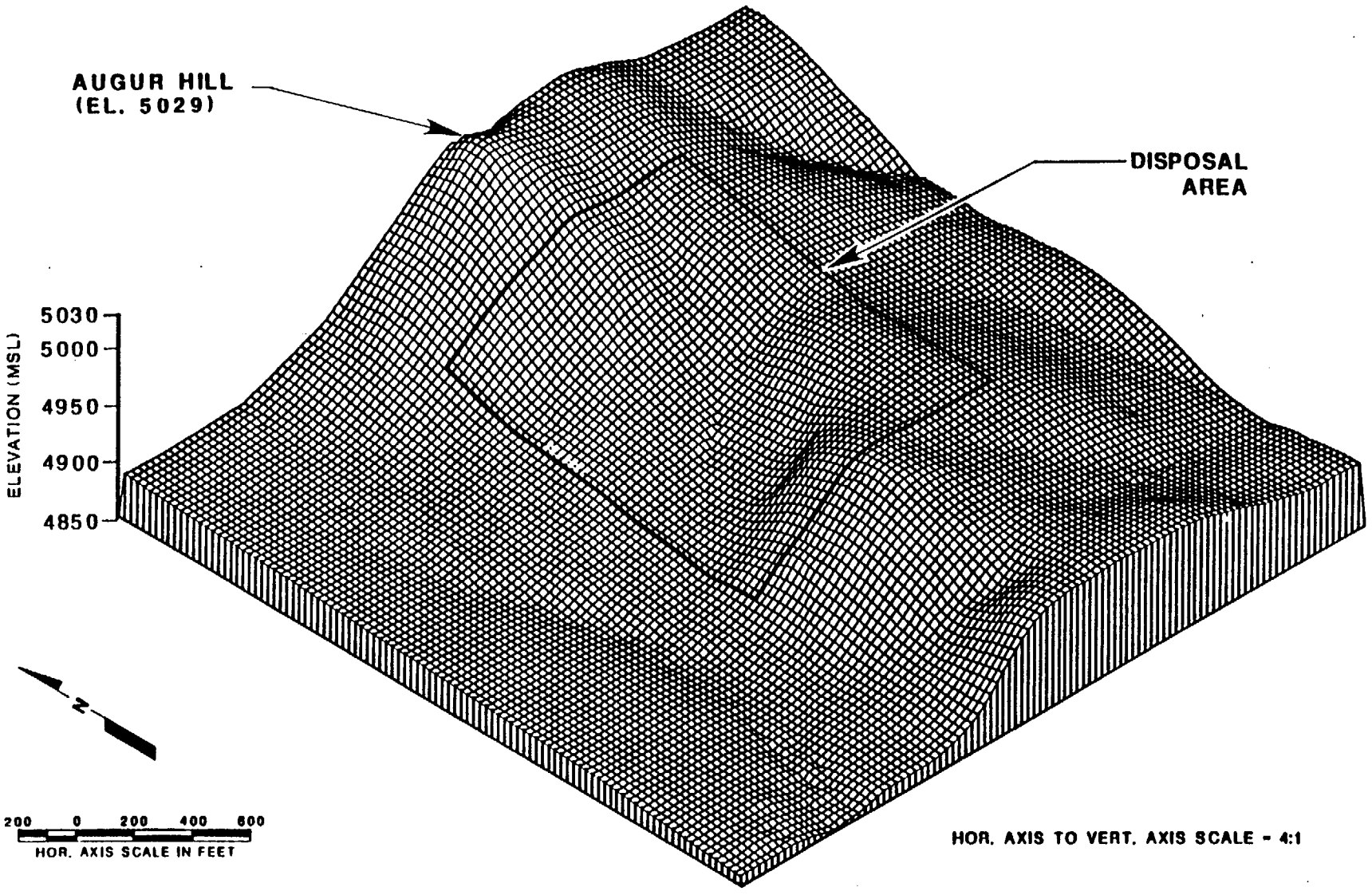

FIGURE 5.1
ORIGINAL CONDITION, COLLINS RANCH DISPOSAL SITE - ISOMETRIC

were placed and compacted first, then the less contaminated material was placed and compacted, and finally the radon barrier placed and compacted. The embankment sideslopes were covered with rock erosion protection material designed to withstand the erosional effects of wind and water, and to impede inadvertent disturbance by man or animal. The topslopes were capped with a rock-soil matrix that will support vegetation and at the same time protect against erosion. The rock-soil matrix will both minimize plant root intrusion and facilitate revegetation of the surface. The final embankment is shown in Figure 5.2. The final design of the disposal cell was modified slightly in order to accommodate an additional 263,810 cubic yards of contaminated materials. This modification increased the height of the embankment by 3.6 feet.

Relocation of the tailings from the processing site was by truck, primarily along the Fremont Lumber Company logging road. On-site access roads were constructed as needed at both sites. The trucks drove directly from the Lakeview processing site into the excavated area and spread their loads for compaction. Details are provided in Section 5.6.1. Excavated areas at the Lakeview processing site were backfilled and graded to promote drainage.

At least one source for each required construction material was identified; however, it is recognized that the construction subcontractor selected material from other sources. The fine-grained soils required for the radon barrier, the geochemical/flow barrier liner, and fine-grained fill material were obtained from the disposal site excavation. Sources of rock for erosion protection material were identified at commercial quarries in Deadman's Canyon, near Lakeview.

5.3 DESIGN OBJECTIVES

The principal objective of this remedial action was to design control measures which meet EPA standards. These standards include specific limitations for the disposal site on the release of radon, limitations on the release of radiation from radium and radon daughter products, and the protection of groundwater beneath the Collins Ranch disposal site. There is also the requirement for long-term stabilization that stipulates controls will be effective for up to 1000 years, and for at least 200 years. At the processing site, radiation and radioactive contaminants must be removed until sufficiently low levels are achieved. Applicable requirements of the city of Lakeview, Lake County, the Oregon Department of Energy, and other involved state and Federal agencies were adhered to during construction. These requirements are included in Appendix A, Regulatory Compliance.

The purpose of remedial action and adherence to standards during this effort is to ensure protection of the local environment. The public must be protected both during and after remedial action from unsafe levels of radiation. The quality of surface water and groundwater must not be adversely affected by discharges from the site. The remedial action must provide assurance of long-term stabilization of the site primarily by ensuring erosion control, flood protection, and earthquake

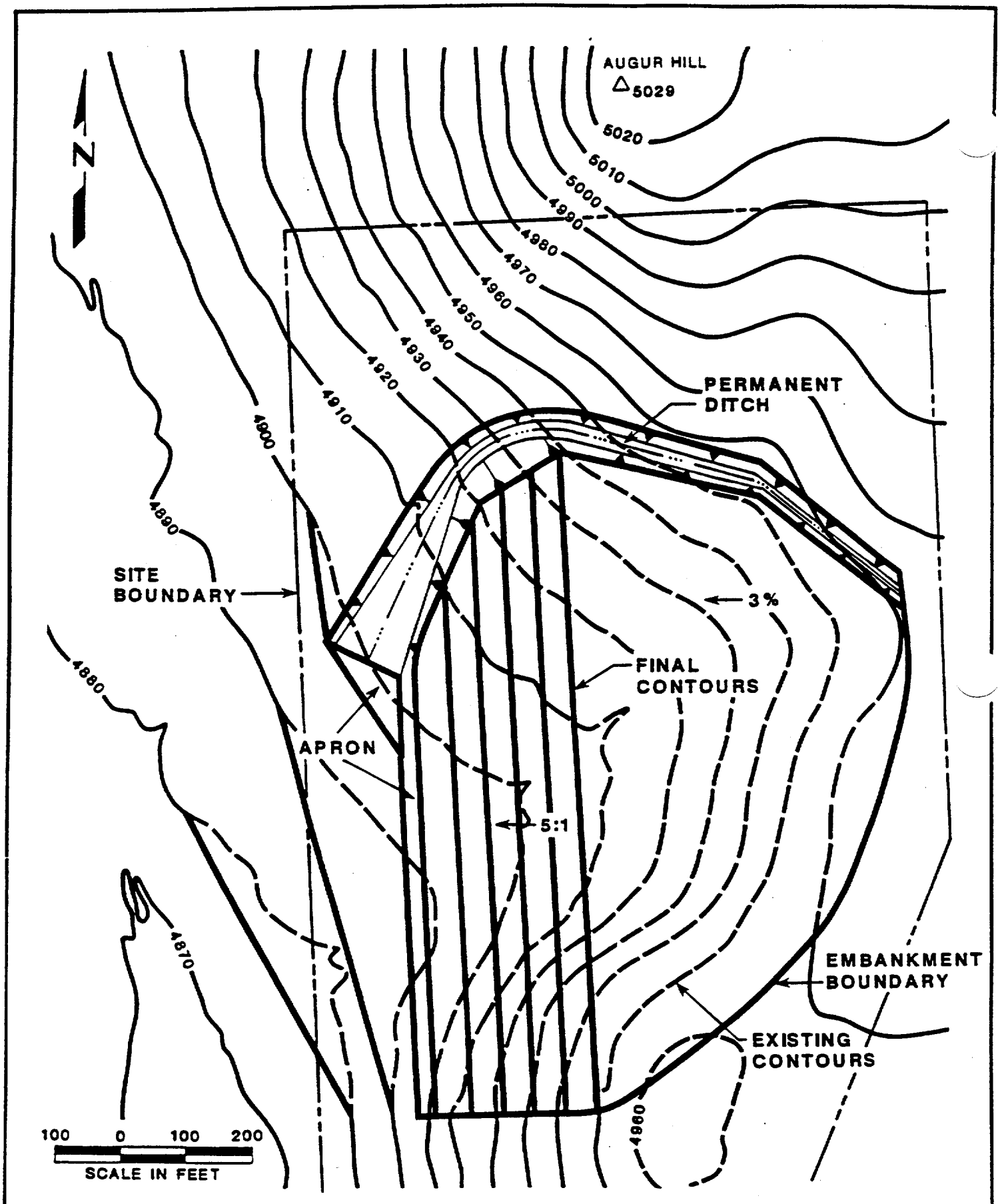

FIGURE 5.2
FINAL CONDITION, COLLINS RANCH DISPOSAL SITE

stability. Inconveniences and increased hazards to the local public were minimized by considering working schedules and construction vehicle routes. The sites were fenced during construction to prevent public access and the completed Collins Ranch disposal site will have custodial surveillance and maintenance to assure continued long-term compliance with EPA standards once construction of the remedial action is completed.

The following major design objectives were established:

- Relocate the contaminated material to the Collins Ranch site, which is in a less populated and more environmentally stable location than the processing site.
- Reduce the average radon flux from the tailings disposal embankment to the atmosphere to levels less than 20 pCi/m^2s.
- Design controls at the embankment to be effective for up to 1000 years, and at least 200 years, with minimum maintenance.
- Minimize inadvertent human or animal intrusion into the disposal site.
- Ensure that existing or anticipated beneficial uses of ground and surface water are not adversely affected by the stabilized tailings.
- Reduce contaminant levels at and around the Lakeview processing site to levels which do not exceed 5.0 pCi/g of Ra-226 above background in the top 15 cm of soil and do not exceed 15 pCi/g in any 15-cm layer below that depth.
- Minimize the land area of the final disposal area.
- Protect against releases of contaminants from the site during construction through runoff and sediment control.
- Minimize areas disturbed during construction and minimize exposure of workers and the general public to contaminated materials.
- Release the entire Lakeview processing site for unrestricted use by private or public entities consistent with Lake County zoning ordinances.

5.4 DESIGN FEATURES

The remedial action stabilized the uranium mill tailings and contaminated material at the Collins Ranch disposal site in a manner that complies with EPA standards. Detailed engineering design plans and construction specifications provided the basis for final cost estimates and for the award and execution of construction contracts. The permanent and temporary construction design features, including the rationale for the results of the design, are discussed in this section. The calculation summaries in Appendix B provide detailed support for the design rationale.

The principal feature of the design was the removal of contaminated materials from the Lakeview processing site and consolidation of the tailings and contaminated soils into a disposal embankment at the Collins Ranch site. The major construction activities for the action are listed below.

- Preparation of both sites, and construction of wastewater retention basins at both sites to protect against release of contaminants. Temporary security fencing was installed at both sites.

- Construction of drainage control measures to direct generated wastewater and storm water runoff to the retention basins during construction activities.

- Installation of groundwater monitor wells at the Collins Ranch site.

- Re-routing of Hammersley Creek to flow east and then south of the existing tailings pile as necessary to keep water out of the construction area, and relocation of uncontaminated wood chips from the raffinate pond to a clean area on the site.

- Installation of measures to control erosion and sedimentation from disturbed areas during construction if required.

- Protection of surface and subsurface utilities at the Lakeview processing site during construction.

- Where required, upgrading of the haul road, the Fremont Lumber Company logging road, from northwest of the processing site to the north side of Augur Hill.

- Construction of on-site access roads to the haul road at the processing site and the disposal site.

- Excavation of materials at the Collins Ranch site and preparation of the geochemical/flow barrier liner.

- Excavation and loading of tailings and other contaminated material into trucks and transport to the disposal site.

- Construction of the tailings embankment at the Collins Ranch disposal site.

- Construction of the final cover system over the tailings to inhibit water infiltration, radon emanation, and wind and water erosion.

- Restoration of the excavated areas at the Lakeview processing site.

- Revegetation of disturbed areas at the Lakeview processing site and of the topslope of the completed tailings embankment and disturbed areas at the Collins Ranch site.

- Construction of a four-strand barbed wire fence along the western site boundary; construction of 270 feet of new fence from the northwest corner eastward to a tie-in point into the existing woven wire fence; and installation of an access gate along the southeast site boundary line.

- Installation of warning signs at the Collins Ranch site to prevent inadvertent human intrusion and discourage unauthorized alteration of the site.

5.5 PERMANENT DESIGN FEATURES

5.5.1 Layout

The tailings embankment at the Collins Ranch site was sized to contain approximately 925,810 cubic yards of contaminated material and covers approximately 13 acres. The height of the tailings pile design was increased by 3.6 feet to accommodate the additional cubic yards of contamination. The embankment was built against the southwest slope of Augur Hill. A drainage ditch directs runoff water away from the site (Figure 5.2). The site is approximately seven miles northwest of Lakeview, Oregon. The northern edge of the embankment is approximately 0.75 mile south of the Forest Service road at the north line of Section 12. (See Figure 5.3.)

5.5.2 Decontamination and restoration

The mill area, tailings pile, and evaporation ponds area of the Lakeview processing site were decontaminated by excavation of the contaminated soil, demolition of some small foundations, and consolidation of this material into the stabilized embankment at the Collins Ranch disposal site. All uncontaminated wood chips, which were located in the evaporation ponds area, were relocated to a clean area on Precision Pine Lumber Company property. The contaminated wood chips were placed in the embankment; however, the amount was limited and evenly distributed so that no more than five percent organics by volume are contained in any area of the pile.

The evaporation ponds area contained 1.0 to 1.5 feet of contaminated soil. Contamination below the tailings pile averaged two feet below the tailings-subbase interface. The contaminated materials to be consolidated in the embankment are discussed in greater detail in Appendix B, Calculation Summaries.

During processing site preparation, Hammersley Creek, which flowed north of the existing tailings pile, was rerouted to a channel east and south of the tailings pile. After the remedial action was completed, Hammersley Creek remained in the relocation channel. The completed channel was designed to contain the flow resulting from a 10-year storm event; however, the channel will

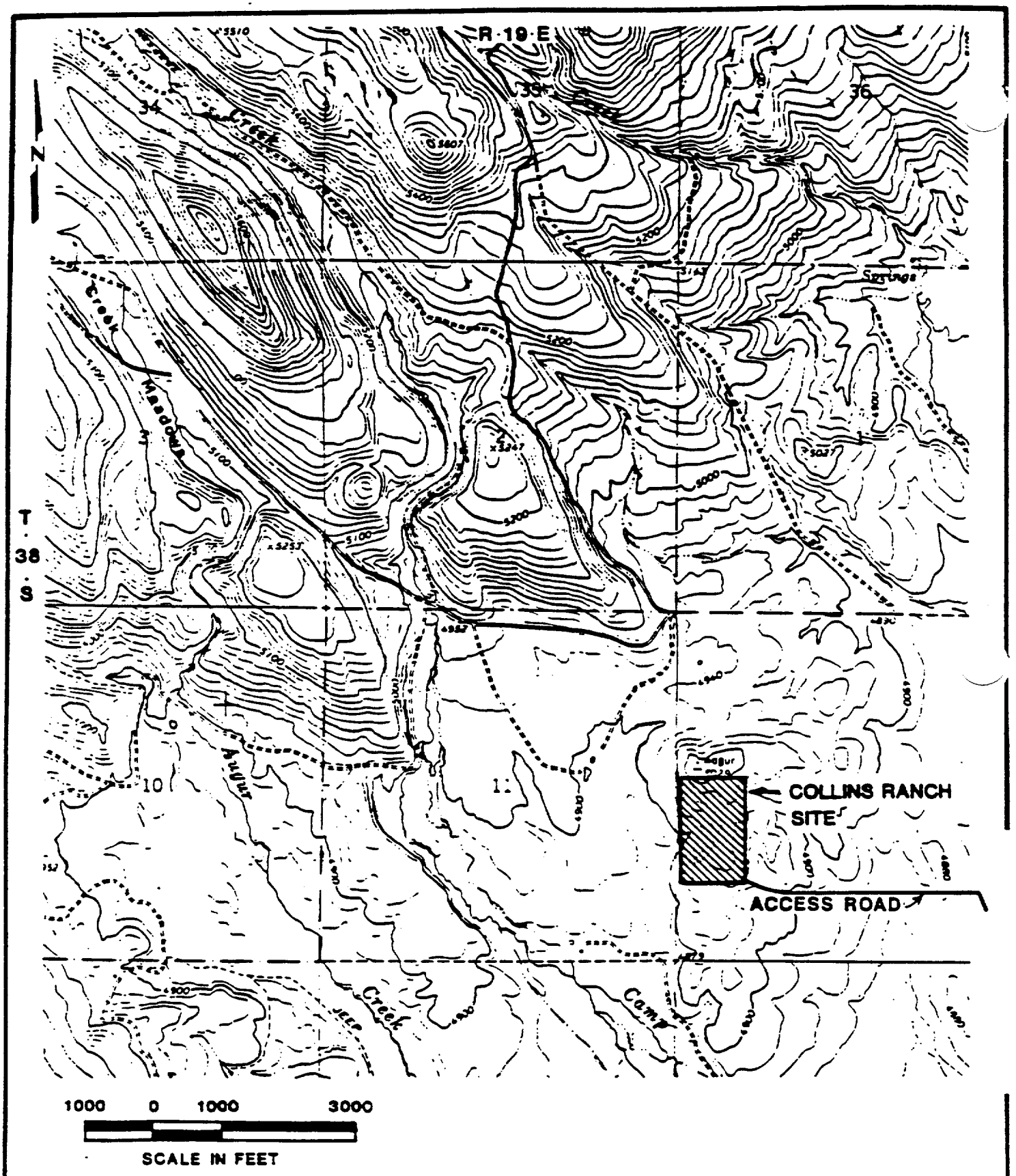

FIGURE 5.3

COLLINS RANCH DISPOSAL SITE

never flow at its design discharge because the culvert beneath the road east of the site will constrict the flow in the channel to much less than the design flow. There is virtually no possibility for the relocated creek channel to migrate or meander since erosion protection in the channel has been designed for the 10-year event. Therefore, the relocation is considered to be permanent. The rerouting is shown in Figure 5.4.

After removal of all contaminated material, the areas of excavation on and around the Lakeview site were backfilled with uncontaminated fill and contoured as required for site drainage.

The design for the backfill at the Lakeview processing site was modified due to the additional contaminated materials encountered during remedial action and the availability of smaller quantities of clean fill than expected at the processing site. The DOE proposed to the owners of the processing site that the finished grade be reduced by six to 12 inches, thereby reducing the required backfill volume by approximately 150,000 cubic yards. The owners of the processing site agreed to this modification. However, it was still necessary to excavate and haul approximately 287,000 cubic yards of additional backfill materials from nearby borrow sources.

5.5.3 Embankment construction

The embankment was designed to contain approximately 925,810 cubic yards of contaminated materials from the Lakeview processing site and vicinity properties, to provide long-term stability, and to ensure adequate radon control. The embankment is located to most effectively use the natural topography of the area in order to reduce the potential effects of erosion.

Relocated tailings were placed in lifts and compacted on top of a geochemical/flow barrier liner constructed of select, in situ soils from the site. This layer reduces the amount and rate of possible contaminant migration toward the groundwater table. The groundwater table is approximately 30 feet below the tailings at its closest point, depending on seasonal fluctuations. Because the tailings were incidentally mixed during excavation and again during the unloading, spreading, and compacting at the Collins Ranch disposal site, extensive lenses of slimes did not exist in the compacted tailings. Consequently, differential and total settlement will not adversely affect the long-term integrity of the embankment. Detrimental settlements will not occur in the foundation, due to the overconsolidated nature of the soils there.

Once placement of the tailings was completed, contaminated soil from the evaporation ponds and windblown areas was placed in lifts and compacted on top of the relocated tailings.

Organic materials such as wood demolition debris and grubbed vegetation were evenly distributed throughout the embankment so

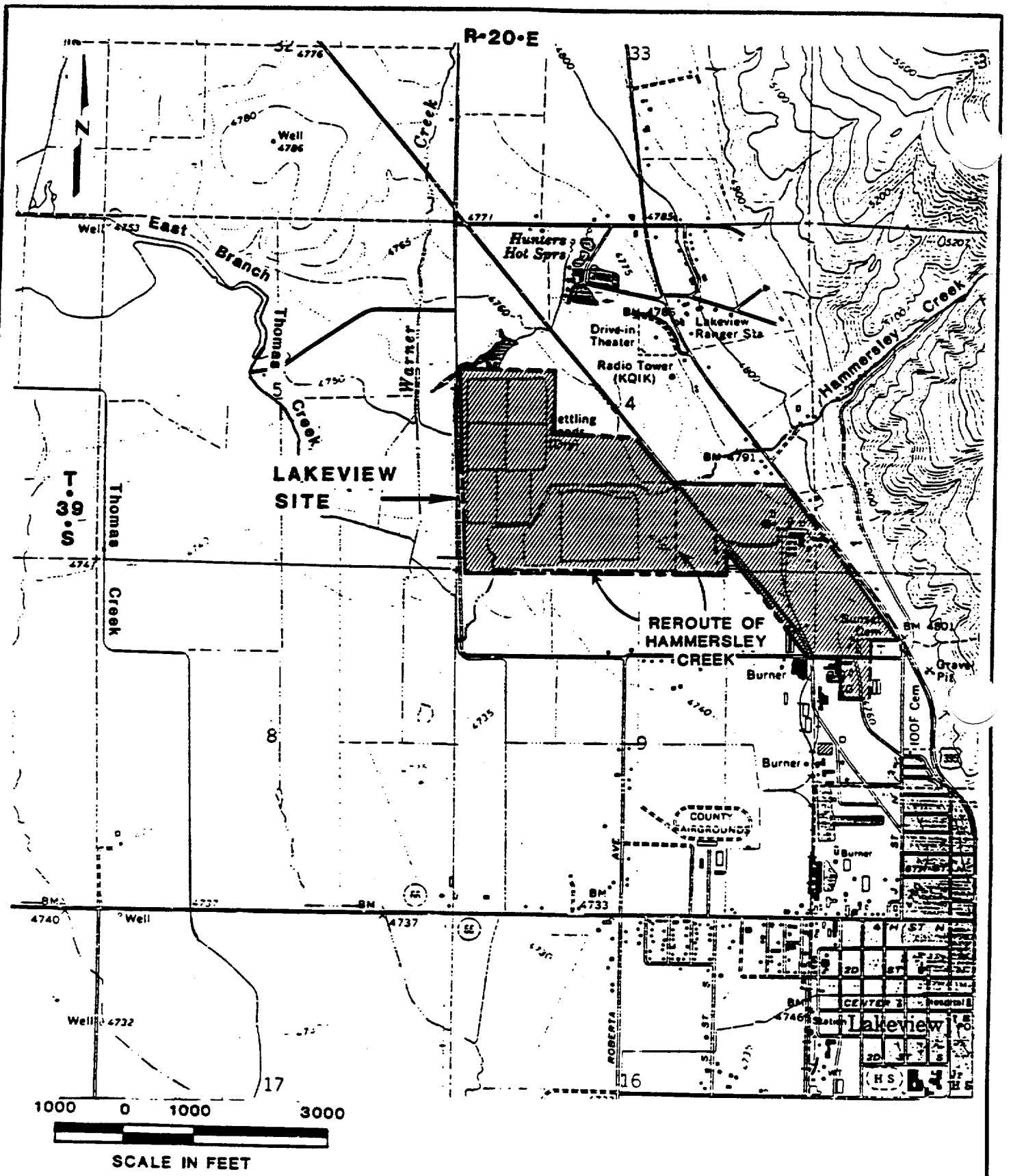

FIGURE 5.4
LAKEVIEW SITE MAP

that no more than five percent organics by volume are contained in any area of the pile. Rubble pieces were placed in the lower portions of the embankment and surrounded with compacted tailings. The procedures for this activity were specified to ensure the material was placed to avoid concentration in any area and to ensure good compaction of material around the rubble. The soils excavated from the evaporation ponds, windblown areas, and other areas of lesser contamination were the last contaminated materials placed in the embankment, in order to help reduce the overall radiation levels. Site preparation details and embankment compaction criteria are presented in the Project Site Design Criteria (DOE, 1984a) and Appendix B, Calculation Summaries.

Limiting the embankment topslopes to a two to four percent grade and the sideslopes to a 20 percent grade provided the necessary factor of safety against embankment slope failure and reduced the potential effects of erosion. A typical section of the embankment is presented in Figure 5.5.

5.5.4 Cover construction

The radon emanation rate was reduced to less than the EPA standard of 20 pCi/m^2s by placing a compacted 1.5 foot thick radon barrier layer of uncontaminated silt and clay. The radon barrier thickness was based on information obtained during construction to provide the optimum design. The actual test data on the radon barrier are available for this report and included in Appendix B, Calculation Summaries. The materials in the upper portion of the tailings embankment are materials from the windblown areas and the evaporation ponds. These materials showed average contamination of about 16 pCi/g Ra-226. The construction sequence specified that the less contaminated materials would be placed over the more contaminated tailings to reduce the radon exhalation. The compaction of the radon barrier layer produced a barrier that also retains moisture and lessens infiltration.

The radon barrier is protected by a one-foot-thick layer of rock and a six-inch highly conductive sand filter/drainage layer on all sides, and a rock-soil matrix on the topslope (two to four percent). The rock layer is designed to protect the radon barrier from erosion for 1000 years and thus prevent exposure of contaminated materials. The rock and rock-soil matrix cover will increase the long-term soil moisture content of the compacted radon barrier. The rock cover will also prevent erosion due to wind and water on or adjacent to the pile. The highly conductive sand filter/drainage layer will protect the fine-grained soils of the radon barrier from piping and erosion and at the same time will provide a means of shedding water from the pile surface quickly.

The rock erosion protection material is designed to withstand the occurrence of the Probable Maximum Precipitation (PMP). A PMP is defined as the maximum precipitation that could occur from the

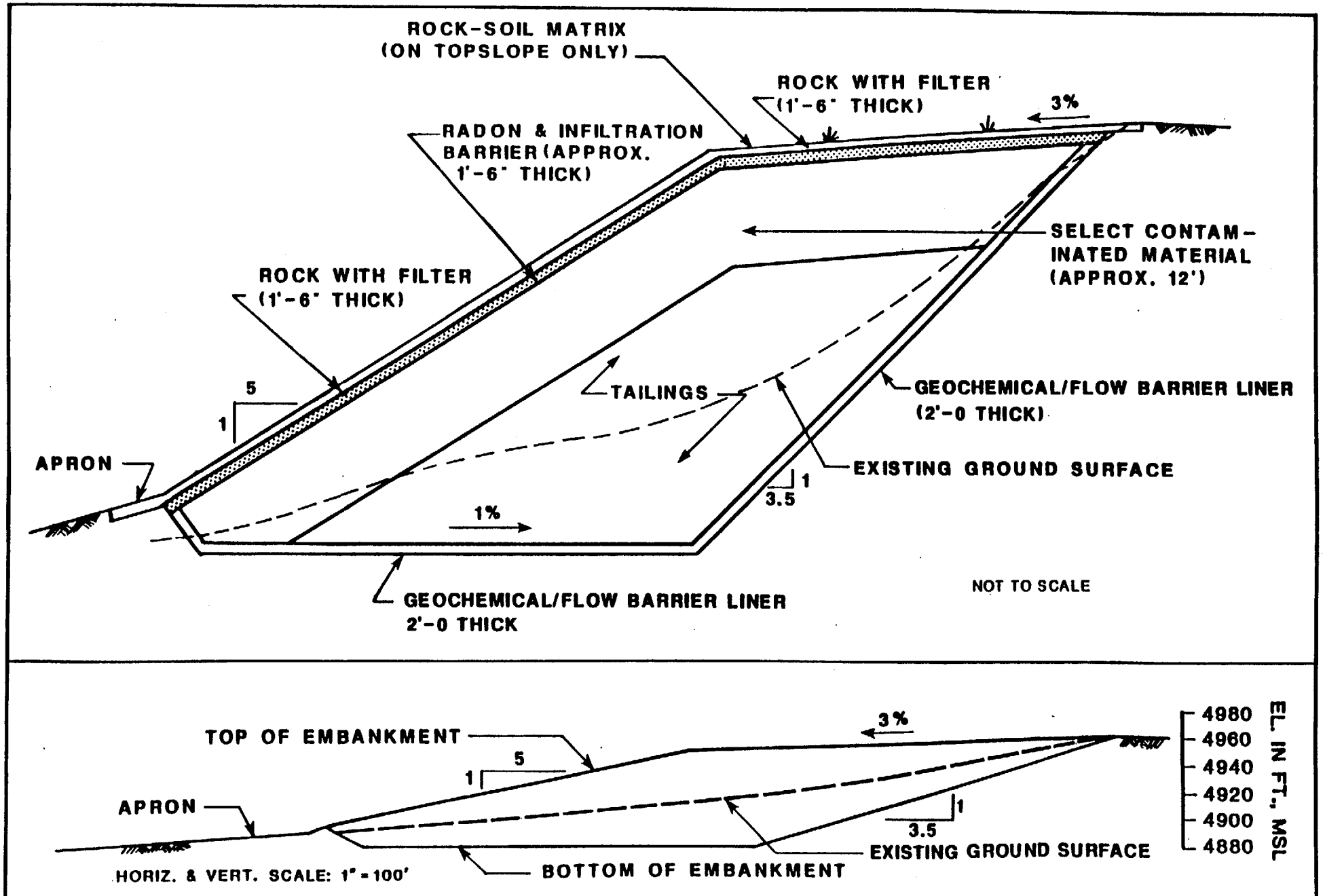

FIGURE 5.5
COLLINS RANCH DISPOSAL SITE, TYPICAL CROSS SECTION

most severe combination of meteorological conditions that are reasonably possible in a region. For the Collins Ranch area, the local one-hour PMP storm is 8.4 inches. Based on this one-hour intensity, the maximum (2.5 minute) intensity was calculated. This 2.5 minute intensity was converted to an equivalent one-hour rainfall intensity of 39.6 inches per hour, which was then used for sizing the topslope erosion protection material. An intensity of 30.6 inches per hour was required to size the sideslope erosion protection material. A one-foot-thick erosion protection layer of 1.5-inches (or larger) mean diameter rock on the topslopes (two to four percent) and a one-foot-thick layer of 2.7-inch (or larger) mean diameter rock along the sideslopes (20 percent) protects the embankment from the effects of a PMP. (See Appendix B, Calculation Summaries.)

The rock layer also protects the embankment from wind erosion and discourages burrowing animals. The completed embankment topslopes are covered with a rock-soil matrix and revegetated with native grass species. Slopes steeper than 10 percent are subject to high erosion stresses, which lead to rill and gully erosion (DOE, 1985e).

A rock-soil matrix, a combination of vegetation and surface rock, was used to cover the completed topslopes rather than vegetated topsoil. A topsoil cover would increase the potential for gully formation and flow concentrations, thereby requiring larger mean diameter rock for erosion protection on the embankment slopes and at its base. The rock-soil matrix is capable of supporting vegetation similar to that found in the Collins Ranch area and at the same time protect against erosion. The rock-soil matrix was not used on the sideslopes. Figure 5.6 illustrates the embankment cover system for the embankment topslopes (see Appendix B, Calculation Summaries).

5.5.5 Site drainage

The drainage features of the embankment, along with general site grading, ensure long-term embankment stability. The embankment sideslopes blend into the natural slopes south of Augur Hill. Runoff from the embankment flows to the apron and then to the adjacent natural ground, modified by grading to inhibit formation of gullies, and then to the natural drainage patterns southwest of the site. Runoff from Augur Hill is intercepted by a drainage ditch located adjacent to the embankment and directed to the natural drainage patterns southeast of the site. The ditches have depths sufficient to carry the runoff from the PMP storm event (see Section 5.5.7 and Appendix B, Calculation Summaries). Rock erosion protection in the ditches prevent erosion of the adjacent embankment cover (see Appendix B for pertinent calculations). Sediment buildup in the ditches are flushed during significant precipitation events, which create velocities capable of moving sediment.

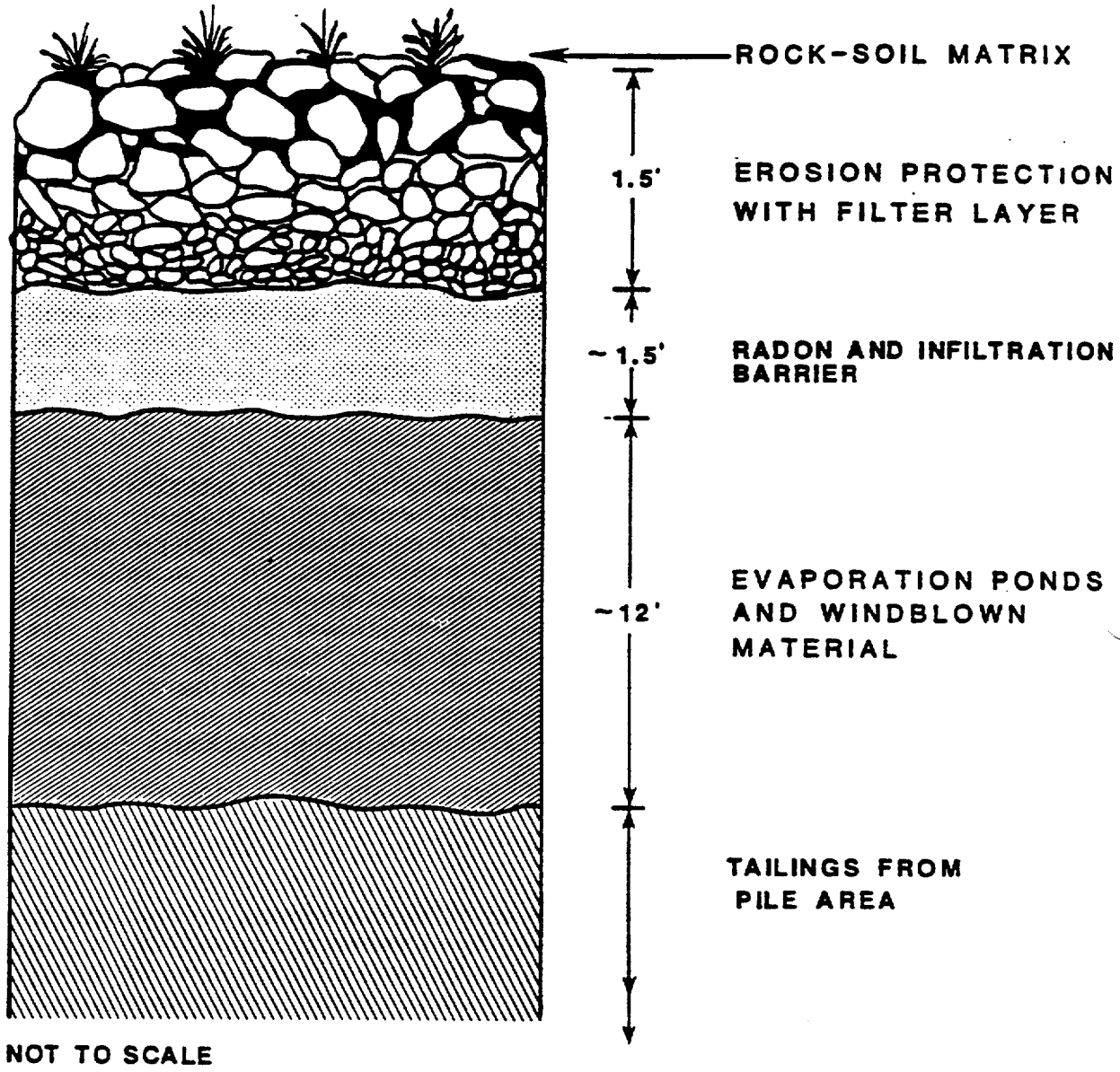

FIGURE 5.6
COLLINS RANCH COVER SYSTEM, TOPSLOPES

The exposure of two seeps along the north wall of the disposal cell during excavation resulted in the need to provide a drainage system for any potential water exiting these areas. A subsurface drain system was installed to carry any potential seep water away from the tailings and channel such water around the northern perimeter of the cell. A series of monitor wells was installed above the drainage system to monitor any accumulation of water in the seep area. These wells are monitored for water quantity only.

5.5.6 Groundwater protection

An unconfined to semi-confined groundwater system has been identified in the Collins Ranch disposal site area. The groundwater exists in a series of silty fine sands and clayey silts to an estimated depth of 1000 feet. Depth to water ranges from at least 20 to 30 feet below the proposed base of the tailings. The groundwater moves from northwest to southeast beneath the site, counter to the topographic slope, with depths to groundwater increasing towards the divide of Augur Hill. This indicates that predominant recharge to the groundwater system is from the Fremont Mountains to the west, rather than through the on-site soils. Details of existing groundwater quality and calculated hydraulic parameters are discussed in Appendix B, Calculation Summaries.

Three major design features that serve to mitigate potential groundwater contamination at the Collins Ranch site are placement of a geochemical/flow barrier liner on the sides and below the tailings; installation of a compacted radon/infiltration barrier above the tailings, and the inclusion of a high conductivity sand filter/drainage layer placed on top of the radon barrier.

The high conductivity sand filter/drainage layer is composed of clean sand and gravel with a hydraulic conductivity of 1.0 cm/s or greater. Bedding thickness was increased to require a minimum thickness of at least six inches instead of 90 percent of six inches. This allows for rapid shedding of water off the tailings pile.

The radon barrier was made less permeable than the liner by compacting the radon barrier to a higher density than the liner at the base of the tailings; this avoids the possibility of a "bathtub" effect. The low permeability (hydraulic conductivity) of the soils in the radon barrier reduces seepage of water below the tailings pile and cause a uniform seepage front. Laboratory analyses of recompacted soils taken from test pits at the site indicated that the permeability (hydraulic conductivity) of the soils in the compacted earth cover is less than 1×10^{-7} centimeters per second (cm/s). Thus, infiltration, the driving force for leachate production, and mobilization of contaminants into the groundwater system is minimal.

The liner placed underneath the tailings and the radon barrier is composed of natural recompacted silt and clay soils (ML, MH, and CL designations in the Unified Soil Classification System). These types of soils have high neutralization, adsorpion, and ion exchange potential and thus provide a high attenuative capacity to restrict downward contaminant migration through the liner. Together, the filter layer, radon/infiltration barrier and geochemical/flow barrier will provide adequate groundwater protection to comply with the proposed EPA groundwater standards.

Presently, the depth to groundwater is greater than 50 feet beneath most of the existing ground surface at the disposal site; depths decrease at the toe of the excavated embankment on the edge of the valley. Water-level fluctuations from the autumn of 1984 to the summer of 1985 were less than two feet. The minimum depth to groundwater is about 20 feet below the geochemical/flow barrier liner. Groundwater monitoring is being performed after construction to verify that unacceptable groundwater contamination does not occur.

5.5.7 Flood protection

Cross-drainage runoff at the Collins Ranch disposal site would result from the collection of runoff due to precipitation over the 29-acre drainage area above and including the site. A permanent drainage ditch was constructed with depths capable of carrying the runoff resulting from a PMP event. The PMP runoff discharge for the ditch adjacent to the north edge of the embankment is 230 cubic feet per second. Erosion protection in the ditch and on the embankment is designed to remain intact during and following the unlikely occurrence of a PMP (calculations and summaries are given in Appendix B).

The protection described above will prevent any possible flooding of the tailings site. Flooding from the drainage area northwest of the site is estimated to produce flows that will not reach the toe of the embankment.

5.5.8 Site access

Access for custodial inspection purposes is provided by an easement to the site. An access gate is located along the southeast site boundary fence.

5.6 CONSTRUCTION FEATURES

5.6.1 Layout

Construction activities occurred at the processing and disposal sites and along the haul road, where required.

The Remedial Action Contractor (RAC) was responsible for determining the exact location and size of all construction features such as the staging areas, decontamination facilities, temporary drainage ditches, and wastewater retention basins. The following paragraphs present the general layout to allow a better understanding of all aspects of the remedial action.

At the processing site, the staging area was northeast of the tailings pile. An equipment decontamination pad was located adjacent to the staging area. Hammersley Creek, which flows just north of the present tailings pile, was relocated to flow east of the pile and then south of the designated site boundary. Ditches or berms surrounding the site directed uncontaminated water flows to Hammersley Creek. Contaminated water was directed to a wastewater retention basin constructed on the site. A temporary fence isolated the staging area and the entire site.

At the Collins Ranch disposal site, the staging area and the decontamination pad were located in the southwest corner of the site. Drainage ditches surrounded the site and collected all runoff on the site and any water collected from excavation dewatering (if necessary). Flow in these ditches was channeled to a wastewater retention basin, located west of the embankment area. Temporary fences enclosed the entire site, the staging area, and the lease area. A stockpile area was located west of the embankment, and was used for stockpiling materials from the excavation.

5.6.2 Site access

Equipment was decontaminated as required prior to leaving the Lakeview processing site and the tailings embankment area at the Collins Ranch disposal site. The temporary fences controlled traffic entering and leaving the site and prevented unauthorized traffic from entering controlled areas.

5.6.3 Staging area facilities

During construction operations, temporary facilities were required for construction workers along with supervisory, engineering, administrative, security, and radiation monitoring personnel. The facilities consisted of office space, showers, and change facilities for personnel decontamination (if necessary), and included provisions for laundering contaminated clothing. Portable construction toilets were provided for on-site workers. On-site equipment was stored in the staging areas.

5.6.4 Utilities

All known existing utilities at the Lakeview site, as shown in Figure 5.7, were protected during construction or were relocated as necessary prior to construction.

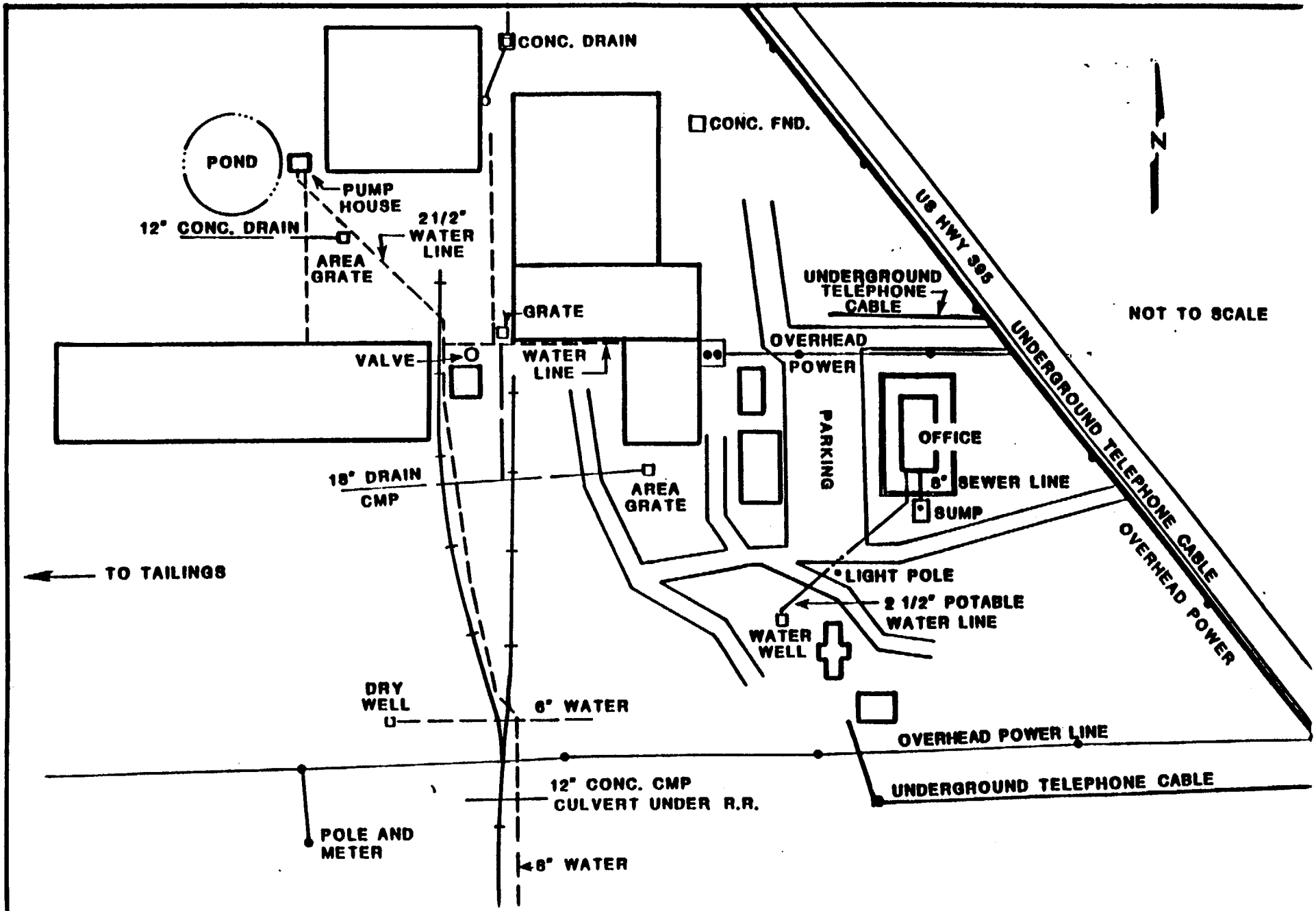

FIGURE 5.7
LOCATION OF EXI[illegible]G UTILITIES, LAKEVIEW SITE

Potable water for personnel needs at the processing site and the disposal site and a source of construction water for both sites were provided by the RAC or its construction subcontractor, as necessary.

No electricity, gas, or other utilities are available at the Collins Ranch disposal site. Electricity was supplied by running power lines and by generators. Telephone service was provided.

There is no developed water supply at the disposal site. Water for equipment decontamination, compaction, and dust control on the site was developed from an on-site well. A holding pond was developed to store water. Potable water was hauled from the nearest available source.

5.6.5 Drainage, erosion control, and wastewater retention basin

During remedial action, all drainage from both sites was effectively diverted from any waterways. Areas disturbed by construction activities were graded to direct runoff to the wastewater retention basins. In addition, the ditches were designed and maintained to carry the peak flow due to the 10-year one-hour storm event, for the area tributary to the channel. Runoff from land outside of affected areas was diverted away from the site by diversion ditches designed and maintained to prevent overflow from the peak flow due to the 10-year one-hour storm event (see Appendix B, Calculation Summaries).

The wastewater retention basins received waters resulting from:

- Runoff from contaminated materials (potentially the greatest source of water) and disturbed areas.
- Decontamination activities, including equipment and truck washdown.
- Wastewater from laundering protective clothing and shower and wash basin wastewater generated from occasional personnel decontamination.
- Processing site dewatering effluent (if contaminated).

The retention basins at both sites were designed to retain the runoff from a 10-year 24-hour storm as well as the wash water from the decontamination operations and site dewatering. The retention basins additionally had sufficient capacity to hold all sediment inflow over the life of the project without any need for removal. The emergency outlets from the basins were designed to safely discharge the one-hour, 25-year storm peak runoff while maintaining one foot of freeboard or as required by permit. The final location of the retention basins is shown on the final design drawings. Appendix B provides design criteria for these basins.

5.6.6 Wastewater handling

Wastewater generated from sources listed in Section 5.6.5 was collected and handled to minimize the need for any discharge from the sites. Wastewater handling comprises the following major elements:

- Settlement of sediment in wastewater in the retention basins.
- Evaporation from the retention basins.
- Construction water for moisture conditioning and dust control in contaminated areas.
- Snowmelt runoff from the partially stabilized tailings pile at Collins Ranch.

Contaminated water was effectively treated using the means listed above. The number of retention basins was increased to contain all the sediment generated during construction as necessary. At the end of construction, contaminated sediment was added to the embankment at the Collins Ranch site.

The retention basins were shaped to maximize evaporation by having as much surface area as practical.

If unusually wet conditions made an emergency discharge necessary, wastewater was tested prior to discharge. Under such conditions, it was considered unlikely that contaminant concentrations would be above acceptable levels due to the high amount of dilution that occurred. In the event unacceptable concentrations were encountered, the RAC specified measures to ensure that any discharge meets applicable standards. (See Appendix B, Calculation Summaries, for more details.)

The original design for a wastewater retention basin at the disposal site had insufficient capacity to hold stormwater and snowmelt runoff during winter and spring seasons without release of water from the basin. This factor, along with an increased volume of water generated from the decontamination facility, required the installation of two additional wastewater retention basins, with a design capacity of five acre feet and 10 acre feet. Figure 5.8 shows the location of the two new retention basins.

Due to the additional water impounded at the Collins Ranch site, it was necessary to transport the former Canonsburg, Pennsylvania, wastewater treatment plant to Lakeview for water treatment. This chemical precipitation/membrane filtration system is capable of treating 160 gpm average with a peak capacity of 210 gpm. The location of the treatment plant is visible on Figure 5.8, adjacent to the middle evaporation pond (pond 2).

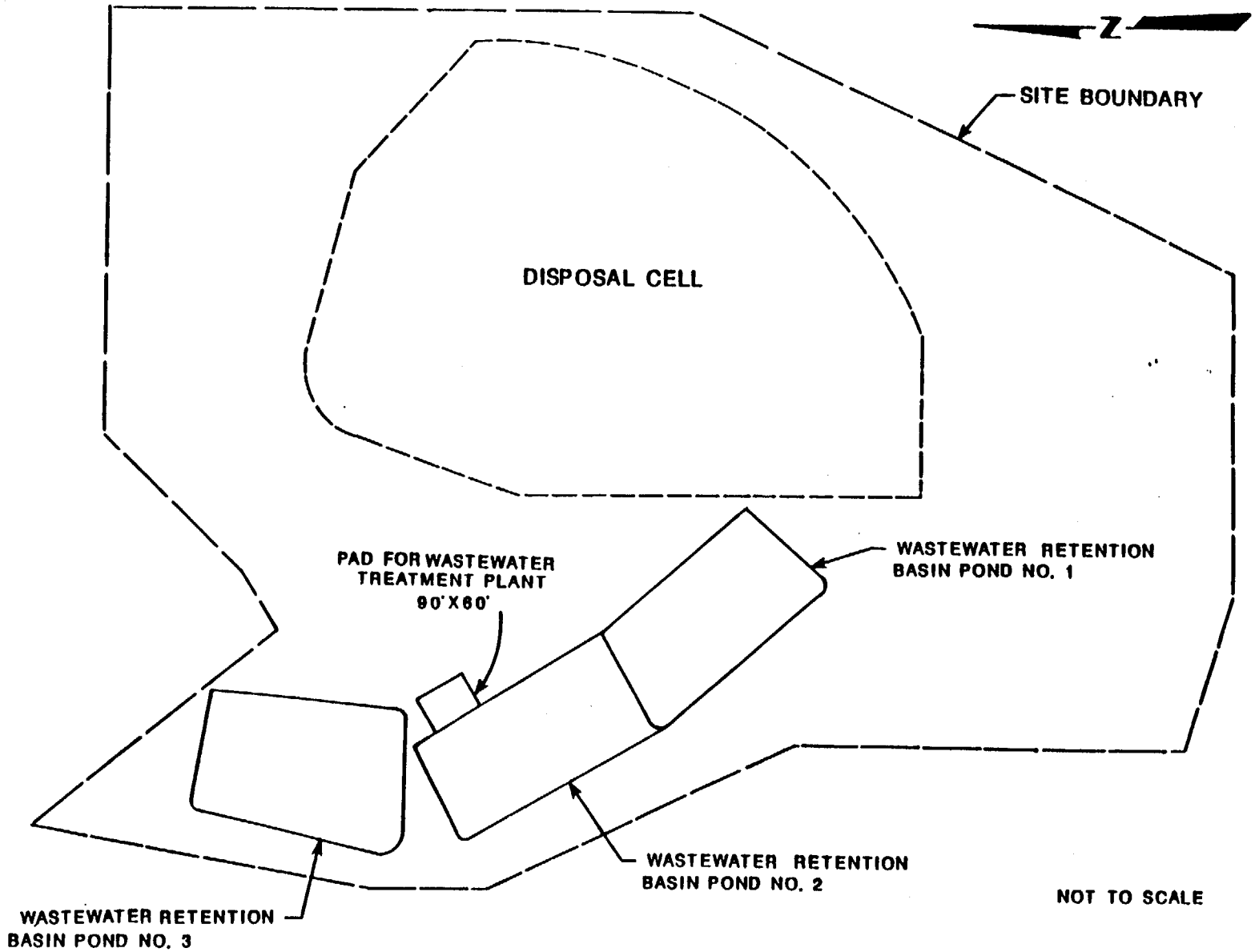

FIGURE 5.8
WASTEWATER RETENTION BASINS

5.6.7 Dewatering

Groundwater at the Lakeview processing site is one to 25 feet below the ground surface and at times rises into the base of the tailings. The RAC encouraged the construction subcontractor to excavate deeper materials during drier portions of the year to minimize dewatering. A small volume of tailings was dried to a compactable moisture content.

5.6.8 Equipment decontamination pad

Decontamination pads were provided to wash contaminated equipment and trucks at both the Lakeview processing site and Collins Ranch disposal sites, thereby preventing contaminated materials from being carried out of the areas. Ditches and sumps were used to direct washwater to the retention basins.

5.6.9 Dust control

Dust generated by excavation, earth movement, vehicle use, temporary material stockpiling, and similar activities was controlled and minimized by the use of water, and water-based surfactants, sprayed from hoses or trucks. Special care was taken to control dust created by building decontamination or demolition and the temporary stockpiling or mixing of contaminated materials.

The sources for dust suppression water in contaminated areas included recycled water from the wastewater retention basins, or water from tailings and subsoil dewatering. Uncontaminated water was used for the clean areas.

The schedules for spraying the roads and pile areas varied daily and were determined on an hour-by-hour basis. The frequency of spraying increased when combinations of low soil moisture and high wind speed are encountered.

In the event that extreme dust conditions occurred, specific controls were implemented to ensure that radioactive contamination was not dispersed into the general environment of the site.

The RAC Construction Safety and Health Management Program provides more restrictive controls as follows:

Section XIV - Environmental Control and Monitoring

A. Environmental control and monitoring are required to ensure that radioactive contamination, industrial toxics, or other hazardous materials do not disperse, by wind or water, into the general environment of the site. This may be accomplished as follows:

1. Boundary dust collection discs and continuous air monitors will be an integral part of the RAC environmental control program. The dust collection discs will be monitored on a daily basis to track radioactive dust dispersion. Continuous air monitors will give monthly, quarterly, and annual results to monitor off-site dispersion of particulates. The RAC Environmental Assessment Manager will determine when particulates will be analyzed for gross alpha or when isotopic and elemental analyses are necessary.

2. In the event that either of the above control monitors indicate an increase approaching unacceptable levels of radioactivity, subcontractors may be required to take the following action: reduce vehicle speeds, water dusty construction areas, and/or stop work for extreme weather conditions. The site Radiological Safety Officer (RSO) in conjunction with the site manager will determine when these measures will be necessary.

3. Water monitoring is also required to ensure no significant degradation of potable water supplies during remedial action. Construction activities may require modification in the event that a contamination problem is indicated.

B. Noncompliance with the above requests will be resolved through the RAC DOE Albuquerque Project Office.

Additional site-specific controls will be developed and issued by the RAC prior to construction.

5.6.10 Borrow areas

Commercial quarries in Deadman's Canyon, near Lakeview, Oregon, were available that contained erosion protection and filter materials suitable for use on the embankment, ditch, and roads. Materials for radon barrier, geochemical/flow barrier liner, and site grading and restoration (at both sites) were obtained from the disposal site excavation.

5.6.11 Construction sequence

The following construction sequence represents the sequence for remedial action. The construction subcontractor was allowed the flexibility of executing his work as he chose, given certain constraints. Therefore, the actual construction sequence may have differed slightly from the following.

Initially, an access control system was established at each site and coordinated with staging and vehicle decontamination areas. A fence was installed around each site. This provided control of traffic entering and leaving each site and prevented unauthorized traffic from entering either site.

The next major item of site preparation consisted of constructing a wastewater retention basin at each site. Site preparation also included construction of drainage and erosion control measures. At the processing site, Hammersley Creek was re-routed to flow east and south of the existing pile and the uncontaminated on-site wood chips were relocated. Concurrent with these activities, construction of the access roads and any necessary upgrading of the haul road began.

Once the initial site preparation at the Collins Ranch site was completed, preparation of the disposal area began. This involved the excavation and stockpiling of surface materials to allow for the partially below-grade disposal of the tailings. Topsoil was excavated and stockpiled for use in the rock-soil matrix. After the required materials were excavated and acceptable materials were selected, the geochemical/flow barrier liner was constructed.

Concurrently, the building decontamination and demolition process (as necessary) was performed. Dewatering activities also began at this time. Tailings were excavated and moved, then contaminated materials were excavated from the windblown areas and evaporation ponds and consolidated into the disposal embankment. The movement of contaminated materials did not begin until upgrading of the haul and access roads was completed, and a sufficient area opened and prepared at the disposal area.

Uncontaminated cover materials were added to the relocated pile after the contaminated materials were in place. The uncontaminated fill was obtained from selected materials excavated from the disposal site area. Permanent drainage ditches were excavated adjacent to the stabilized tailings pile. Final closure of the embankment was not made until all contaminated materials had been placed, including those materials from demobilization activities. The embankment topslopes were covered with a rock-soil matrix and revegetated. Signs and monuments were placed around the site.

The final stages of restoration at the existing tailings site included providing overall site drainage, grading, and revegetation. Restoration involved the addition of uncontaminated fill to the excavated areas as required to meet EPA standards. Fill was also necessary to restore the excavated tailings area to provide drainage. The fill was obtained from the materials excavated from the Collins Ranch disposal site and other areas as necessary.

Demobilization consisted of the removal of the wastewater treatment plant, wastewater retention basins, and drainage ditches. Any contaminated water was treated and the bottom sediments and dikes were tested, and, if necessary, transported to Collins Ranch for disposal in the embankment. All decontamination areas were removed and the equipment cleaned for salvage. The staging areas were destroyed and contaminated items either

cleaned or disposed of in the embankment. All contractor equipment was decontaminated and inspected prior to release from the contaminated areas. At the present time, all contaminated materials have been relocated to the Collins Ranch site.

5.7 BASIS FOR EXCAVATION

A radiological support plan (RSP) (see Appendix C) defines the monitoring surveys which were required at the processing site during excavation of contaminated materials. A final survey certified that applicable radiation standards were met following completion of construction. The DOE prepares this plan and has the responsibility for implementing the program. The following subsections describe the purpose of the RSP.

5.7.1 Radiological survey plan

Radiological surveys are performed for three purposes: site characterization, excavation control, and final radiological verification. Site characterization surveys or pre-remedial action surveys have been performed to identify volumes of material which exceed the EPA standards. The results have been used for planning and engineering design purposes. Excavation control monitoring is necessary as the work is being done to guide and control the amount of contaminated material to be removed. Finally, when the excavation control monitoring results indicate that the area meets the standards, a final radiological survey will be carefully performed to assure compliance with the cleanup criteria and the results will be documented.

5.7.2 Certification

During the remedial action operations, the DOE made data related to the cleanup available to appropriate Federal and state agencies. In addition, samples could be split for analysis by these agencies to allow comparison of analytical results. These data, along with any additional data reflected at the discretion of the certifying agent, are being used for the final certification report.

The DOE is certifying that remedial action has been completed according to the plan and final design, and the site meets applicable standards.

5.8 PROPOSED FINAL CONDITION

The completed tailings embankment is partially below grade. The embankment fits into the natural contours on the southwestern slopes of Augur Hill. The embankment extends approximately 1060 feet at its longest section and 870 feet at its widest. From its base it rises approximately 60 feet at a slope of 5 horizontal to 1 vertical; at this

point it is approximately 40 feet above the present ground surface. From this section it rises at a two to four percent slope until it blends into the existing topography to the east and south. Tailings and contaminated material are located below the present ground surface at depths varying up to 40 feet. The completed embankment covers an area of approximately 13 acres. The embankment is covered with one foot of rock to protect against erosion, and the topslope is covered with a rock-soil matrix to support revegetation. Drainage channels adjacent to the embankment divert off-site surface drainage away from the embankment. Monuments were established at set intervals designating the embankment as Federal property.

6.0 WATER RESOURCES PROTECTION STRATEGY

6.1 INTRODUCTION

This section summarizes the water resources protection strategy used to achieve compliance with the proposed EPA groundwater protection standards at the Lakeview uranium mill tailings disposal site. A more detailed discussion is provided in Appendix F, Compliance Strategy for the Proposed EPA Groundwater Standards.

The proposed remedial action at the Lakeview uranium mill tailings site consisted of relocating the mill tailings and other contaminated materials seven road miles northwest to the Collins Ranch disposal site. There they were stabilized in a partially below-grade disposal cell which consists of a two-foot thick geochemical/flow barrier below the tailings, a low permeability radon barrier on top of the tailings, and a rock cover layer containing a highly conductive sand filter/drainage layer to allow the tailings pile to shed surface water quickly. The disposal unit at the Collins Ranch site was designed to control residual radioactive materials and nonradioactive contaminants as required by the proposed EPA standards in 40 CFR Part 192(a)(3).

Testing of the background water quality data for those constituents that are part of the proposed EPA standards (52 FR 36,000) at the Collins Ranch site indicated that all constituents were below EPA standards. Tailings source concentrations have been measured from chemical analyses or pore fluids gathered from suction lysimeters placed in the Lakeview tailings pile and nearby evaporation ponds. A total of 26 samples were gathered and analyzed in this area.

Mean analytical values were obtained for all constituents in the tailings pore water or evaporation ponds except for net gross alpha and Ra-226 and -228. Three constituents exceeded the maximum concentration limits (MCLs) established by the proposed EPA groundwater standards. These were arsenic, cadmium, and uranium (U-234 and U-238). All constituents were within the MCL requirements in less than 50 feet and met or exceeded the MCL level at the point of compliance (POC), which is the downgradient edge of the tailings waste management unit. Appendix IX organics (40 CFR Part 264) were not detected in samples collected from two shallow monitor wells at the Lakeview processing site. Analytical test results are found in Appendix F.

6.2 PERFORMANCE ASSESSMENT

The performance evaluation to assess compliance of the disposal unit with the proposed EPA groundwater protection standards (by demonstrating MCLs are met) indicates that performance is primarily a function of the relative low concentrations of hazardous constituents in excess of the proposed EPA standards. Groundwater transport modeling utilized the method-of-characteristics (MOC) model developed by Konikow and Bredehoeft (1978) to represent lateral flow while the analytical procedure of Domenico and Robbins (1985) was used to estimate the distance required to

effect mixing of leachate and groundwater through hydrodynamic dispersion. The results showed attenuation of concentrations of all constituents to EPA MCLs within 50 feet of the edge of the tailings pile. Further details are presented in Appendix F.

6.3 PERFORMANCE MONITORING

A program to monitor groundwater quality in the uppermost aquifer downgradient from the Collins Ranch disposal site during the post-construction period will be addressed in the long-term surveillance plan (LTSP) prepared for the Collins Ranch site. At the point of compliance and downgradient from the cell, the DOE installed eight monitor wells to monitor groundwater quality and static water levels.

The exposure of two seeps along the north wall of the disposal cell during excavation resulted in the need to provide a drainage system for any potential water existing in these areas. A subsurface drainage system was installed to carry any potential seep water away from the tailings and channel such water around the northern perimeter of the cell.

6.4 CORRECTIVE ACTION

The EPA's proposed standards, 40 CFR 192(c), require that a corrective action program be implemented within 18 months after verifying that the established concentration limits for one or more of the monitored constituents have been exceeded. The NRC's regulations, 10 CFR 40.27 (c)(5) specify that the DOE will notify the NRC prior to implementing any significant action(s) that may be required.

Once a potential problem has been identified, the DOE will notify the NRC and will submit an inspection/preliminary assessment report to the NRC for review within 60 days of the report of the problem. After the NRC has reviewed the report and the recommendations in the report, the DOE will develop a corrective action program and submit it to the NRC for approval. The DOE will transmit a copy of the inspection/preliminary assessment report and corrective action plan to the affected state or tribe for review. Once the NRC has approved the corrective action, the plan will be implemented by the DOE.

6.5 AQUIFER RESTORATION

The DOE has decided that aquifer restoration (groundwater cleanup) will be addressed under the next task of the UMTRA Project and be part of a separate National Environmental Policy Act (NEPA) process because the present level of site characterization is sufficient only to address whether the remedial action will comply with proposed EPA standards. Groundwater cleanup requires extensive geochemical characterization of residual wastes and a more intensive investigation of unsaturated flow and aquifer properties. A conceptual strategy must be developed, modeled,

and/or tested on a benchmark scale if restoration is to take place. Realistic concentration limits and a cleanup standard could be proposed after this has been performed.

Aquifer restoration at the Lakeview processing site is not addressed in this remedial action plan because the contaminated materials were disposed of at the Collins Ranch site. For this reason, water quality impacts resulting from disposal of contaminated materials at Collins Ranch will have no impact on aquifer restoration at the Lakeview processing site. Hence, remedial action can be decoupled from aquifer restoration at the Lakeview site.

7.0 ENVIRONMENTAL, HEALTH, AND SAFETY

7.1 UMTRA PROJECT HEALTH AND SAFETY POLICY

The UMTRA Project health and safety policy requires that the DOE and its contractors take all reasonable precautions in the performance of the remedial action work to protect the health and ensure the safety of employees and the public. The DOE must comply with all applicable Federal and state health and safety regulations and requirements including, but not limited to, those established pursuant to the Occupational Safety and Health ACT (OSHA).

7.2 ENVIRONMENTAL, HEALTH, AND SAFETY PLAN

The Environmental, Health, and Safety Plan, Appendix D, specifies the basic Federal safety and health standards and special state, local, and DOE requirements applicable to the remedial action at Lakeview. This section provides an overview of the plan and summarizes its key features. Responsibilities in carrying out this plan are delineated. Where not otherwise specified, the RAC had principal responsibility for implementing this plan. Guidance on program requirements and radiation control and monitoring is also included.

7.3 RESPONSIBILITIES

The responsibilities of the DOE, state and local governments, and the RAC for environmental, health, and safety are described below:

7.3.1 The DOE UMTRA Project Office, and appropriate divisions of the Albuquerque Operations Office

- Conduct periodic surveys, with assistance from the Technical Assistance Contractor (TAC), of contractor programs and site activities, and prepare Health and Safety Audit Reports.
- Act on employee inquiries and complaints in accordance with procedures outlined in this plan.
- Ensure compliance with the health and safety standards by reviews of UMTRA Project contractor performance, and reviews of violations of the prescribed plan and the timing and manner of correction.

7.3.2 The State of Oregon and local governments

- Participate in the remedial action planning by identifying and interpreting applicable local or state regulations.

- o Advise the DOE UMTRA Project Office of changes to regulations which apply to this project.

- o Identify and assist in obtaining necessary reviews and approvals to comply with environmental regulations.

7.3.3 The RAC

- o Develop implementation procedures for the requirements set forth in this plan.

- o Execute programs and policies in a manner that shall ensure compliance with the requirements set forth in this plan.

- o Assure that the required information specified in subsequent sections of this plan is recorded and reported.

- o Submit requests for variance from the design criteria of this plan to the DOE Contracting Officer or Contracting Officer's Representative.

- o Include implementation requirements and procedures of the plan in all applicable subcontracts.

7.4 KEY FEATURES OF THE HEALTH AND SAFETY PLAN

The following elements are included in the Environmental, Health, and Safety Plan (Appendix D):

7.4.1 General

The RAC maintained on-site professional radiation health staff members whenever contaminated materials were exposed. These personnel developed and implemented procedures for all activities involving potential safety or radiological health risks.

7.4.2 Community protection

During construction, an environmental monitoring program was conducted to document the effects on the environment and exposure of the general population to environmental hazards resulting from remedial action activities. Air particulate samples, radon-222 (Rn-222) samples, groundwater samples, and surface water samples were collected and analyzed for radiological parameters. In addition, groundwater and surface water samples were analyzed for stable chemical parameters. Monitors were located in areas mutually acceptable to the state and the DOE. Monitoring locations included the upwind and downwind site boundary, and a background location.

In addition, an array of environmental radon monitors were placed around the site to provide a measurement of the average radon concentration. In order to provide immediate information, one or more real-time continuous radon monitors were also located near the site or in the community to provide an hourly read-out of radon concentrations.

Operating response plans were prepared by the RAC to formulate response to severe weather events, construction accidents, or medical emergencies. Operational alert levels were developed to control any elevated radon emissions detected by monitoring programs during construction activities. Typical responses to elevated radon levels include additional wetting of exposed contaminated material, reduction of the uncovered area, or suspension of operations. Administrative controls were utilized to limit increases in off-site radon levels to three pCi/l averaged during a 52-week period, and six pCi/l averaged during any calendar quarter.

7.4.3 Worker protection

Training sessions applicable to the degree of radiation hazard present at the site were conducted for all employees prior to the start of work. These sessions included a discussion of site conditions, potential radiological hazards, effects of radiation, and emergency procedures. Records were maintained to document successful completion of training by employees.

Controlled areas were designated and conspicuously marked. Access control points were established for controlled areas, and all personnel and equipment were monitored. Access control records were maintained and included a log of personnel and equipment entering and leaving the restricted area, and a log of dosimeters issued.

Protective clothing was distributed to employees at the access control point when conditions warranted. Change and cleanup facilities were provided.

Thermoluminescent dosimeters (TLDs) or film badges were supplied to permanent employees working in controlled areas. Dosimeters were changed quarterly, or more frequently if necessary. Urinalysis was used to monitor employee internal exposures, and additional dosimetry was required if positive results were noted. A system of employee health records was maintained to document individual radiation exposures and the results of personnel dosimetry and bioassays.

Air particulate samples were collected in work areas and at site boundaries. Samples were analyzed for gross alpha levels, and stored for later isotopic analyses if necessary. Additional samples were collected in work areas where ventilation is limited, and analyzed for radon daughter concentrations.

A respiratory protection program, with procedures for training employees and checking for adequate fit of respirators, was developed by the RAC. Respirators were used in work areas where the airborne particulates cannot be controlled by dust suppression measures. An administrative warning limit was established to restrict exposure to airborne particulate concentrations to 25 percent of the regulatory limit for radionuclides. Industrial hazards were controlled in accordance with OSHA regulations.

As referenced in the Health Physics Monitoring Plan, a formal radiological training program was initiated to include the following.

Health physics training program

A formal radiological training program, including discussion of the biological effects associated with exposure to ionizing radiation, was provided to all site workers. The program included discussion of the radiological safety procedures, emergency procedures, and instructions concerning prenatal radiation exposure. Practical demonstrations of equipment usage were incorporated where appropriate. Literature concerning biological effects of radiation was provided to workers, as were copies of USNRC Reg. Guide 8.13, "Instructions Concerning Prenatal Radiation Exposure."

All site personnel received formal instruction in construction safety procedures, as per the program outlined in the RAC Safety and Health Management Program Plan.

Initial training sessions were approximately two hours in length. An appropriate level of training was required of workers, based on anticipated exposure levels, and upon level of management responsibility as discussed previously. Each worker passed a written examination demonstrating comprehension of the training program contents. Permanent records of instruction and examination results were maintained by the site Radiation Safety Officer and the RAC, with copies forwarded to DOE upon completion of each training session.

Topics considered during the radiological training sessions included:

- Summary of UMTRA Project objectives.

- Radiation types.
  - Beta.
  - Gamma.
  - Alpha.

- Units.
  - Roentgen.
  - Rad.
  - Rem.
  - Counts per minute (CPM).
  - Disintgration per minute per 100 cm^2 (DPM/100 cm^2).
  - Curie (Ci).

- Protection against radiation.
  - Time (including calculation of dose and stay time).
  - Distance.
  - Shielding.

- Protection against contamination.
  - Protective clothing (including demonstration).
  - Smoking, eating, or drinking in controlled areas.

- Biological effects.
  - Effects of acute dose.
  - Effects of chronic dose.

- Radiation zones.
  - Radiation symbol and colors.
  - Controlled area.
  - Radiation area.
  - Airborne radioactive area.
  - Posting, physical, and administrative areas.

- Personnel monitoring for radiation.
  - Film or TLD badges.
  - Self-reading dosimeters.
  - Exposure records.
  - Other types of personnel monitoring instrumentation.

- Dose limits (DOE Order 5480.1A).
  - Whole body dose.
  - Skin dose.
  - Extremity dose.
  - Airborne activity.
  - Emergency dose.
  - NRC form, NRC-4.

- Personnel monitoring for contamination.
  - Survey when leaving contaminated area.
  - Whole body counting.
  - Bioassay.

- Radiation records.
  - Exposure records.
  - Bioassay records.
  - Accuracy of information.
  - Records retention.

An appendix to the RAC Health Physics Monitoring Plan, entitled "Lakeview Health Physics Plan," (Chem-Nuclear, 1986) was also issued prior to start of construction. That appendix addressed training and other programs tailored to site-specific conditions.

8.0 RESPONSIBILITIES OF PROJECT PARTICIPANTS

8.1 INTRODUCTION

The following defines the various responsibilities of the DOE UMTRA Project Office, the NRC, and the State of Oregon during detailed design and remedial action, and through the initiation of custodial surveillance and maintenance. Responsibilities are divided into major categories to be performed by the parties. The DOE has been assisted by its TAC, the Jacobs-Weston Team, and RAC, Morrison-Knudsen, Inc., (M-K). In general, the TAC assists in the preparation of concept designs and remedial action plans and provides quality assurance, audits, and recommendations for final certification. The RAC prepares detailed designs, manages field construction and environmental, health, and safety activities, provides quality assurance/control, and provides certification data. Most of the State of Oregon responsibilities were performed by the Oregon Department of Energy.

Major areas of responsibility for actions by the DOE, the State of Oregon, and the NRC can be summarized as follows:

1. DOE (including TAC, RAC):

   Manage project activities.
   Assist State of Oregon in site acquisition.
   Obtain permits and approvals.
   Prepare detailed designs and specifications.
   Prepare Remedial Action Inspection Plan (RAIP).
   Prepare and implement Environmental, Health, and Safety Plan.
   Conduct remedial action.
   Audit remedial action.
   Negotiate in good faith with the state regarding any changes to this RAP.
   Prepare licensing plan and submit license application.
   Prepare LTSP.
   Certify remedial action.
   Obtain license.
   Conduct surveillance and maintenance.

2. DOE/State of Oregon:

   Coordinate project activities.
   Implement public participation and information plan.
   Provide funds.

3. State of Oregon:

   Concur in Remedial Action Plan (RAP).
   Acquire designated processing and disposal sites.
   Assist in obtaining local permits.
   Issue applicable state permits.
   Review preliminary design documents.

Review final design documents and issue notice to DOE consenting to incurrence of construction costs.
Review and comment on the Environmental, Health, and Safety Plan.
Review and comment on the LTSP.
Agree with DOE on the remedial action schedule.
Negotiate in good faith with DOE regarding any changes to this RAP.
Review and provide comments on site Remedial Action Inspection Plan (RAIP).
Support DOE in the interim and final inspections of remedial actions for the purpose of meeting compliance or noncompliance with applicable EPA Standards.
Provide notice to DOE indicating state agreement that this Remedial Action Plan has been carried out and completed.

4. NRC:

Concur in acquisition of disposal site.
Review and concur in RAP and RAP changes.
Review and concur in LTSP.
Review and concur in final certification report.
Accept LTSP and issue a general license.

8.2 RESPONSIBILITIES

Responsibilities of project participants, including permitting, licensing, land acquisition, detailed design, construction, health and safety, public information, radiological support, quality assurance, and custodial surveillance and maintenance, are defined in the following text.

8.2.1 Regulatory compliance

Requirements for regulatory compliance, previously identified by Federal, state, and local agencies, were incorporated into the final design specifications, as needed, by the DOE.

The RAC submitted permit applications and supporting details to the agencies for permit issuance.

During the remedial action, the DOE audited construction activities for compliance with provisions in the permits and approvals. (Permitting agencies may independently audit relevant activities consistent with normal practice.) Summary audit reports were prepared by the DOE and were submitted to appropriate agencies as required.

8.2.2 Licensing

Section 104(f)(2) of the UMTRCA requires that the permanent disposal sites be cared for under one general license issued by the NRC after surface remedial action activities have been completed and the residual radioactive material (RRM) has been stabilized in the permanent disposal cell. The NRC finalized their regulations for licensing and long-term care, 10 CFR 40, in 1990. These regulations define the conditions that must be met before the general license becomes effective for each disposal site, and the requirements for long-term care.

The general license is for the Title I disposal sites only. The UMTRCA mandates that responsibility for the long-term care of these Title I disposal sites will remain with the Federal government. The purpose of the license is to ensure that the disposal cell remains undisturbed and that the stabilized RRM will not present a hazard to the public or the environment. The DOE, in accordance with the provisions of the UMTRCA, will be the licensee and the Federal agency responsible for carrying out a long-term surveillance program to meet the licensing requirements for long-term care.

The general license will become effective for the Collins Ranch disposal site at Lakeview, Oregon after (1) the NRC concurs in the DOE's certification that the surface remedial action has been completed in accordance with 40 CFR 192 and other applicable standards, (2) title to the RRM and the disposal site has been transferred to the DOE from the state of Oregon, and (3) the NRC has formally accepted the site-specific long-term surveillance plan (LTSP). The long-term surveillance program does not begin formally until after the license is in effect. Until that time, the UMTRA Project Office will monitor the site under its prelicensing program. After the disposal site is licensed, programmatic responsibility for carrying out the long-term surveillance program will be transferred from the UMTRA Project Office to the Grand Junction Project Office.

8.2.3 Land acquisition

The State of Oregon completed title searches and appraisals, and acquired the designated disposal site. The state will transfer title of the disposal site to the DOE.

8.2.4 Detailed design

In accordance with Article II.D.6 (a) (1) of the DOE-Oregon Cooperative Agreement, the DOE provided to the state the preliminary engineering drawings for state review. The DOE also prepared final design documents. The RAC consulted with the state to prequalify bidders so as to maximize the number of qualified local area bidders.

The final design and specifications were provided to the NRC and the state. In accordance with Article II.D.6.a (2) of the Cooperative Agreement, the state provided written notice to the DOE consenting to the incurrence of construction costs.

8.2.5 Construction

The RAC acquired the necessary permits and approvals from the appropriate agencies.

Construction activities were audited by the DOE, the state, and NRC. Required revisions to the remedial action resulting from site audits were incorporated into the final design, as necessary, by the DOE. Items of non-conformance identified by the state or NRC were corrected as soon as possible.

In accordance with Article II.D.7. of the DOE-State Cooperative Agreement, the state is to indicate in writing its agreement with the DOE that the Remedial Action Plan has been carried out and completed. After such agreement, the site will be certified by the DOE. The NRC will concur in the final site certification report.

8.2.6 Health and safety

The DOE prepared a site-specific Environmental, Health, and Safety (EH&S) Plan in conformance with the UMTRA Project Health and Safety Plan. The EH&S Plan was provided to the state for review and comment. As part of the implementation procedures, the DOE instituted radiation control and environmental monitoring, and developed response procedures for severe weather and medical emergencies.

Construction contractors complied with approved procedures and filed reports with the DOE that recorded the results of monitoring, and reported accidents and illnesses. Copies of reports were provided to the state as required. Records were maintained by the DOE following remedial action construction.

Employee and public complaints were investigated by the DOE. The DOE audited construction activities. The state and the NRC may perform independent audits.

8.2.7 Public information

The DOE established a local site manager who provided input into the public information process.

Prior to and during construction, the DOE and state, with assistance from local citizens, conducted public information meetings to inform the interested public of key aspects and current progress of the remedial action.

8.2.8 Radiological support

The DOE prepared and implemented a Radiological Support Plan, and took measures to independently assure the quality of the analyses and compliance with the procedures. The Radiological Support Plan was provided to the state for review and comment.

The DOE prepared a completion report, conducted a final certification survey, and provided a recommendation for site certification. The final completion report was provided to the state and NRC for review and comment. The NRC will concur in the final site certification.

8.2.9 Quality assurance

The DOE prepared a RAIP in conformance with guidelines established in the UMTRA Project Quality Assurance Plan (DOE, 1983). The DOE audited the construction activities and prepared audit reports as appropriate. The RAIP was reviewed by the state and concurred upon by NRC.

8.2.10 Long-term surveillance plan

The LTSP contains the licensing conditions for the specific disposal site. As defined in 10 CFR 40.27b, the LTSP must contain the following information:

1. A legal description of the disposal site to be licensed, including documentation on whether land and interests are owned by the United States or an Indian tribe.

2. A detailed description of the final site conditions, including existing groundwater characterization and any necessary groundwater protection activities or strategies.

3. A detailed description of the long-term surveillance program, including the proposed inspection program, reporting to the NRC, and the extent of groundwater monitoring, if required.

4. The criteria for follow-up inspections in response to observations from routine inspections or extreme natural events.

5. The criteria for instituting maintenance or emergency measures (e.g., corrective action).

The "Guidance for Surveillance and Monitoring for the UMTRA Project Long-Term Care Program" (DOE, 1990) provides guidance for carrying out the long-term care program in accordance with the licensing conditions and for preparing the site-specific LTSPs.

At the time the disposal site is completed, a draft LTSP will be prepared for review and comment by the NRC and the state of Oregon. The final LTSP will be submitted to the NRC for acceptance after their concerns and those of the state of Oregon have been addressed. The final LTSP for the Collins Ranch disposal site will contain detailed information for conducting the long-term surveillance program specific to this site. The final LTSP will be submitted to the NRC after the NRC has concurred in the DOE's certification of completion of remedial action and title to the RRM and the disposal site has been transferred from the state of Oregon to the DOE.

8.2.11 General

The state's Program Manager reviewed DOE's schedule and associated cost estimates, monthly statements of work performed, and funds expended. Any discrepancies with overall site-approved schedules, plans, and specifications were reconciled with the DOE. The Oregon Department of Energy maintained close communications with the UMTRA Project Office throughout project implementation.

The State of Oregon received quarterly billings for actual work performed. Concerns raised by local residents were jointly addressed by DOE and the state as required.

The Lakeview local task force is involved in reviewing site design and construction progress and in making recommendations to the State of Oregon, which in turn may submit such recommendations to the DOE. These include but are not limited to:

- The task force may address problems associated with such local impacts as dust control, traffic problems and road deterioration, contractor employee conduct, and others.

- The task force may suggest ways that the remedial action program can be of maximum benefit to the economic health of the community.

9.0 SURVEILLANCE AND MONITORING

9.1 INTRODUCTION

The objectives of the custodial long-term surveillance program are to assure that, upon completion of remedial action, the stabilized embankment remains undisturbed, the tailings continue to be nonhazardous to the public and the local environment, and all conditions comply with the EPA standards.

The custodial long-term surveillance program will be defined jointly by the DOE and the NRC during the license application and approval process. Following are the basic elements that may be included in this program.

9.2 SURVEILLANCE

9.2.1 Site inspections

The most effective way of ensuring that the disposal cell is functioning as designed is by conducting on-site inspections. The primary objective of the site inspection is to record any changes or modifications to the disposal cell and disposal site over time and identify potential problems at an early stage prior to the need for extensive maintenance, repairs, or corrective action. The three types of inspections are described below.

Scheduled inspections

Currently it is expected that it will take two to three years before a site is licensed. During this interim period, regularly scheduled site inspections will be conducted each year until the license is in effect.

After the license is in effect, these regularly scheduled inspections will be conducted annually for an additional five-year period. An inspection checklist, tailored to the conditions specific to the Collins Ranch disposal site, will be used to perform this inspection. The checklist will be developed and included in the draft LTSP. An inspection report with the results of the inspection and any other activity at the disposal site will be prepared annually (see Section 9.2.4).

At the end of this five-year period, the DOE will review all inspection reports, as well as any maintenance or corrective action reports. If a determination is made that less frequent inspections are required, the DOE will modify the LTSP and submit it to the NRC for acceptance. The state of Oregon also will receive a copy for review.

Follow-up inspections

Follow-up inspections are a second level of inspection to investigate and further quantify specific site problems detected during a scheduled inspection. A follow-up inspection could be required to evaluate the need for custodial maintenance, repair, or corrective action. These inspections will be conducted by technical specialists in the discipline appropriate to the problem that has been reported. Based on the recommendations from this inspection, a program of evaluative monitoring may be recommended, or immediate initiation of a corrective action program.

At the conclusion of the follow-up inspection, an inspection/preliminary inspection report will be submitted to the NRC within 60 days of the initial report of the problem. The DOE also will provide copies of these reports to the state of Oregon within the same time frame.

Contingency inspections

Contingency inspections are unscheduled inspections ordered by the DOE when it receives outside information indicating that the disposal site integrity has been threatened. This inspection could be triggered by a report of severe vandalism, continuing intrusion by livestock, or a report of an extreme natural event such as flooding or, possibly, an earthquake.

The procedures for conducting a contingency inspection, as well as the reporting requirements, are the same as those for a follow-up inspection.

To ensure that the DOE is notified in a timely manner of unusual or extreme events, the DOE will implement the contingency plans and reporting procedures with appropriate state, local, and Federal agencies (e.g., the National Weather Service and the Earthquake Information Center) when the LTSP is under preparation.

9.2.2 Aerial photographs

Aerial photographs may be used to supplement site inspections. The objectives will be to identify changes in site conditions (e.g., patterns of developing erosion that may affect the function of the design), provide visual documentation of long-term variation in site conditions, and to identify activities (e.g., road conditions, storm drainage construction) adjacent to the site that may affect its function.

Aerial photographs may also be taken on a periodic schedule. Photographs will be taken at both low (i.e., high resolution) and high (i.e., for adjacent activities) altitudes, and at oblique and vertical angles. The type of film, ground control, camera specifications, amount of aerial overlap, interpretative keys, and other

requirements will be established prior to completion of remedial action.

9.2.3 Groundwater monitoring

The need for groundwater monitoring is identified and described in the RAP. The LTSP will provide a summary of the groundwater protection strategy identified in the RAP. The LTSP also will include:

- o A summary of the hydrogeologic conditions, including background and baseline groundwater conditions.
- o The identification of hazardous constituents to be monitored, their established concentration limits, and excursion criteria.
- o A description and definition of the point of compliance (POC).
- o The groundwater monitoring network, including the number and location of the monitor wells, site surveyed coordinates and ground elevations, the unit and depth of completion, the screened interval, and well completion records.
- o Groundwater quality and water level data.
- o The frequency and extent of the groundwater monitoring program.

9.2.4 Reporting and record keeping

The DOE will prepare a report to the NRC that provides the results of the scheduled site inspections, the groundwater monitoring data, and any unscheduled inspections, repairs, or corrective actions that may have been required at the disposal site. This report will be prepared annually, in accordance with the requirements of 10 CFR 40. A copy of this report also will be provided to the state of Oregon.

The DOE will maintain complete records and supporting documentation in permanent site files. The reports, records, and supporting documentation will demonstrate that the license provisions continue to be met, provide the DOE and NRC information necessary to forecast future surveillance and monitoring, and provide information to the public to demonstrate that site integrity has been maintained.

9.3 CUSTODIAL MAINTENANCE OR REPAIR

The need for custodial activities can only be determined during the site inspection. It is anticipated that custodial maintenance or repair would be limited to fence or sign repair or weed control. If the disposal cell has a vegetated cover, planned maintenance (e.g., grass mowing) may be identified in the LTSP. The final LTSP will identify any planned custodial activities that may be required, the timing and frequency with which they will be performed, and the manner in which the work will be authorized.

9.4 CORRECTIVE ACTION

The need for corrective action will be defined by the nature and magnitude of the problem and its effect on the disposal cell's ability to comply with the EPA standards. If the need for corrective action is indicated, the DOE will initiate a program to identify the factors that caused the problem and to determine the best course of action for correcting the problem and ensuring that its recurrence is precluded.

Once a potential problem is identified, the DOE will notify the NRC and will submit an inspection/preliminary assessment report to the NRC for review within 60 days of the report of the problem. After the NRC review, the DOE will develop a corrective action program for NRC approval. Copies of these reports will be provided to the state of Oregon for review. Once the NRC has approved the corrective action, the plan will be implemented by the DOE.

If an excursion is identified during the groundwater monitoring program, 40 CFR 192.02(c) requires that corrective action be implemented within 18 months of verification of the excursion.

10.0 QUALITY ASSURANCE

10.1 GENERAL

The RAC provides and maintains an effective quality assurance (QA) program and procedural system which assures that all work, materials, supplies, and services required under the contract conform to contract requirements, whether constructed or processed by the RAC or its subcontractors or procured by subcontractors or vendors. The RAC performed adequate inspections and tests to ensure and substantiate that all work, materials, supplies, and services conformed to contract requirements.

The RAC furnished a QA test and inspection plan which defines the health, safety, and environmental activities to be incorporated into the design and/or performed during construction to ensure contract compliance and site certification. Test and inspection requirements were approved by the DOE prior to the start of any physical job site construction work under this contract. If the RAC revises the plan, the RAC will concurrently furnish a copy of the revision to the DOE for approval prior to implementing the revision on work under the contract.

10.2 QUALITY ASSURANCE PLAN

Before construction operations were started, the RAC met with the authorized DOE QA representative to review and discuss the RAC's proposed project QA plan. The meeting developed mutual understanding relative to details of the individual site plan requirements, including the formats to be used for recording and reporting tests and inspections, administration of the plan, personnel assignments, and the interrelationship between the RAC and the DOE QA representative. The RAC furnished a list of the procedures required to implement the project plan. This list included, at a minimum, procedures for data collection, analyzing samples, inspection and testing, and formats of reports to be used.

10.3 DAILY INSPECTION REPORT

The RAC prepared a daily report for every day worked, and a weekly summary report covering the RAC and/or subcontractor's operations in an appropriate format. These daily reports were maintained at the site until work was completed. These logs provide complete and factual evidence that continuous, effective quality control construction inspections and tests were performed, including but not limited to: (1) the type and number of inspections and tests involved; (2) results of inspections and tests; (3) nature of deficiencies requiring corrections; and (4) corrective actions taken.

The RAC maintained current records of all inspections and shall furnish, as part of the files at the end of the project, copies of the inspection reports and all other files appropriate to each individual

subcontract. The reports of inspection covered all work placement subsequent to the previous report and were verified by the RAC's designated QA representative.

10.4 MEASURING AND TEST EQUIPMENT CALIBRATION AND CONTROL

The RAC provided measuring and test equipment having the precision and accuracy needed to establish conformance with specified quality requirements. Calibrations were in accordance with nationally recognized standards. The RAC identified procedural systems for test equipment calibration and recall.

10.5 NONCONFORMANCES

A nonconformance and change procedural system was developed by the RAC and approved by the DOE.

10.6 RECORDS CONTROL

The RAC was responsible for generation, retention, and retrieval of legible records which provided objective evidence of conformance to the specified quality requirements. These records are considered valid only if they are completed and signed or otherwise authenticated and dated by authorized personnel. These records included, but were not limited to:

- Data on radionuclides in soil.
- Air monitoring data.
- Design review files.
- Water contaminant analysis.
- Data on personnel radiation exposure.
- As-built drawings.
- Test and inspection reports.
- Engineering specifications.
- Material certifications.
- Certificates of compliance.
- Reports and corrective action requests.
- Operating procedures.

All records are available to the DOE for review upon request. All personnel radiation exposure records were turned over to DOE upon completion of the site remedial action.

10.7 CODES AND STANDARDS

The RAC had on the job site, no later than three weeks after site mobilization, the applicable quality assurance codes and standards available for ready reference by all personnel. The RAC maintained at the job site copies of all approved-for-construction drawings, specifications, and other documents which describe the remedial action.

10.8 RECORD DRAWINGS

The RAC developed QA procedural systems to assure the use of authorized (approved-for-construction) drawings and specifications and the maintenance of current record drawings. Two full-sized sets of contract drawings were used by the RAC for this purpose. All variations from the contract drawings were depicted. Generally, the drawings reflected only such changes and/or corrections to data and dimensions shown on contract drawings. Where the contract specifications or drawings permitted optional use of more than one type of material or equipment, the type of material or equipment installed was shown on the drawings. The drawings were maintained in a current condition at all times, and were made available for review by the DOE at all times. Variations from the contract drawings were shown in the contract working drawings and were incorporated into the record drawings. Upon physical completion of the contract work, two reproducible copies of these drawings were furnished to DOE.

10.9 MATERIAL CERTIFICATION

The technical specifications may require that certain materials be certified. Two types of certifications that may be specified are:

- o Certificate of compliance.
- o Certified material test report (CMTR). When a CMTR is requested from the RAC or its subcontractors, it shall be accomplished by a certificate of compliance certifying that the tested material is actually that material incorporated in the work.

10.10 QUALITY ASSURANCE PROGRAM VERIFICATION

Verification of the QA program's implementation by the DOE may be accomplished by:

- o Review of daily or weekly summary reports.
- o On-site inspections and surveillance.
- o Periodic audits.
- o Acceptance of DOE QA recommendations based on DOE QA audits of RAC activities.
- o Any combination of the above.

11.0 PUBLIC INFORMATION AND PUBLIC PARTICIPATION

11.1 INTRODUCTION

Section III of the UMTRCA states,

> "In carrying out the provisions of this title, including the designation of processing sites, establishing priorities for such sites, the selection of remedial actions and the execution of cooperative agreements, the Secretary (of Energy), the Administrator (of the Environmental Protection Agency), and the (Nuclear Regulatory) Commission shall encourage public participation and, where appropriate, the Secretary shall hold public hearings relative to such matters in the state where processing sites and disposal sites are located."

It is the intent of the public information and public participation program to inform the interested public fully and use the feedback in the decision-making processes and remedial action activities relative to the UMTRCA-designated site near the city of Lakeview, Lake County, Oregon. The following sections describe the actions the DOE and state have taken to encourage the participation of an informed public in this project.

11.2 PUBLIC PARTICIPATION

The National Environmental Policy Act (NEPA) of 1969 requires an evaluation of the environmental impacts of major Federal actions that may significantly affect the environment. Before remedial action construction began, an EA was completed for the Lakeview site. Public participation was an important part of the preparation of the EA; the participation requirements are detailed in the Council on Environmental Quality (CEQ) Regulations (effective July, 1979) for implementing the provisions of the NEPA, and in the DOE guidelines of 1980 for NEPA compliance.

In preparing the EA, the DOE conducted individual meetings with community officials and private citizens to discuss the purpose of the proposed remedial actions and ascertain the extent of public interest in this project. At these meetings, the people were given the opportunity to express their concerns and identify what they believed to be significant issues.

The identified issues were documented in the EA and incorporated into the decision-making process. The DOE accepted written comments for a 30-day period after publication of the EA. Interested parties were given the opportunity to comment on the EA at an official comment-taking meeting in Lakeview after the EA was published.

In addition to meetings on the EA, the DOE continued to hold public information meetings in Lakeview to describe the remedial action plan for the project and receive comments which were used in the design for remedial action.

The Lakeview Remedial Action Advisory Committee, comprised of local citizens and formed to serve as a major communication link in the decision-making process, met with the DOE and state to convey community response on project activities. The advisory committee continued to meet periodically throughout the duration of remedial action construction.

Frequent meetings and briefings were held to provide information and project status updates and solicit public participation in the project activities. The DOE, state, local officials, and interested citizens were involved in discussions regarding remedial action construction schedules, radiation monitoring reports, groundwater protection plans, and other project activities.

11.3 PUBLIC INFORMATION

In order for public participation to be effective, the public had to be informed about the remedial action project in Lakeview. Several methods of information dissemination were used by the DOE. Press releases and press packets were prepared for project status updates, including report summaries, texts of presentations, and graphics.

The names and addresses of individuals, media representatives, and Federal, state, and local officials were computerized for information dissemination purposes. Information was provided to interested persons in the Federal government, state administration, and private citizens in Lake County.

A public pre-construction meeting was conducted by the DOE. Principal topics of discussion included the remedial action design and construction schedules.

An on-site representative was designated by DOE to respond to public inquiries during remedial action construction. This representative worked closely with the DOE to provide information and met frequently with the public throughout the construction period.

A variety of printed materials were prepared concerning the UMTRA Project and the Lakeview site. These included project fact sheets, a site fact sheet, and the EA. As they were printed, these materials and other fact sheets and documents were sent to interested individuals and are available in the public libraries, county offices, and the Oregon State Environmental Office. The same materials are also available at DOE designated libraries nationwide.

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APPENDIX A

REGULATORY COMPLIANCE

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A.1 INTRODUCTION

Obtaining permits and other regulatory approvals prior to the initiation of the remedial action was essential for the successful completion of the U.S. Department of Energy's (DOE's) Uranium Mill Tailings Remedial Action (UMTRA) Project at Lakeview, Lake County, Oregon. Appendix A of the draft remedial action plan (RAP) and Appendix K of the environmental assessment (EA) identified the permits, licenses, and approvals that might be required to complete the remedial action (DOE, 1985a,b). The RAP identified the agencies responsible for the various permits, the procedures and information needed for preparing these permit applications, the supervisory and principal technical personnel contacts, and the agency review processes.

The remedial action contractor (RAC), MK-Ferguson Company (MK-F), was the organization with the responsibility for obtaining most of these permits. The RAC sequenced the preparation and filing of the permit applications so that approvals were received in a timely manner without causing delay to the construction activities. The Environmental Services personnel of the Technical Assistance Contractor (TAC) provided additional assistance as needed.

This appendix summarizes the actual need for permits identified in the draft RAP, as well as additional permits identified by the RAC. Summaries of the permits issued and any special permit conditions that may have been required also are included in this appendix. Additional information can be found in Appendix F of the draft Completion Report for the Lakeview, Oregon, site (MK-F, 1990).

A.2 PERMITS

A.2.1 THREATENED OR ENDANGERED SPECIES CONSULTATION PROCESS

LEGAL CITATION: Endangered Species Act of 1973, as amended 16 USC 1531, et. seq.

AGENCY: U.S. Fish and Wildlife Service
Division of Endangered Species Office
Olympia, WA 98502

The regulations implementing Section 7 of the Endangered Species Act allow Federal agencies such as the DOE to consolidate the consultation, conference, and biological assessment procedures of Section 7 into the National Environmental Policy Act compliance documents. Consultation with the U.S. Fish and Wildlife Service (FWS) revealed that the only threatened or endangered species potentially present at the tailings site, alternate disposal sites, or borrow sites would be the bald eagle and the American peregrine falcon, occurring as vagrants or migrants. Three "biological system investigations" conducted in 1984 revealed that use of these site areas would be limited and irregular. The consultation with the FWS and the results of the biological system investigations were incorporated and referenced in the EA.

A.2.2 CULTURAL RESOURCE CLEARANCE

LEGAL CITATION: Historic Preservation Act of 1966, 16 USC 470; Executive Order 11593; and 36 CFR 800

AGENCY: Historic Preservation Office
State Parks and Recreation Division
Salem, OR 97310

Section 106 of the National Historic Preservaton Act requires that the DOE, as a Federal agency, take into account the effects of its proposed actions on properties listed or eligible for listing in the National Register of Historic Places. A Class III cultural resource survey was conducted at the processing site and alternate disposal sites; this survey did not identify any sites of historic or prehistoric significance. At one of the proposed borrow sites, two historic use sites were identified, but were not affected by the excavation of the borrow materials. The results of the Class III cultural resource survey were incorporated and referenced in the EA.

A.2.3 SECTION 404 DREDGE AND FILL PERMIT

LEGAL CITATION: Clean Water Act of 1977, 33 USC 1344; 33 CFR 323.1 (1982), 33 CFR 230 and 40 CFR 230

AGENCY: U.S. Army Corps of Engineers
Portland District
Portland, OR 97208

Placement of dredged or fill material in floodplain or wetland areas is subject to a permit issued by the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act. The remedial action at the Lakeview processing site included the removal of contaminated soils within the 100-year floodplain of Hammersley Creek. Wetlands, as defined by the FWS, also were identified in this area after the publication of the EA. However, the COE determined that a Section 404 permit was not required because the project involved excavation in non-navigable waters and no fill or dredged material was disposed of in these areas.

A.2.4 WASTEWATER DISCHARGE (NPDES) PERMIT

LEGAL CITATION: ORS 468.740; OAR Division 340-41 & 340-45

AGENCY: Department of Environmental Quality
Water Quality Control Division
Portland, OR 97204

An NPDES permit is required for all operations that discharge storm water runoff and other possibly contaminated wastewater generated by a construction site into waters of the state of Oregon. The Water Quality Control Division of the Oregon Department of Environmental Quality determined that an NPDES permit was not required for the remedial actions since storm water runoff and other possibly contaminated wastewater would be retained in on-site evaporation ponds.

A.2.5 WATER POLLUTION CONTROL FACILITIES PERMIT

LEGAL CITATION: ORS 468.740; OAR 340-41 & 340-45

AGENCY: Department of Environmental Quality
Water Quality Control Division
Portland, OR 97204

This permit is required for the construction of wastewater treatment facilities and limits the use of wastewater to on-site uses. Permit WPCF No. 100199 was approved and issued to MK-F on June 20, 1986

and expired on December 31, 1988. A special Emergency Permit (File No. 100118) for 21 days was issued to MK-F on April 25, 1988. This permit granted permission to discharge treated wastewater from the retention ponds.

A.2.6 WATER QUALITY CONSTRUCTION PERMIT

LEGAL CITATION: ORS 486.74, Oregon Administrative Rule 340-14-150

AGENCY: Water Quality Control Division
Department of Environmental Quality
Portland, OR 97204

A special permit for construction is required to control water quality (primarily turbidity) in the state of Oregon unless a Water Pollution Control Facility Permit is in effect. MK-F was issued a Water Pollution Control Facility Permit on June 20, 1986, therefore the special permit was not required.

A.2.7 WATERWAY RELOCATION PERMIT

LEGAL CITATION: ORS 541.605-541.695 and 541.990; OAR 141-85-100

AGENCY: Oregon Division of State Lands
Salem, OR 97310

This permit regulates the removal of materials from beds and banks or the filling of waterways. However, because Hammersley Creek is not a fisheries stream, the Oregon Division of State Lands determined that this permit was not required for either the removal of contaminated materials along the creek or the relocation of the creek around the processing site.

A.2.8 PERMIT TO APPROPRIATE GROUNDWATER

LEGAL CITATION: OAR Chapter 690

AGENCY: Water Resources Department
Water Rights Division
Salem, OR 97310

Prior to drilling a well, a groundwater permit is required for water used exceeding 5000 gallons per day. This permit is not required for monitor wells or pump test wells. Permit No. G-10639 was issued to MK-F on August 5, 1986. A Commencement of Construction Notice was filed on July 9, 1986 prior to well drilling, and a well report was

filed on August 18, 1986 after completion of the drilling by Roger Chancellor Well Drilling, a state-licensed drilling subcontractor, of Klamath Falls, Oregon.

All monitor wells that were abandoned during the remedial action were abandoned in accordance with ORS 537.765 and filed with the Oregon Water Resources Department in Salem, Oregon.

A.2.9 COUNTY REZONING FOR RADIOACTIVE WASTE DISPOSAL

LEGAL CITATION: ORS 197.005-197.850,
Lake County Land Use Ordinance and
Lake County Comprehensive Land Use Plan

AGENCY: Lake County Board of Commissioners
Lakeview, OR 97360

The permanent disposal of the uranium mill tailings and residual radioactive material at the Collins Ranch disposal site in Lake County required a new zoning classificaion for radioactive waste disposal. A formal written request for this zoning change was submitted to the Lake County Commissioners. Amendments to the Lake County Comprehensive Plan specifying a radioactive waste disposal classification were adopted on September 15, 1985. The Oregon Energy Facility Siting Council then applied to the Lake County Board of Commissioners for rezoning of the Collins Ranch disposal site. The Lake County Board of Commissioners approved the state of Oregon's zoning change application in County Ordinance No. 10-U, dated May 7, 1986.

A.2.10 SOLID WASTE DISPOSAL PERMIT

LEGAL CITATION: ORS 459.205

AGENCY: Department of Environmental Quality
Portland, OR 97204

A solid waste permit is required prior to operating or maintaining a woodwaste disposal site. In April 1984, the proposed woodchip disposal site was investigated by the Water Resources Department and was deemed suitable with some drainage modificatons. MK-F submitted the permit applicaiton on behalf of Goose Lake Lumber Company of Lakeview, Oregon to the state of Oregon Department of Environmental Quality and to the Lake County Planner on June 26, 1986. The Lake County Planning director submitted a Land Use Compatability Statement on July 11, 1986. Plans for the woodchip pile were approved on August 6, 1986. Permit No. 1151 was issued on October 24, 1986 to Goose Lake Lumber Company and expired on September 30, 1991.

A.2.11 BORROW SITE CONDITIONAL USE PERMIT

LEGAL CITATION: Lake County Planning Ordinance.
Lake County Comprehensive Land Use Plan

AGENCY: Lake County Board of Commissioners
Lakeview, OR 97630

The Lake County Board of Commissioners requires a Conditional Use Permit for borrow pits within Lake County. Permit No. 356 was issued to Industrial Constructors Corporation (ICC) on April 15, 1988 for work performed on the Lakeview Ministries property. After all set forth conditions had been met, the permit was closed on July 27, 1989.

Pepperling Quarry and McNeley's Borrow Pit were deemed pre-existing in July 1986 letters from the Lake County Planning Director, thereby exempting them from the permit requirement.

On June 25, 1987, Permit No. 333 was issued to Jere Barry of Lakeview, Oregon for Sheer's Quarry by the Lake County Planning Director. No special conditions or a closure date were imposed.

A.2.12 COUNTY ROAD APPROACH PERMIT

LEGAL CITATION: Lake County Ordinances

AGENCY: Lake County Road Department
Lakeview, OR 97630

Lake County, Oregon requires a County Road Approach Permit for any roads constructed off of county roads. During the remedial action no roads were constructed off any of the county roads and this permit was not required.

A.2.13 SPECIAL USE PERMIT

LEGAL CITATION: 36 CFR 251 and 252

AGENCY: U.S. Forest Service
Fremont National Forest
Lakeview, OR 97630

During the remedial action, there were no borrow sites located on National Forest lands; all hauling occurred on county and private roads, both to the disposal site and to the borrow sites. Since no National Forest lands were used, a special use permit was not required.

A.2.14 PERMIT TO OPERATE POWER DRIVEN EQUIPMENT

LEGAL CITATION: ORS 477.625

AGENCY: Oregon State Forestry Department
Lakeview, OR 97630

The Oregon State Forestry Department requires a permit for operating power driven machinery on forest lands, or within 0.25 mile of forest lands. However, since the remedial action did not operate on or within 0.25 mile of state forest lands, this permit was not required.

A.2.15 OPERATING PERMIT

LEGAL CITATION: ORS 517.750-990; OAR 632-30, et. seq.

AGENCY: Oregon Department of Geology & Mineral Industries
Mined Land Reclamation Division
Albany, OR 97321

Mining of non-Federal borrow sites requires an Operating Permit and Reclamation Plan from the Oregon Department of Geology and Mineral Industries.

Permit No. 19-0077 was issued to ICC of Lakeview, Oregon, on April 11, 1989 for the Lakeview Ministries property. After all conditions of the permit had been met, the permit was closed on July 27, 1989.

Permit No. 19-0066 was issued to ICC on June 30, 1987 for Pepperling Quarry. This permit was converted to a grant of total exemption on July 20, 1989.

Permit No. 19-0068 was issued to ICC on July 29, 1988 for the McNeley Pit. After all conditions of the permit had been met, it was closed on July 20, 1989.

Permit No. 19-0068 was issued to Jere Barry of Lakeview, Oregon, in May, 1987 for Sheers Quarry and will remain in effect so long thereafter as the permittee pays the annual permit renewal fee.

A.2.16 COMMON CARRIER PERMIT

LEGAL CITATION: ORS Chapters 756 and 767; OAR 860 Divisions 61-68

AGENCY/CONTACT: Public Utility Commission (PUC)
Safety Section
Salem, OR 97310

The Public Utility Commission (PUC) determined that permits would be required through Lake County for crossing county roads at two separate locations. The PUC also determined that a Radioactive Materials Permit (ORS 469.605(1); OAR 345-60-001 and -004(1)) was not required.

A.2.17 COUNTY STANDARD ANNUAL (HAULING) PERMIT

LEGAL CITATION: ORS 483.528

AGENCY: Lake County Road Department
Lakeview, OR 97630

Lake County, Oregon, requires a permit for hauling materials on county roads. Permit No. 86-11 was issued to ICC on July 12, 1986 and was terminated at the end of the hauling operation.

A.2.18 INSTALLATION OF MOBILE HOME

LEGAL CITATION: Lake County Land Use Ordinance
Lake County Comprehensive Land Use Plan

AGENCY: Lake County Board of Commissioners
Lakeview, OR 97630

A permit is required for the installation of all mobile homes within Lake County. This requirement applied to the office trailers at the processing and disposal sites. Permit No. 860025 was issued to MK-F on August 7, 1986, with no expiration date.

REFERENCES

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DOE (U.S. Department of Energy), 1985b. "Environmental Assessment of Remedial Action at the Lakeview Uranium Tailings Site at Lakeview, Oregon," UMTRA-DOE/EA-0271, DOE UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

MK-F (MK-Ferguson Company), 1990. Draft "Lakeview Oregon Completion Report, Volume 4, Appendix F," Albuquerque, New Mexico.

APPENDIX B

CALCULATION SUMMARIES

The draft Remedial Action Plan (RAP) proposed inserting Sections B.1 and B.2 of this Appendix in the final printed RAP upon completion and approval. This approach has been modified due to the voluminous materials involved. The final design for construction is bound separately in four volumes (Volumes I through IV), entitled "Calculations, Final Design for Construction." Full sets of these have previously been supplied to the U.S. Nuclear Regulatory Commission and the State of Oregon. Additional copies of these calculations are available for review in the UMTRA Project Office, U.S. Department of Energy, Albuquerque Operations Office, Albuquerque, New Mexico.

Appendix E, Final Plans and Specifications, contains detailed information on the remedial action design.

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B.3 GEOHYDROLOGY

B.3.1 CONCEPTUAL OVERVIEW

Data were collected at the Lakeview processing site and at the Collins Ranch disposal site for the purpose of evaluating the present and future characteristics of the groundwater regimes. From these evaluations, the changes in water levels and the rates, characteristics, and concentrations of contaminant migration resulting from the remedial action plan have been estimated.

Due to the proximity of the Lakeview processing site to geothermal activity, an alternate disposal site selection process was undertaken. The Collins Ranch site was selected as the preferred alternative based upon an initial technical evaluation, a field drilling program, and subsequent data analysis.

The detailed Lakeview processing site hydrology is described in Section 5.0 of the draft Processing Site Characterization Report for the Lakeview site (DOE, 1984). Additional data and analyses collected by the Technical Assistance Contractor (TAC) were incorporated into Appendix D of the draft Environmental Assessment (DOE, 1985a). A summary of the processing site hydrology is presented in the following paragraphs. Appendix F to this document presents the groundwater compliance strategy for the Collins Ranch disposal site, and includes site characterization data collected since publication of the draft EA and draft RAP.

The stratigraphy beneath the Lakeview processing site is extremely heterogeneous. Correlations between lithologic types from borehole logs could not be made, even for holes 20 feet apart. Directly beneath the pile are four to seven feet of moist to wet silty clay, underlain by 10 to 20 feet of saturated clayey sand and gravel, followed by three to six feet of moist silty clay. Beneath this silty clay layer are sequences of silty sands and gravel separated by interlayered silty to sandy clays to a depth of at least 2000 feet below the site (Brown et al., 1980). In the upper 75 feet, borehole logs from the processing site area show that the number and thickness of less permeable silty clay lenses decreases from the northeast to the southwest corner of the site.

Beneath the Lakeview processing site, groundwater occurs in a series of interfingered silty sands and gravels separated by discontinuous lenses of clays and silty clays. This entire sequence of sediments behaves as a single leaky hydrologic system. Monitor wells have been drilled within two groundwater zones in the vicinity of the tailings pile: a shallow zone screened about 16 to 30 feet deep, and a deeper zone screened between depths of 60 to 75 feet. The water table is lowest in the summer due to a combination of natural discharge, evapotranspiration, and downward migration caused by heavy irrigation pumpage, but is restored every year by natural recharge (Glender, 1985). This system was investigated by Ford, Bacon and Davis, Inc. (FBD, 1983).

The two shallowest perennial systems were investigated by the TAC. The locations and depths of the TAC monitor wells were based on the results of electromagnetic and surface resistivity surveys of the site and surrounding areas. The surface geophysics indicated that contamination extends approximately 600 feet west of the site boundary to a depth of about 20 to 25 feet (Darr et al., 1985). Well pairs screened in the two zones showed less than seven feet difference in water levels, indicating a small potential for downward movement of water from the shallow to the deep zone. Aquifer tests conducted in both screened zones show restricted hydraulic interconnection between saturated zones and leakage occurring between semi-confining lenses.

Groundwater beneath the Lakeview site moves from the northeast to southwest under a hydraulic gradient of approximately 0.01 (Figure B.3.1). Values of hydraulic conductivity from pump tests averaged 3.4 feet per day (ft/day) for the shallow zone and 6.9 ft/day for the deeper zone. Using the measured hydraulic conductivities, and a conservative estimate of effective porosity equal to 0.15, the calculated average linear velocity is between 0.23 and 0.46 ft/day (80 to 170 ft/year).

The maximum, potential source of groundwater contamination has been characterized with chemical analyses of 26 tailings and raffinate pore water samples. Table B.3.1 summarizes these analyses for key constituents. Table 4.1 in Appendix F includes tailings pore water analyses for several additional hazardous constituents, and includes U.S. Environmental Protection Agency (EPA) proposed maximum contaminant levels (MCLs) for these constituents. Considering that these concentrations were measured in pore water within the source, rather than in underlying groundwater, the concentrations can be considered low for arsenic, cadmium, molybdenum, and uranium. Sulfate, manganese, and aluminum concentrations in the tailings pore water are high; however, these constituents generally do not cause severe health effects. Although contaminant concentrations are higher in the tailings, the primary contaminant plumes originate from the raffinate ponds. The acid-forming potential of the residual aluminum and iron will be considered further in discussion of the Collins Ranch design.

Groundwater at and around the processing site is characterized by four different geochemical facies: (1) evaporation (raffinate) pond seepage; (2) tailings pile seepage; (3) low temperature, background water; and (4) high temperature, upward-moving geothermal water. The first two facies are contaminant sources. The last two facies are ambient. Migration of evaporation pond and tailings pile seepage is generally confined to the shallow zone above 30 feet. Leachate produced by the downward movement of water through the tailings pile and the evaporation ponds or by groundwater inundation of contaminated material is generating two plumes that merge in the area west of the tailings pile area (Figure B.3.2). The most significant source area is the southeast evaporation pond.

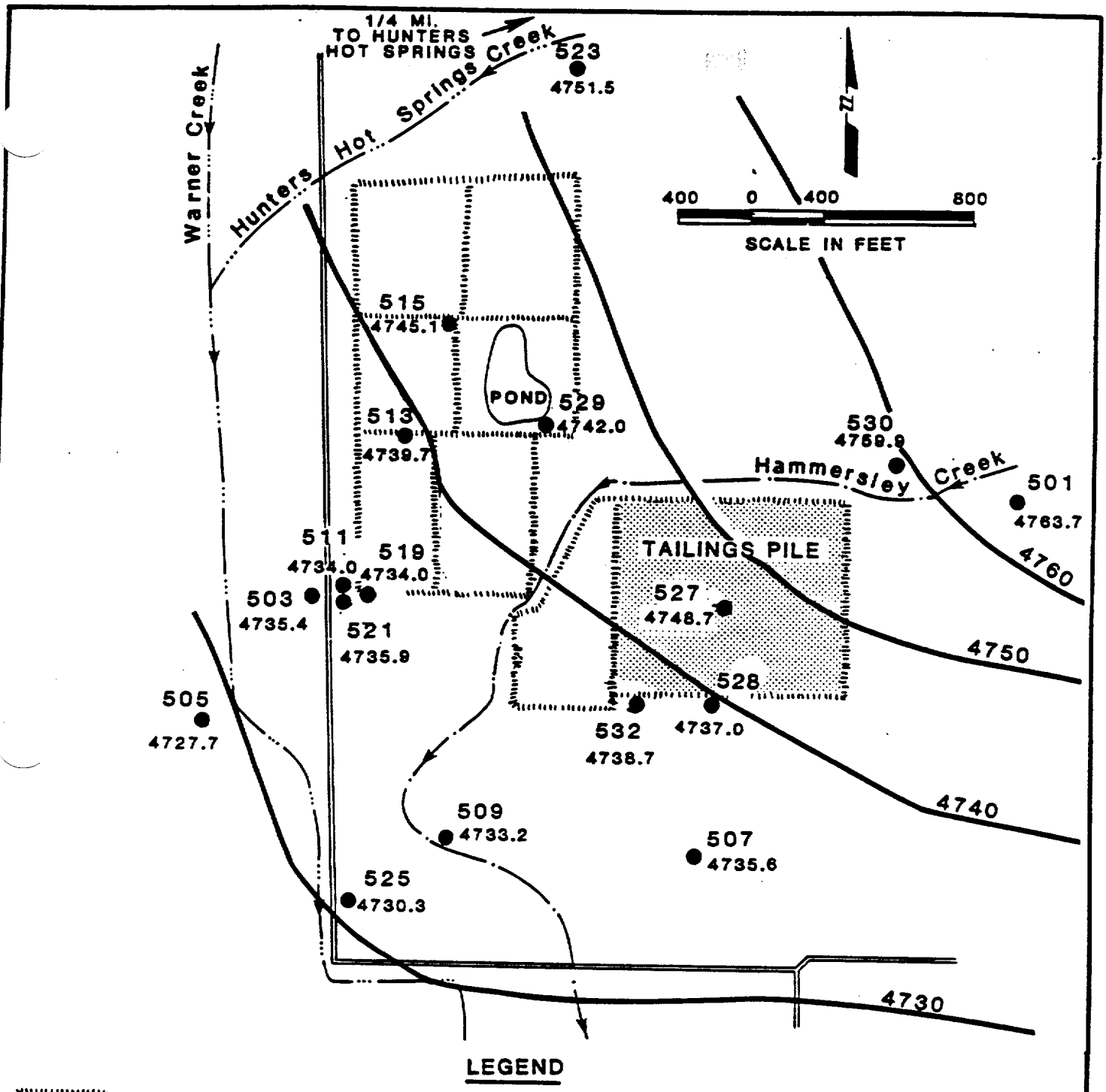
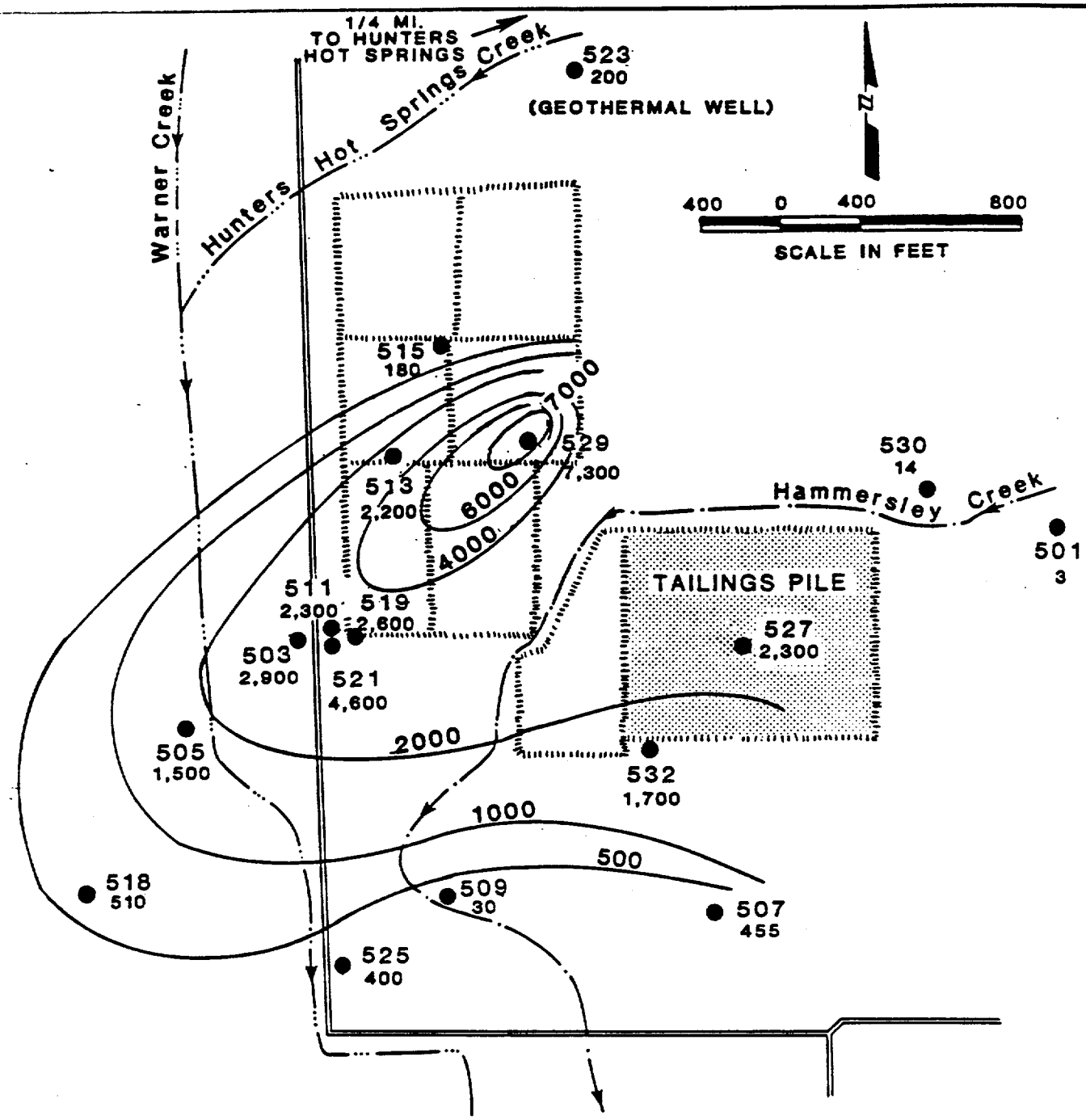


FIGURE B.3.1
POTENTIOMETRIC SURFACE OF SHALLOW AQUIFER AT THE LAKEVIEW PROCESSING SITE



LEGEND

505 - LOCATION ID

● - MONITOR WELL SCREENED IN SHALLOW ZONE

1,500 - SULFATE CONCENTRATION (mg/l)

EVAPORATION POND

INTERMITTENT FLOW

CONTINUOUS FLOW

FIGURE B.3.2
SULFATE PLUME IN THE SHALLOW AQUIFER
LAKEVIEW SITE

Table B.3.1 Lakeview pore water samples

Constituent	Number of samples	All concentrations in mg/l[a] Maximum	Minimum	Median	Arithmetic mean	Geometric mean
		Pile (primarily from slimes)				
Arsenic	6	2.19	0.012	0.078	0.535	0.122
Cadmium	6	0.249	<0.001	0.114	0.110	0.043
Molybdenum	5	0.03	<0.001	0.02	0.018	0.014
Uranium	6	0.30	0.01	0.075	0.107	0.061
Sulfate	6	12,700.0	2400.0	3400.0	6000.0	4940.0
Manganese	6	81.5	1.32	24.7	35.2	18.6
Iron	6	1.65	0.04	0.17	0.54	0.68
Aluminum	6	979.0	0.20	200.0	333.0	72.0
		Raffinate pond				
Arsenic	19	0.084	<0.01	0.01	0.029	0.016
Molybdenum	18	0.25	<0.01	0.01	0.038	0.014
Uranium	20	0.18	0.01	0.02	0.03	0.02
Sulfate	18	1600.0	840.0	1150.0	1136.0	1117.0
Manganese	20	2.64	1.09	1.78	1.68	1.63
Iron	19	4.2	<0.03	0.03	0.26	0.037
Aluminum	19	10.8	1.3	5.2	6.3	5.4

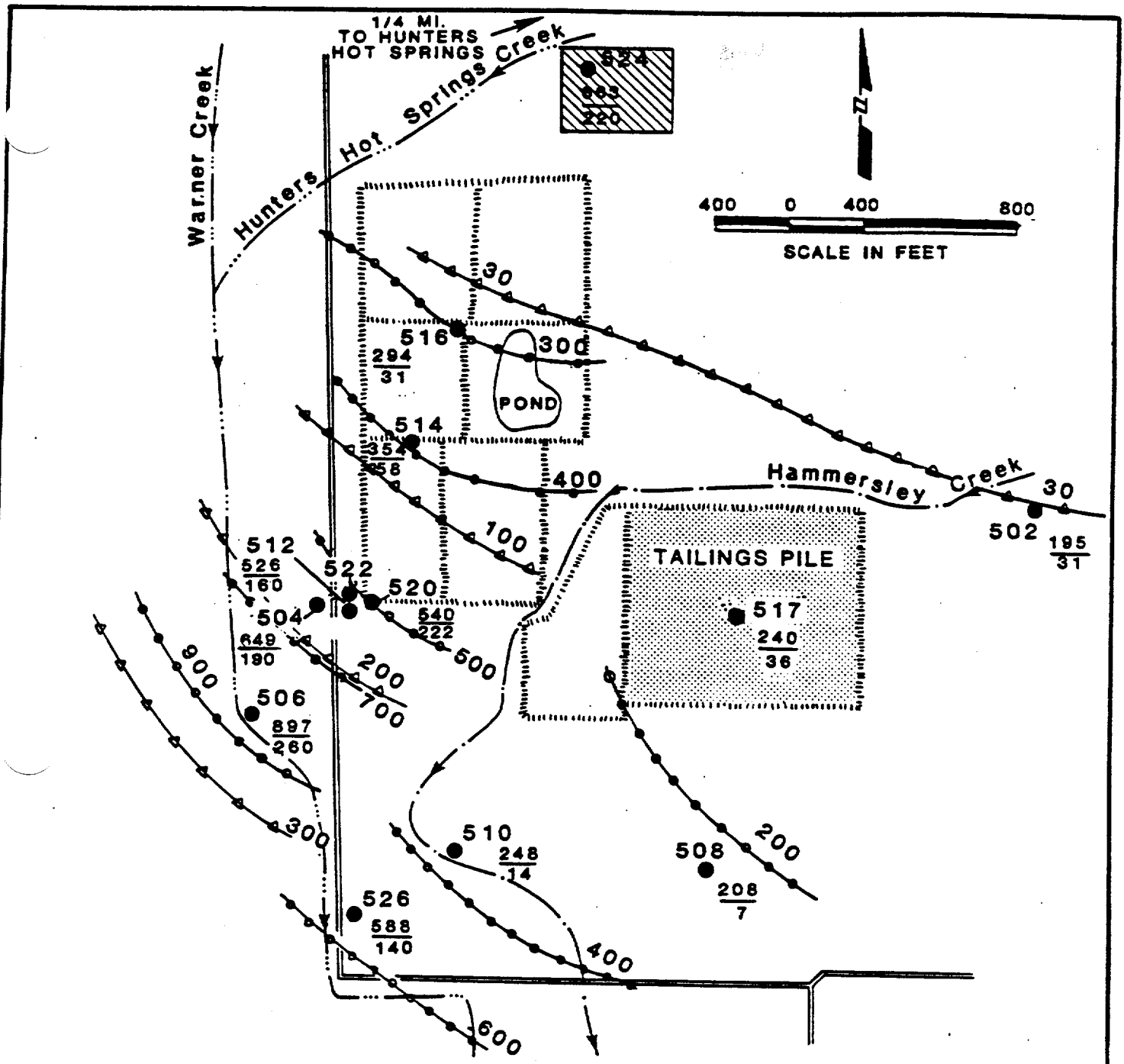
[a]mg/l = milligrams per liter.

Some samples of low temperature upgradient "background" waters exceed Oregon Department of Environmental Quality (DEQ) standards for zinc, manganese, and iron, with natural concentrations of 0.02, 2.2, and 0.28 mg/l, respectively. Samples of high temperature geothermal water exceed EPA primary drinking water standards for arsenic, and secondary standards for boron and fluoride. Representative background values for each constituent are 0.11, 4.0, and 6.0 mg/l, respectively. High temperature (>20°C) geothermal water is manifest in domestic wells north of a diagonal line cutting approximately northeast to southwest through the lower evaporation ponds, in TAC wells 523 and 524 directly north of the evaporation ponds, and in Hunter and Warner Creeks. Total dissolved solids (TDS) in geothermal water ranged from 368 to 690 mg/l compared to values of about 200 mg/l in low temperature background waters.

Seven constituents have elevated concentrations above state and/or Federal standards in the shallow aquifer beneath and downgradient of the evaporation ponds and tailings pile. Measured concentrations of arsenic, sulfate, antimony, chromium, iron, cadmium, and manganese were as high as 0.45, 7300, 0.056, 0.08, 15.5, 0.08, and 16.6 mg/l, respectively. The maximum sulfate value is greater than the EPA secondary drinking water standard as well as state water-quality standards for the Goose Lake Basin. Maximum arsenic, antimony, and chromium values were greater than EPA primary drinking water standards and cadmium exceeded Oregon DEQ limits for natural waters of Goose Lake Basin in one sample from beneath the tailings pile. Iron and manganese values exceeded EPA secondary drinking water standards and State of Oregon standards.

Groundwater samples from the deeper zone (60 to 75 feet) beneath the ponds and downgradient from the site did not exceed state standards for chromium, cadmium, or antimony and showed much reduced sulfate concentrations. However, Figure B.3.3 shows TDS and sulfate isopleths increasing downgradient from the evaporation ponds and tailings pile. This may indicate that shallow contaminated groundwater is migrating downward as water moves downgradient of the site. Alternatively this water may be of geothermal origin with naturally elevated sulfate and TDS concentrations.

To investigate the origin of sulfate in this deeper saturated zone, stable isotope analyses were used to discern between a geothermal source or a processing site source. Samples were collected from wells representing low temperature background water (wells 502 and 533), wells and a spring representing geothermal background water (wells 514 and 523 and Hunters Hot Spring), wells representing shallow groundwater contaminated by raffinate pond leachate (wells 511 and 513), and monitor wells furthest downgradient from the raffinate ponds, completed at depths of 20 to 25 feet and 70 to 75 feet (wells 518 and 506). Samples from wells 518 and 506 contain high sulfate and TDS. Stable isotope analyses were used to "tag" the source of the sulfate, TDS, and other constituents that are found both in the geothermal groundwater and the leachate from the raffinate ponds. Hydrogen-1, Hydrogen-2, Oxygen-16,



LEGEND

508 – LOCATION ID

● – MONITOR WELL SCREENED IN DEEPER ZONE

208 / 7 – TOTAL DISSOLVED SOLIDS CONCENTRATION (mg/ℓ) / SULFATE CONCENTRATION (mg/ℓ)

GEOTHERMAL WELL

EVAPORATION POND

INTERMITTENT FLOW

CONTINUOUS FLOW

TDS

SO_4

FIGURE B.3.3
TOTAL DISSOLVED SOLIDS AND SULFATE ISOPLETHS IN THE DEEPER AQUIFER – LAKEVIEW SITE (AUGUST–SEPTEMBER 1984)

Oxygen-18, Sulfur-32, and Sulfur-34 were analyzed in each sample. A comparison of the total sulfate concentrations to the Sulfur-32/ Sulfur-34 ratio gave the clearest indication of the source of contaminants to these two downgradient wells (Figure B.3.4). The samples from two downgradient wells group with the geothermal background samples, while the samples from wells 511 and 513 are separated. This analysis indicates that the primary source of sulfate, TDS, and trace constituents at distances greater than 600 feet from the site or depth greater than 25 feet is the geothermal system.

Restoration of the residual contamination in the groundwater downgradient of the Lakeview processing site will be considered in detail during a later phase of the UMTRA Project. It is probable that restoration will not be warranted because:

- The contaminant species originating at the raffinate ponds and tailings pile are non-toxic with the exception of arsenic; however, the arsenic concentrations in the background geothermal groundwater are greater than the concentrations in the contaminant plume.

- As indicated by water quality and stable isotope data, groundwater contamination is limited to a distance of about 800 feet downgradient of the site and a depth of approximately 25 feet.

- There are no known groundwater uses within the contaminant plume.

- No future source of contamination will exist at the site because of relocation of the tailings and other contaminated materials.

Analyses of groundwater samples collected from the Collins Ranch site in October 1984 are displayed in Table B.3.2. All groundwater quality data collected up to February 1991 at the former processing site and the Collins Ranch disposal site are included as Attachment A to Appendix F, Water Quality Data. The major ions present are calcium and carbonate with a relatively large amount of dissolved silica, in a low TDS (300 mg/l) water. All samples show similar chemical speciation; however, there are notably high pH values in samples 508, 513, and 514.

B.3.2 METHODOLOGY

Because assurance of long-term stabilization at the Lakeview site was not considered possible, an alternate site selection process was initiated. A field hydrologic assessment program was conducted at the Collins Ranch alternate disposal site to physically and chemically characterize the groundwater regime. Seventeen boreholes, including ten completed as monitor wells, were drilled directly on the selected site and in the adjacent valley to the west (Figure B.3.5). Both disturbed and undisturbed samples and well-log data were obtained to

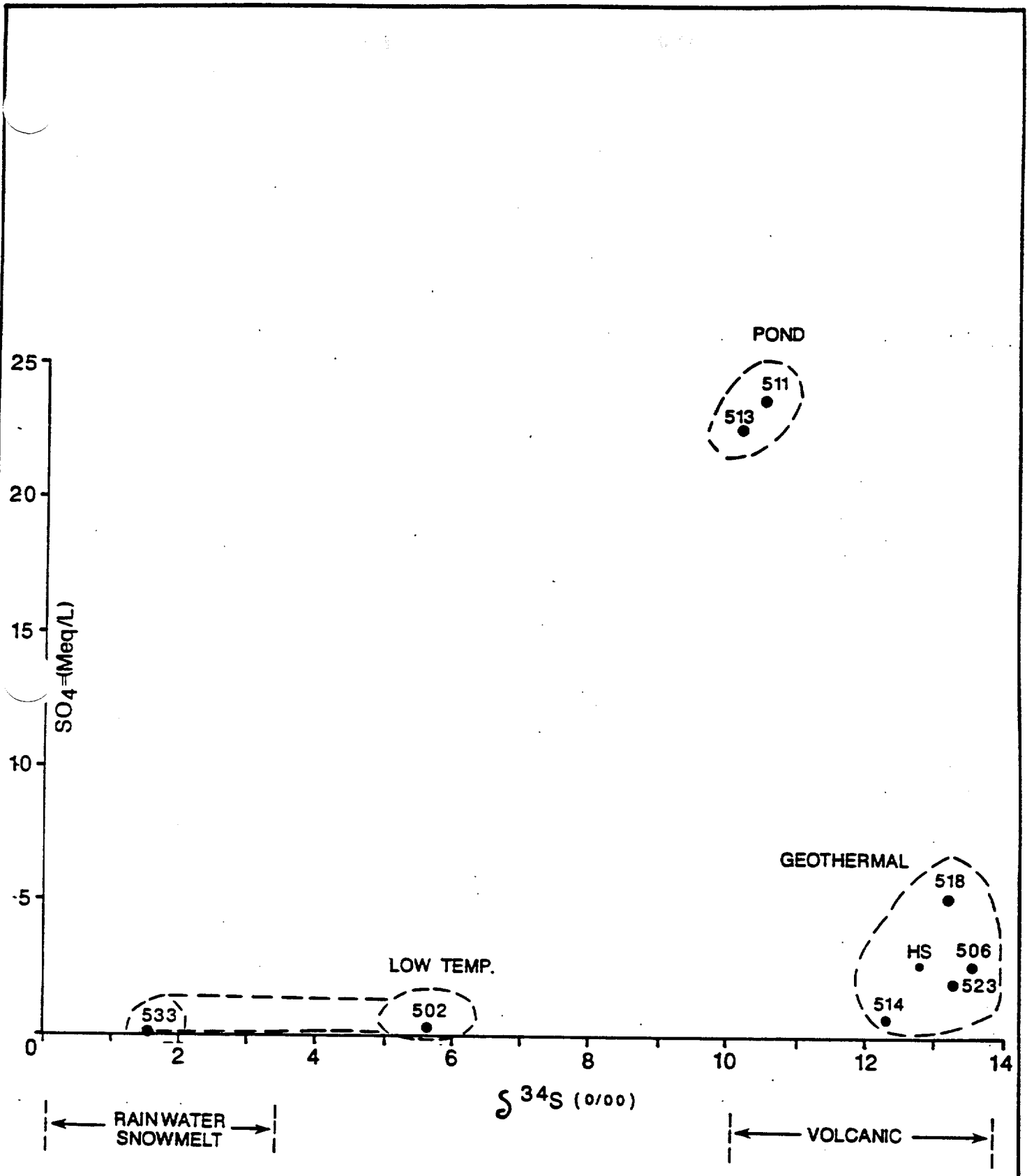


FIGURE B.3.4
DISTRIBUTION OF SULFATE CONCENTRATION vs. SULFUR-34 ISOTOPE RATIO

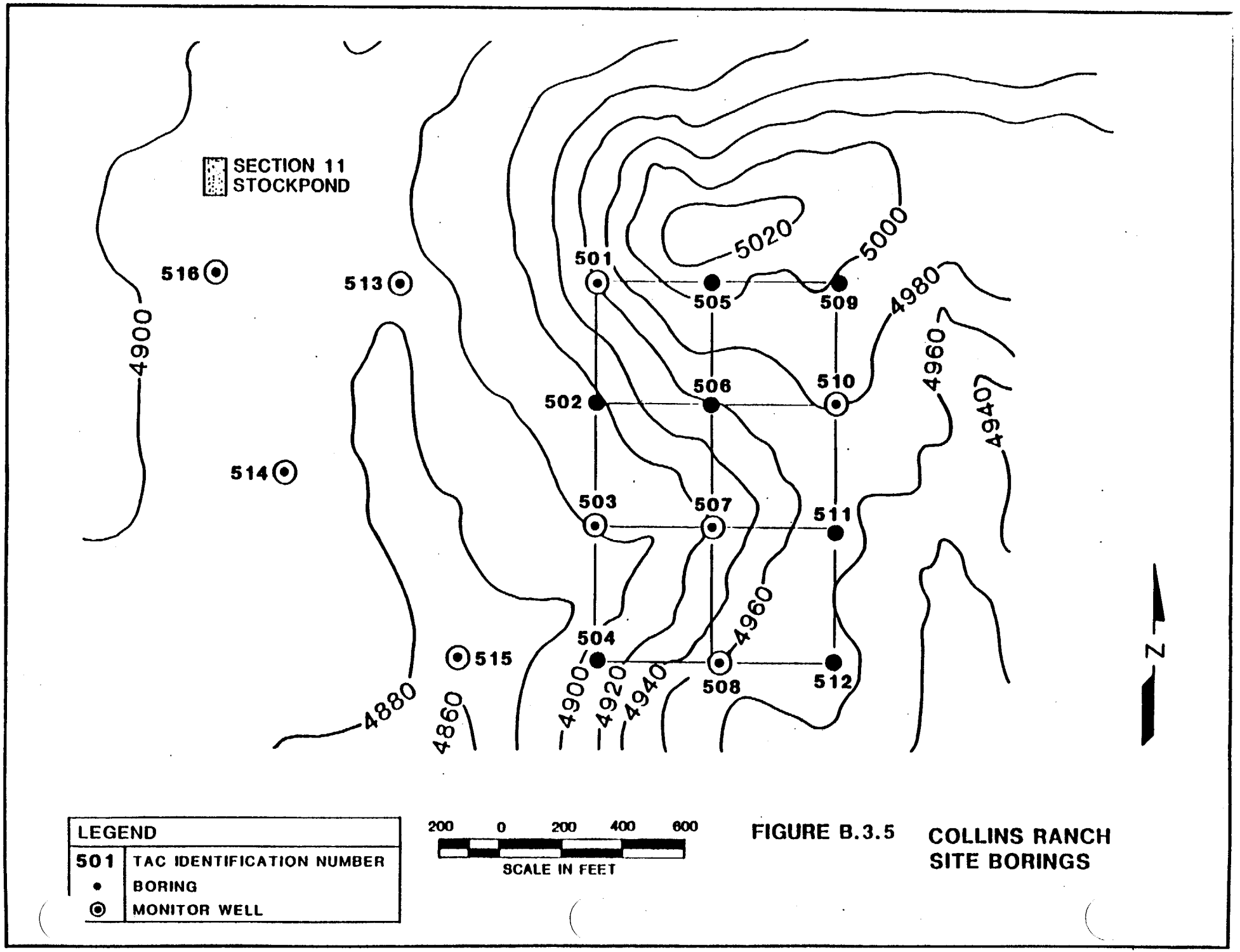


FIGURE B.3.5 COLLINS RANCH SITE BORINGS

Table B.3.2 Analyses of groundwater samples at the Collins Ranch disposal site (October, 1984)

Parameter[a]	Location ID				
	LKV02-508	LKV02-513	LKV02-514	LKV02-515	LKV02-516
Na (mg/l)	20.9	27.6	21.0	13.8	24.1
K (mg/l)	8.01	11.2	10.3	7.12	11.3
Mg (mg/l)	5.45	4.48	0.77	9.53	4.41
Ca (mg/l)	29.0	21.7	51.7	36.8	15.6
Cl (mg/l)	4	6	6	3	3
SO_4 (mg/l)	13	22	23	8	7
NO_3 (mg/l)	<1	4	10	4	7
Fe (mg/l)	<0.03	<0.03	<0.03	<0.03	<0.03
Mn (mg/l)	0.02	<0.01	<0.01	<0.01	<0.01
As (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01
Cr (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01
Mo (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01
Pb (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01
Sb (mg/l)	<0.003	<0.003	<0.003	<0.003	<0.003
Se (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005
U-234 & -238 (pCi/l)	<1/<1	<1/<1	<1/<1	<1/<1	<1/<1
Cu (mg/l)	0.05	0.02	<0.02	<0.02	<0.02
/ (mg/l)	0.01	0.02	0.05	0.01	0.01
Zn (mg/l)	0.012	<0.005	0.005	0.014	0.009
NH_4 (mg/l)	0.20	0.20	0.20	0.20	0.10
B (mg/l)	0.11	0.28	0.08	0.03	0.20
F (mg/l)	0.20	0.20	0.20	0.10	0.20
Si (mg/l)	24.1	29.3	34.0	32.0	31.6
PO_4 (mg/l)	0.79	1.49	0.53	0.59	2.45
TDS (mg/l)	182	190	240	188	164
CDT (/mhos/cm)	287	322	389	310	270
pH (mg/l)	8.88	8.96	10.35	7.14	7.78
Temp (°C)	12	12	14	14	14
ALK (mg/l as $CaCo_3$)	144	109	142	142	120

[a]pCi/l = picocuries per liter; /mhos/cm = micromhos per centimeter.

characterize properties of the foundation materials and to describe site lithology. Seven of the original 10 monitor wells encountered groundwater (507, 508, 513, 514, 515, 516, and 517). Slug tests were performed to obtain a range of characteristic hydraulic conductivities at these locations. Groundwater levels were recorded to define the potentiometric surface, and continuing measurements provided indications of seasonal fluctuations. Groundwater samples were collected, with in situ parameters such as pH, temperature, and electrical conductivity recorded in the field. Analyses of chemical constituents were used to characterize the existing hydrogeochemical environment.

Four additional monitor wells (520-523) were installed in August 1986 at the Collins Ranch site. These wells are included in the Appendix F analyses.

B.3.3 EXISTING CONDITIONS

Figure B.3.6 is a potentiometric contour map based upon water levels encountered in five of the monitor wells in the autumn of 1984. Figure B.3.7 is a map based on seven water level measurements from the summer of 1985. Groundwater moves under an apparent hydraulic gradient of 0.018 from northwest to southeast, opposite the topographic slope of the site. Groundwater was encountered at depths from seven feet (516) to 15 feet (515) in the adjacent valley west of the disposal site. Beneath the proposed disposal site, groundwater was encountered in three of the six monitor wells at depths of 76, 73, and 65 feet. The remaining three of these on-site wells did not produce groundwater throughout the maximum depth penetrated by the borehole (DOE, 1985a). The fluctuation of the water levels generally was less than two feet through the autumn of 1984 and the winter, spring, and summer of 1985.

Groundwater occurs under unconfined to semi-confined conditions within a series of fine silty sands and clayey silts that extend to an estimated depth of 1000 feet. An average hydraulic conductivity calculated from five slug tests is 0.37 ft/day for sediments above 87 feet at the site. This falls in the range of values for silty loesses and silty sand materials (Freeze and Cherry, 1979). Laboratory porosity values were calculated for a representative sand sample. The value was 0.45. Values of effective porosity listed by Todd (1980) for loess (a mixture of sediments most descriptive of the site) are about one-third the value of total porosity. A representative value of effective porosity for the Collins Ranch sediments would be 0.15.

An estimate of the average linear velocity based upon the average hydraulic conductivity of 0.37 ft/day, the hydraulic gradient equal to 0.018, and an estimated conservative value for effective porosity of fine-grained, silty, clayey soils equal to 0.15 is calculated from Darcy's Law:

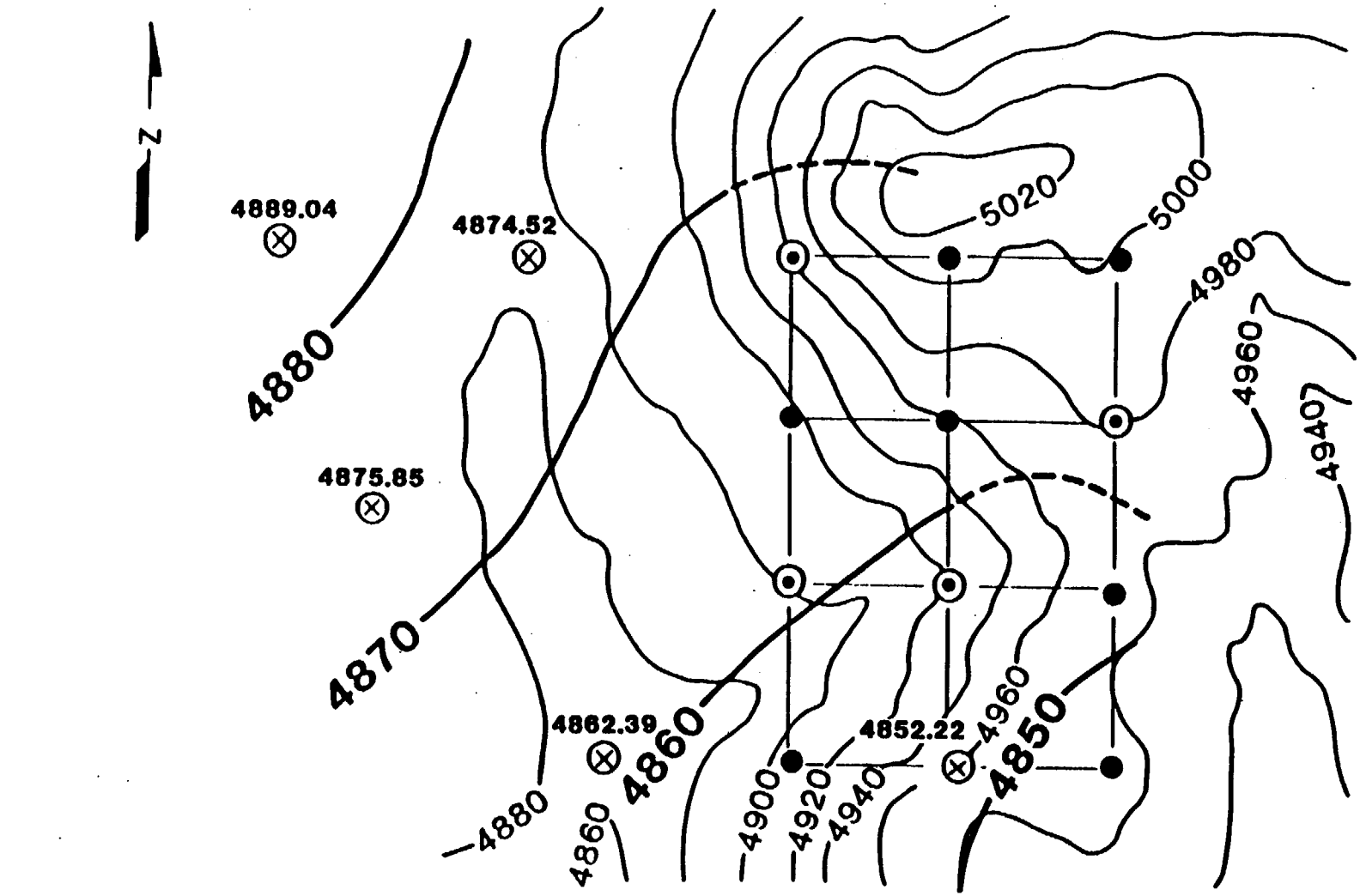


FIGURE B.3.6 POTENTIOMETRIC SURFACE AT COLLINS RANCH SITE AUTUMN, 1984

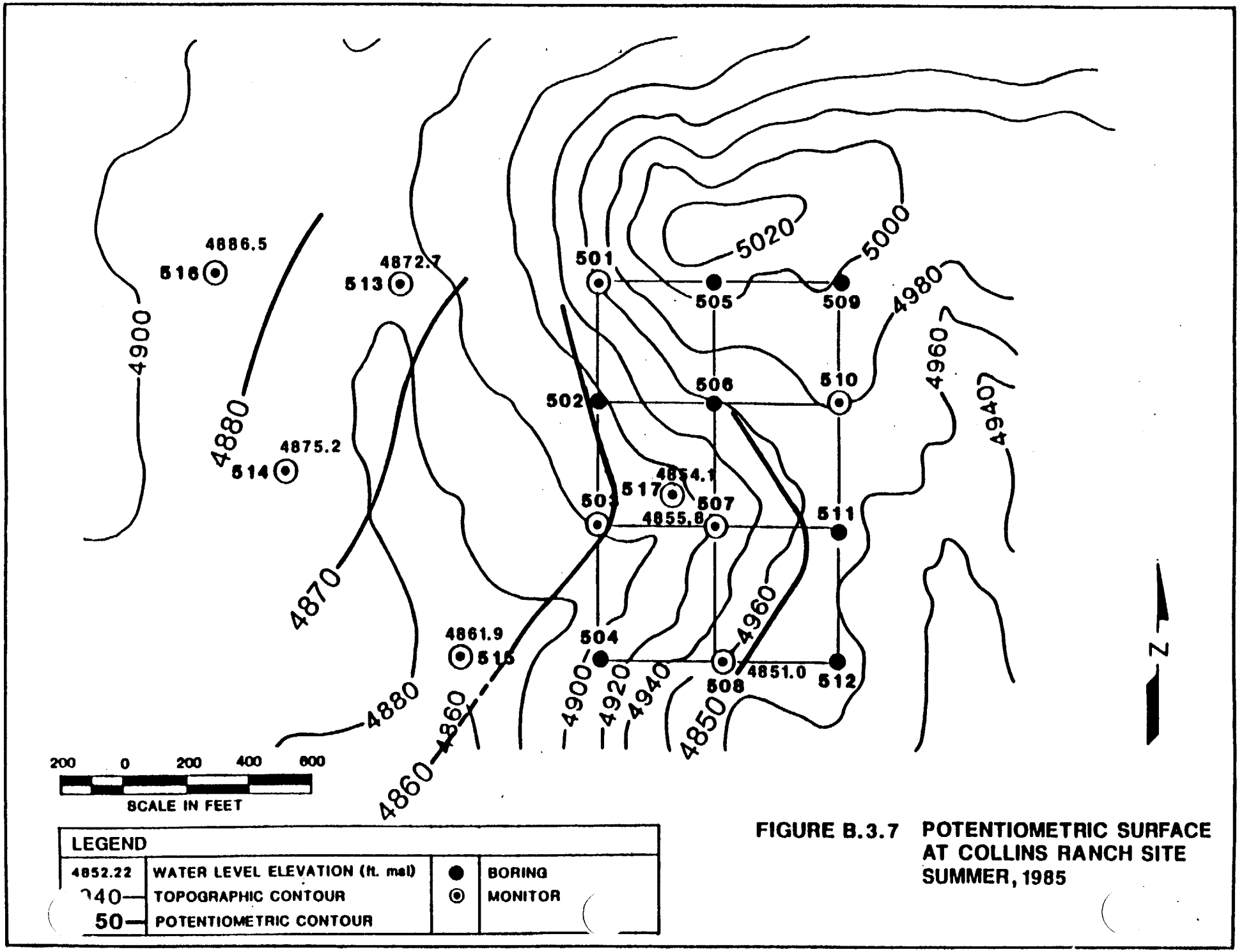


FIGURE B.3.7 POTENTIOMETRIC SURFACE AT COLLINS RANCH SITE SUMMER, 1985

$$V = \frac{K\ h}{n_e}$$

where

V = horizontal component of average linear velocity

K = hydraulic conductivity

h = hydraulic gradient

n_e = effective porosity (minimum assumed value)

Thus, based upon the assumed values stated above, the calculated groundwater velocity is approximately 0.044 ft/day, toward the southeast.

The groundwater flow direction and the lack of seasonal fluctuations in static water levels show that the predominant source of recharge to the groundwater system is from the Fremont Mountains to the west, rather than infiltration through on-site soils. This is also supported by groundwater quality data showing low TDS, high silica, and high pH water typical of groundwater recharge through volcanic deposits. Soil samples, laboratory permeability tests, tensiometer measurements, and lysimeter sampling further indicate that groundwater recharge through the soils at the Collins Ranch site is minimal. These data also show that most of the recharge that does occur moves through thin, connected lenses and stringers of silty sand, rather than uniformly through the soil horizon.

- Soil samples - Undisturbed soil samples, collected while drilling well 517, contained primarily a silt matrix with horizontal and vertical connections of sand that were one to several millimeters thick. These thin sand lenses and stringers were much moister than the surrounding silt matrix.

- Permeability tests - Tests on eight samples for laboratory hydraulic conductivity produced seven values ranging from 10^{-8} to 10^{-6} centimeters per second (cm/s), while one value was approximately 10^{-4} cm/s. The seven lower values represent the predominant silt. The one higher value indicates silty sand.

- Tensiometer measurements - The solid line in Figure B.3.8 shows the suction profile recorded with a nest of seven tensiometers. The dashed line shows a typical profile expected for uniform soil during dry conditions. The profile at the Collins Ranch site indicates that water moves along tortuous paths through vertical and horizontal preferential pathways of sand rather than uniformly downward.

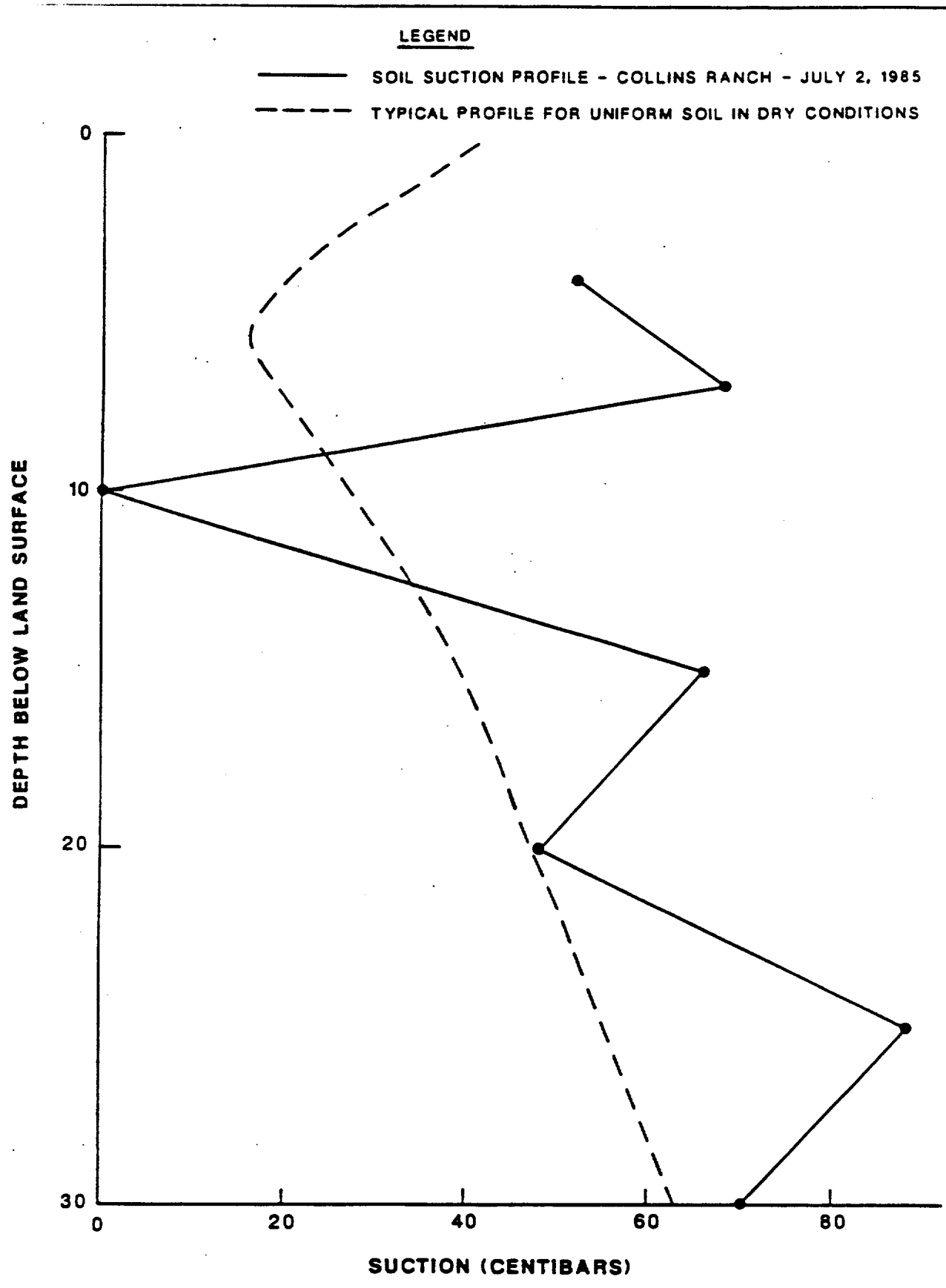


FIGURE B.3.8
SOIL SUCTION PROFILE - COLLINS RANCH SITE

- o Lysimeters - Samples could be collected where a sand lens was encountered. This was at four, 10, and 30 foot depths. Samples could not be collected at seven, 15, 20, and 25 foot depths. The samples were analyzed for tritium. Tritium analyses can be used to estimate the age of modern (less than 30 years old) water. Using tritium concentrations at the three depths, relative to the tritium concentrations of a nearby surface water sample, the estimated travel times are:

  - to a depth of four feet: at least 2.2 years.
  - to a depth of 10 feet: at least five to six years.
  - to a depth of 30 feet: at least 30 years.

Details of these calculations and supporting data are given in the Disposal Site Characterization Report (DSCR) (DOE, 1985a).

Groundwater discharges to surface drainages east of the site in the Goose Lake Valley and to heavily pumped irrigation wells.

B.3.4 REMEDIAL ACTION AND POST-REMEDIAL ACTION CONDITIONS

Appendix F represents the proposed groundwater compliance strategy for the Collins Ranch site. The following section discusses in qualitative terms the site-specific hydrogeologic, geochemical, and engineering (design) factors that allow the site's compliance with proposed EPA groundwater standards for UMTRA disposal sites.

During relocation of the tailings to the Collins Ranch site, there were no impacts to the groundwater. The excavated and contoured disposal area on the western slope of Augur Hill did not encounter any saturated formations. Under this design, the base of the tailings rests at least 20 feet above the current groundwater level beneath the southwest toe of the embankment. Depth to groundwater increases in the direction of increasing tailings thickness and levels of increasing contamination from the western toe of the disposal site east to the Augur Hill divide. Two seeps on the north wall of the disposal cell were breached during remedial action. A French drain system has been installed to handle any water in this area.

During remedial action, impacts to groundwater at the Lakeview tailings site could have resulted from excavation of the contaminated materials due to the shallow position of groundwater at the site. The Remedial Action Contractor (RAC) excavated deeper materials when the water table was deeper. Excavation below the water table was avoided. Any increase in the release of contaminants was only for a short duration until all materials were removed. Dewatering of the shallowest saturated zones was not necessary to prevent the release of intercepted contaminated groundwater.

After remedial action, impacts to groundwater at the Collins Ranch disposal site will be minimal. The one-foot compacted radon and infiltration barrier cover design should further reduce the naturally low

infiltration capacity of the soils at the site. This cover has a saturated hydraulic conductivity of less than 1×10^{-7} cm/s. At the lowest point of the embankment excavation coinciding with the highest groundwater elevation, the water table is presently at least 20 feet below the base of the tailings. In 1987, the water table rose less than two feet anywhere around the site following the spring snowmelt. Therefore, groundwater inundation at the base of the pile is extremely unlikely.

At the base of the excavation, a two-foot, recompacted, natural soil layer was installed under the tailings before they were placed. The layer is composed of excavated site materials consisting of silts and clays with an average permeability from laboratory tests of about 1×10^{-6} to 1×10^{-7} cm/s (DOE, 1985b). This layer has three functions:

- Preferential pathways of silty sands will be eliminated. The homogeneous soil layer guarantees uniform seepage around the embankment, if and when seepage does occur.

- Laboratory tests on soils representative of this layer show that any remaining acidity produced by the relocated materials would be neutralized by the first foot of this two-foot thick layer assuming:

  - That acid will be produced by the hydrolysis of the remaining water-soluble aluminum and iron in the relocated tailings and raffinate material.

  - That the average concentrations of aluminum and iron (see Table B.3.1) in the pore water accurately represent potentially water-soluble concentrations in the total volume of relocated material.

  - That the layer contains an average of 1.3 percent carbonate, as determined by eight tests on representative soil samples.

  - That the neutralization occurs, aluminum and iron hydroxides, oxides, and oxyhydroxides, and amorphous sulfate compounds such as a gypsum will precipitate (Pyrih, 1983; Henry et al., 1982; Pyrih, 1982). Trace constituents, such as arsenic and uranium, tend to coprecipitate with the amorphous compound, thus reducing their soluble concentration. Also, the precipitates will reduce the permeability of the layer by clogging the pore space. Details of the neutralization calculations appear in the DSCR (DOE, 1985b).

- Judging from laboratory soil tests, this layer contains approximately 10 percent clay and 90 percent silt. Although the major chemical effect of this layer is to neutralize acid tailings solution, the absorptive quality of the layer also

removes trace metal contaminants from solution contacting the layer.

This soil layer provides a continuous, highly attenuative zone for contaminant adsorption and ion exchange. The properties of the soils in this layer (Section 5.0 of the RAP text) create a geochemical barrier against contaminant transport similar to, but more effective than, the interface zone between the tailings and soil present at the Lakeview processing site (DOE, 1985a).

Beneath this recompacted geochemical/flow barrier, there are presently a minimum 20 feet, and generally 50 feet or more, of unsaturated soils composed of predominantly silts, silty sands, and clayey sand-silt mixtures. By the Unified Soil Classification System, all of these soils are classified as fine-grained with more than half the particles smaller than No. 200 sieve size (or the limit visible to the naked eye). Such soils provide high dispersivity and a very large particle surface area required for sorption processes to remove solutes from solution (Bouwer, 1978). Specific sorption processes that remove contaminants from solution are ion exchange, matrix diffusion, non-specific electro-static sorption, and chemical partitioning between the aqueous and mineral phase in a system.

Travel times through this fine-grained unsaturated zone are expected to be much longer than seepage rates calculated using available saturated hydraulic conductivity values (DOE, 1985a). In laboratory tests, saturated soils representative of those beneath the site have hydraulic conductivities that range from approximately 1×10^{-6} to 8×10^{-8} cm/s (Section 5.0 of the RAP text). However, numerous investigators have shown that partially saturated, fine-grained porous media have much lower (orders of magnitude) hydraulic conductivities than if the same media are saturated (Elzeftawy and Cartwright, 1979). Furthermore, numerous studies of contaminant migration through fine-grained soils have found that radionuclides move much more slowly than the groundwater velocity (Drever, 1982; Pickens et al., 1980).

The design for tailings stabilization at the Collins Ranch site is intended to isolate the pile from groundwater and minimize infiltration and subsequent leaching of contaminants from the pile. Projected impacts to the groundwater after remedial action are based upon analytical calculations presented in Section D.2.6 of the Lakeview EA (DOE, 1985a).

Based on the analysis of the tritium data from samples at four and 10-foot depths, seepage may require from 40 to 100 years to move from the base of the embankment to the water table. This analysis neglects attenuation time for contaminant species such as uranium and arsenic, which may be on the order of 10^3 to 10^6 years (DOE, 1985a). Because the primary geochemical nature of the tailings and the substrate soils at Collins Ranch will be similar to the Lakeview processing site, it is expected that a similar geochemical equilibrium will be established and a similar chemical plume would eventually emanate from the stabilized

pile well into the future. In this occurrence, radionuclides and most heavy metals would be attenuated at the pile-soil interface zone, and mobile species such as sulfate, manganese, and sodium would mix with the existing low TDS groundwater beneath the site. This mixed water would move slowly (about 20 ft/yr) with the groundwater toward the valley southeast of the site. There are no known shallow groundwater users within 1.5 miles downgradient from the site.

The heavy groundwater uses southeast of the site are for irrigation and municipal supply. The users are required by state statute and historically have allowed water levels to recover to pre-pumping levels (Glender, 1985). Therefore, steep hydraulic gradients toward the nearest irrigation wells should not be produced. Eventually, groundwater moving beneath the Collins Ranch site will be intercepted by these wells; however, the effects of geochemical attenuation, dispersion, and dilution should make any impact on water quality that could result from the site insignificant.

See Appendix F for a more systematic demonstration of the site's compliance with the EPA proposed groundwater standards.

B.4 FLOOD ANALYSIS

B.4.1 CONCEPTUAL OVERVIEW

Flooding is not considered to be a hazard at the Collins Ranch site. The embankment is located along the southwest slopes of Augur Hill adjacent to a drainage divide. An area of approximately 29 acres (including the embankment area) drains toward the site. The closest perennial stream, Camp Creek, flows at an elevation 50 feet below the site at its closest point, approximately 3000 feet from the site. About one mile upstream from the site, the stream is restricted in a narrow valley, which would create high flood levels. As it approaches the site, however, the valley opens into a broad basin that lowers flood levels and reduces velocities, making it improbable that the site could be flooded by Camp Creek.

The primary purpose of this analysis is to assure that the embankment design for the Collins Ranch site satisfactorily addresses short-term and long-term protection. Short-term flood protection simply defines the extent of the 500-year flood and the impacts, if any, on the embankment or on remedial action construction activities. The primary purpose of this assessment is for compliance with Floodplains/Wetlands Environmental Review requirements (10 CFR Part 1022).

To accomplish the objective of long-term flood protection, flow conditions resulting from a Probable Maximum Precipitation (PMP) occurring at the site were analyzed and drainage ditches were designed to protect the embankment from the resultant runoff. Details on the ditch design are included in "Calculations, Final Design for Construction" issued separately from this document, and available from the UMTRA Project Office, Albuquerque, New Mexico.

B.4.2 DESIGN EVENTS

B.4.2.1 500-year flood

As stated in Section B.4.1, an estimate of the 500-year flood is used primarily for compliance with 10 CFR Part 1022.

The 500-year rainfall intensity was estimated using methods outlined in HMR-43 (ESSA, 1966) and Technical Paper No. 25 (USDC, 1955). Times of concentrations were determined using overland flow and basin characteristics (AISI, 1971; 1980). Runoff hydrographs were calculated using the Linear Reservoir Routing technique (Stubchaer, 1975) and Green-Ampt infiltration parameters (Rawls and Brakensiek, 1983). Channel velocities and depths of flow were estimated using the Manning formula (COE, 1970). Cross sections of the stream channel closest to the proposed site were obtained from USGS quadrangle

maps (1:2,400,000) and were assumed to have either triangular or trapezoidal shapes.

A 500-year, 24-hour rainfall of 3.4 inches was determined for the 12.5 square mile drainage area of Camp Creek above the Collins Ranch site. A discharge of 5055 cubic feet per second (cfs) was calculated for the 500-year flood. Estimated velocities ranged from six to 9.5 feet per second. Depths of flow ranged from two to seven feet. The results of this analysis showed that the 500-year flood of Camp Creek would approach no closer than 2400 feet to the Collins Ranch site.

B.4.2.2 Probable Maximum Flood (PMF)

The use of the Probable Maximum Flood as the design flood event to achieve long-term control of uranium tailings is not clear-cut. The EPA has proposed standards requiring that control of tailings from uranium milling must be effective for 1000 years (to the extent reasonably achievable) and, in any case, for at least 200 years. The standard design approach is to determine the magnitude and potential impacts resulting from a PMP event. If a PMP design is not practical, then alternate design events or solutions are assessed.

In the case of the Collins Ranch relocation design, it was determined that due to the single small drainage area above the site, drainage ditches could be practically designed to protect the embankment from PMP flows. If a PMP were to occur, runoff from the embankment would flow to drainage ditches located north of the embankment and be directed to the natural drainage patterns southwest of the site.

B.4.3 GEOMORPHIC CONSIDERATIONS

Camp Creek is deeply incised into joint or fault systems in basaltic bedrock up to about one mile northwest of the Collins Ranch site, and its position appears to be firmly fixed up to that point. South of there, the creek flows in a 0.25 to 0.50 mile wide channel 2800 to 4000 feet west of the site, and from 40 to 60 feet below the base of the proposed embankment. It has a braided channel morphology typical of a bedload stream. Streams of this type are common on alluvial fan deposits. They are generally subject to rapid shifts, bank sediments are easily eroded, and evulsion is a common occurrence. The morphology of Camp Creek indicates a channel of relatively low stability, subject to unpredictable shifts. However, since the channel is fixed in bedrock up to one mile northwest of the site, it could not threaten the stability of the site area without eroding a fairly abrupt eastward bend through the alluvial deposit that forms the terrace levels west and southwest of the Collins Ranch site.

It has also been determined that there is no potential for the formation of mudslides in the site area due to the absence of susceptible materials, such as tuffaceous sediments, alluvial fan deposits, or unconsolidated alluvium. Even though minor rockfalls or small landslides may occur on the steep slopes that flank Camp Creek and Augur Creek upstream of the site, the volumes of material that could be involved are small and could not affect drainage directions, or result in the formation of temporary natural dams or catastrophic floods. These additional geomorphic data are contained in Appendix C of the final DSCR for Collins Ranch site (DOE, 1985b).

At the present time, the creek appears to be following a pattern of continuous downcutting toward the west. The potential for a significant eastward shift through the previously mentioned terrace levels resulting in a potential erosion problem at the Collins Ranch site is very low (SHB, 1985).

Branching gully systems currently infringe on the site area from all sides. The embankment area itself is a large swale formed by a branching gully system. The main gully in this system ranges from two to four feet deep and is fed by branching gullies that drain the entire site. The system bends southward at the boundary of the site and drains to Camp Creek.

The embankment design incorporated filling the major gully infringing on the site area from the west and eliminated the potential for headcutting of this gully system into the stabilized tailings. The placement of rock erosion protection material over the embankment and in the drainage ditches further reduced the potential for erosion of the tailings cover system. Details are provided in "Calculations, Final Design for Construction," available from the UMTRA Project Office, Albuquerque, New Mexico. The Collins Ranch site drainage characteristics are shown in Figure B.4.1.

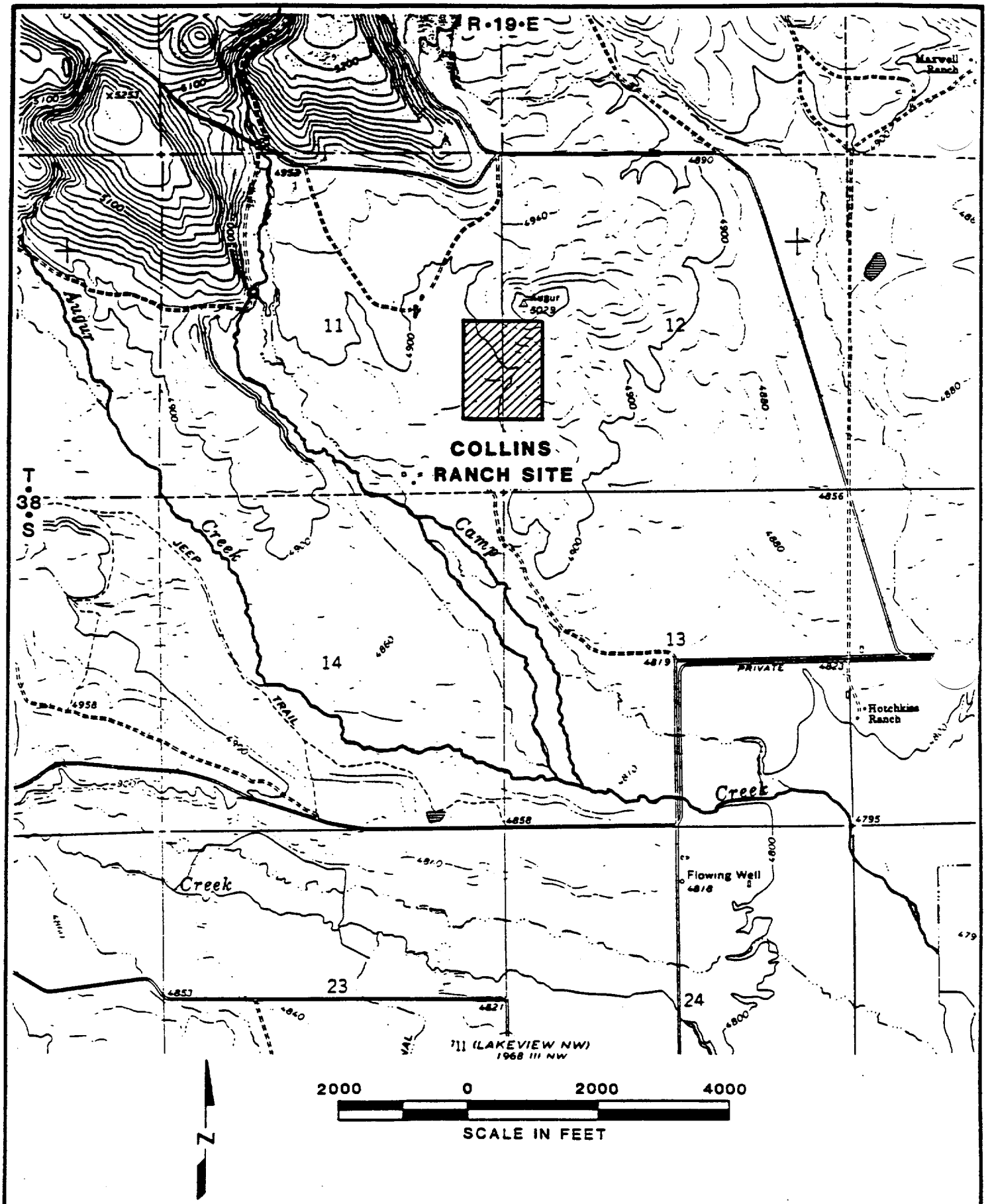


FIGURE B.4.1
COLLINS RANCH SITE - DRAINAGE CHARACTERISTICS

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APPENDIX C

RADIOLOGICAL SUPPORT PLAN

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C.1 INTRODUCTION

The Uranium Mill Tailings Radiation Control Act of 1978 (PL95-604) gave the responsibility of developing standards for remedial actions to the U.S. Environmental Protection Agency (EPA). Section 108 of PL95-604 states that the U.S. Department of Energy (DOE) shall "select and perform remedial actions at designated processing sites and disposal sites in accordance with the general standards" prescribed by the EPA. The EPA standards state:

> "Section 108 of the Act requires the Secretary of Energy to select and perform remedial actions with the concurrence of the Nuclear Regulatory Commission and the full participation of any State that pays part of the cost, and in consultation, as appropriate, with affected Indian Tribes and the Secretary of the Interior. These parties, in their respective roles under Section 108, are referred to hereafter as 'the implementing agencies.'
>
> The implementing agencies shall establish methods and procedures to provide 'reasonable assurance' that the provisions of Subparts A and B are satisfied. This should be done primarily through use of analytical models, in the case of Subpart A, and for Subpart B through measurements performed within the accuracy of currently available types of field and sampling procedures. These methods and procedures may be varied to suit conditions at specific sites."

Subpart B consists of the standards for the cleanup of land and buildings. The standards applicable to the project are:

> "Remedial actions shall be conducted so as to provide reasonable assurance that, as a result of residual radioactive materials from any designated processing site:
>
> A. the concentration of Radium-226 in land averaged over any area of 100 square meters shall not exceed the background level by more than --
>
> (1) 5 picocuries per gram (pCi/g), averaged over the first 15 centimeters (cm) of soil below the surface, and
>
> (2) 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface.
>
> B. in any occupied or habitable building --
>
> (1) the objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 working level (WL). In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL, and
>
> (2) the level of gamma radiation shall not exceed the background level by more than 20 microroentgens per hour (microR/h)."

In addition to the EPA standards for buildings, removable surface alpha contamination shall not exceed 1000 disintegrations per minute per 100 square centimeters (dpm/100 cm^2), and total non-removable alpha contamination shall not exceed 5000 dpm/100 cm^2. This limit will ensure that potential airborne radionuclide concentrations will not exceed 10 CFR 20 Appendix B standards and that physical contact with the surfaces by occupants of the structures will not result in a measurable radiation exposure.

As indicated earlier, the standards suggest that the implementing agencies determine what methods and procedures will be used to provide "reasonable assurance" that the standards are met. Reasonable assurance implies that a site-specific analysis is appropriate where the cost of demonstrating compliance with the standards is to be weighed against the health risks or other impacts associated with leaving areas which slightly exceed the standards.

The sections which follow provide the procedures used at the Lakeview site. Consideration was given to the time required to collect samples and perform the analyses.

C.2 BASIS FOR RADIOLOGICAL SURVEY STRATEGY

The Lakeview site consisted of a tailings pile, raffinate ponds, windblown areas, and small areas of contamination in the mill yard that were missed during previous remedial action activities. Excavation to remove the tailings and off-pile contaminated material from the disturbed site areas required removal of soil to a depth of several feet below grade. Most of the disturbed site areas were restored to a grade that will control the drainage. The fill material was uncontaminated and will minimize the potential health effects due to slight residual contamination.

Clean fill was not required in some of the excavated areas, and residual contamination remained exposed at the surface. In those areas where backfill after excavation was not required, the residual contamination did not exceed the 5.0 pCi/g limit when averaged over an area equivalent to the size of a house (one hundred square meters, or approximately 1100 square feet).

Any occupied or habitable building was decontaminated as needed, and surveyed to ensure that the standard was met. For the Lakeview site, there were nine buildings in use on the site, with only one requiring limited decontamination. No structures were demolished.

C.3 REMEDIAL ACTION RADIOLOGICAL SURVEY PLAN

Radiological surveys are performed for three purposes: site characterization, excavation control, and final radiological verification. Site characterization surveys (or pre-remedial action surveys) are performed to identify the volume of material that exceeds the standard. The results are used for planning and engineering design. Excavation control monitoring is performed as the work is being done to guide and control the amount of contaminated material removed. Finally, when excavation control monitoring results indicate that there is a high probability that the area meets the standards, a final radiological survey is carefully performed and the results documented.

C.3.1 SITE CHARACTERIZATION SURVEYS

Radiological surveys were performed by Bendix Field Engineering Corporation (BFEC) to identify the subsurface boundary of the tailings pile to be excavated as well as the depth and area of the raffinate pond and windblown contaminated materials on adjacent land. Subsurface evaluations were performed using gamma well logging techniques and by analyzing cores from boreholes. In general, these measurements were made on a 200-foot grid. Additional measurements were performed in areas of radiological interest. The grid points were identified by a land survey tied to a state plane survey point and all recordable data were located by these coordinates.

Radiological surveys were performed by BFEC inside the buildings to determine gamma exposure rates and the levels and extent of surface contamination. The sample preparation room of the former laboratory building was identified as having a need for limited contamination.

C.3.2 EXCAVATION CONTROL MONITORING

The purpose of excavation control monitoring is to guide excavation through the use of real-time radiological measurements. It is designed to ensure that the 5.0 pCi/g (surface) and 15.0 pCi/g (subsurface) standards are met. In addition, it minimizes the possibility that material meeting the standards is also excavated. Properly performed excavation control monitoring simultaneously ensures that neither under-excavation nor over-excavation occurs.

Excavation was monitored by qualified technicians relying principally on gamma field measurements employing hand-held instruments such as gamma-scintillation detectors. This technique was used where measurements were not seriously impaired by interference from nearby tailings deposits. In areas where significant interference existed, alternate monitoring techniques were used. These techniques included use of a shielded probe gamma-scintillation instrument (operated in a gross count mode or in a delta mode) or the immediate counting of soil samples. In all cases, these techniques were routinely calibrated by comparison of the field measurements to soil samples analyzed in the

laboratory and reported on a fully equilibrated dry-weight basis. Because the standards are based upon average areas of 100 m^2, the excavation control monitoring was performed on areas of this characteristic size as well.

Elevated gamma-ray radiation fields precluded exclusive use of in situ monitoring devices to estimate the surface radionuclide concentrations in soil on or immediately adjacent to the Lakeview pile. When in situ measurements could not be performed, the suggested method for analysis was to take individual or composite samples of soil, seal by canning, and immediately count the sample by gamma-ray spectrometry. Errors associated with this approach were reduced by taking several samples 30 days prior to starting work to determine calibration factors. These samples were counted, dried, pulverized, and screened with recanning for subsequent analysis. They will be counted later after the radon-222 (Rn-222) daughters reach equilibrium. Analyses of these prepared samples can then be compared to standards. Several samples were collected weekly during the remedial action and analyzed to provide a measure of the variation of the calibration factor. Site-specific procedures were issued by the RAC prior to the start of construction.

C.3.3 BUILDING DECONTAMINATION CONTROL MONITORING

In areas of known contamination, as determined by the site characterization surveys, measurements were performed after each decontamination effort to assess the effectiveness of the effort. For potentially contaminated areas, measurements were made at a minimum of either 100 percent of the area or at approximately 30 locations of surface areas of less than 500 square feet. In addition, biased measurements were made in previously contaminated areas or other areas having a high probability of being contaminated. Areas possibly requiring decontamination included the storage room (former sample preparation room) at the northwest corner of the laboratory building and the basement and crawl space of the Precision Pine Lumber Company office building. The highest total alpha measurement in the laboratory storage room was 3000 dpm/100 cm^2 on the floor, and the highest total alpha measurement in the office building crawl space was 900 dpm/100 cm^2 on the filter of the telephone center. No removable alpha measurements indicated readings above 100 dpm/100 cm^2; however, these areas warranted further investigation and possible decontamination, particularly in the office building basement because of elevated radon concentrations on the order of 8.0 picocuries per liter (pCi/l).

The previous decontamination in the mill building appeared to have been successful. The weathered cement support pads used for pillars indicated the highest total alpha levels of up to 1200 dpm/100 cm^2; however, no removable alpha measurements were above 100 dpm/100 cm^2 and confirmatory removable alpha measurements should be made.

A limited amount of demolition work was required, involving the small pump house at the northwest corner of the tailings pile and some weirs in the vicinity of the evaporation ponds.

C.3.4 FINAL RADIOLOGICAL VERIFICATION SURVEY FOR LAND

The final radiological survey employed a single sampling strategy regardless of the potential for future development. The area surveyed was divided by 10-foot grids. Eleven contiguous 10-by-10-foot grid blocks (approximately 100 square meters total) were declared a unit parcel. Where there was a reason for suspecting a radiologically elevated area, the unit parcel was selected to include the contaminated region, thus maximizing the measured average concentration of Ra-226. A composite sample for each unit parcel was constructed by taking 15 cm deep samples of approximately equal mass at each grid point (19 to 24 samples, depending on the shape of the unit parcel). This sample was prepared and analyzed for Ra-226 content. Further excavation sometimes was required until analytical results of less than or equal to 5.0 (surface) or 15.0 (subsurface) pCi/g above natural background qualified the unit parcel as decontaminated property. Analytical error limits for measurements must be better than plus or minus 30 percent, at the 95 percent confidence level.

If an area to be surveyed was less than that specified above, a minimum of ten, 15 cm deep samples were used to make up the composite sample.

Samples taken in the field for analysis were prepared and analyzed. When convenient, this was done prior to backfilling. When the property was to be backfilled prior to receiving the final analytical results, a quick field method (that provides a high degree of assurance that the property meets standards) was developed and applied. The samples were prepared for laboratory analysis by gamma-ray spectrometry.

C.3.5 FINAL RADIOLOGICAL VERIFICATION SURVEY FOR BUILDINGS

Gamma surveys were conducted using an instrument capable of detecting 2.0 microR/h above background. Buildings were scanned while holding the instrument at three feet above the floor. Maximum, minimum, and average exposure rates were recorded for each room of the buildings. All areas where the exposure rates exceeded 20 microR/h above background were noted.

Alpha detection instruments were used to monitor surface contamination. A grid system was constructed for each room of a structure which had been decontaminated. The grid size was adjusted such that a minimum of 30 grid points were defined by using grid lines not more than 30 feet nor less than three feet apart. Measurements were made at each grid point and other areas of special radiological interest such as floor drains or areas that were the most highly contaminated. Contamination was averaged over a 10 square foot area and compared with the allowable limits, as provided in Section C.1. In cases where the total contamination was greater than the limits for removal, measurements for assessing the removable contamination levels were made.

Radon daughter concentration (RDC) measurements were conducted in areas of the building where previous data indicated elevated radon daughter concentrations. An annual average radon daughter concentration was determined for all structures to assure that they met the standard.

C.4 DATA AND SAMPLE MANAGEMENT

During the cleanup operations, the Remedial Action Contractor collected data to support excavation control. Data used in declaring an area adequately decontaminated was documented in a format approved by the Uranium Mill Tailings Remedial Action (UMTRA) Project Office.

Site characterization survey data, excavation control data, and the final radiological survey data were collected using procedures and analytical methods meeting the requirements of the UMTRA Project Quality Assurance Program Plan (DOE, 1986). All data used in describing the final radiological condition of the site as well as other data as specified by the UMTRA Project Office were provided in a convenient format for input into the UMTRA Project Data Management System. Data generated in the remedial action will be presented in a report documenting the final radiological condition of the property.

C.5 CERTIFICATION

Certification is a professional judgment by an independent party that the remedial action has been completed according to the site-specific Remedial Action Plan and meets the applicable standards.

During the remedial action operations, the Remedial Action Contractor made available to appropriate state agencies, Federal agencies, or UMTRA Project-designated contractors data related to the cleanup. In addition, samples collected during the cleanup operations may be split for analyses by these agencies to allow comparison of analytical results. These data, along with any additional data collected at the discretion of the certifying agent, will be used in the final certification report which will be concurred with by the United States Nuclear Regulatory Commission.

REFERENCE

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APPENDIX D

ENVIRONMENTAL, HEALTH, AND SAFETY PLAN

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D.1 HEALTH AND SAFETY STANDARDS

D.1.1 APPLICABLE REGULATIONS

The Remedial Action Contractor (RAC) complied with all applicable Federal and state health and safety regulations and requirements including, but not limited to, those established pursuant to the Occupational Safety and Health Act (OSHA). Special attention was given to the following OSHA and other Federal regulations.

- 29 CFR Part 1910, "Occupational Safety and Health Standards."
- 29 CFR Part 1926, "Safety and Health Regulations for Construction."
- 49 CFR Parts 172-174, "DOT Transportation of Hazardous Materials."
- 10 CFR Part 20, "Standards for Protection Against Radiation" (as cited in this plan).
- DOE Orders, as cited in this plan.

D.1.2 STANDARDS

The RAC complied with the radiation exposure standards in Tables D.1.1 and D.1.2, unless state regulations take precedence. In all cases, exposures to workers and members of the public shall be as low as reasonably achievable.

Table D.1.1 Exposure of individuals and population groups in uncontrolled areas

Type of exposure	Annual dose equivalent or dose commitment (rem)[a]	
	Based on dose to points of maximum probable exposure	Based on average dose to a suitable sample of the exposed population
Whole body, gonads, or bone marrow	0.5	0.17
Other organs	1.5	0.5

[a]In keeping with U.S. Department of Energy's policy on lowest practicable exposures, exposure to the public shall be limited to as small a fraction of the respective annual dose limits as is reasonably achievable. Dose commitment is defined as the dose equivalent (rem) received by specific organs during a period of one calendar year that was the result of the uptake of radionuclides by a person exposed (from DOE Order 5480.1).

Table D.1.2 Occupational radiation exposure standards

Type of exposure	Exposure period	Dose equivalent (dose or dose commitment[a] rem)
Whole body, head and trunk, gonads, lens of the eye[b], red bone marrow, active blood-forming organs	Year	5
	Calendar quarter	3
Unlimited areas of the skin (except hands and forearms), other organs, tissues, and organ systems (except bone)	Year	15
	Calendar quarter	5
Bone	Year	30
Calendar quarter	10	
Forearms	Year	30
Calendar quarter	10	
Hands	Year	75
Calendar quarter	25	

[a]To meet the dose commitment standards, operations must be conducted in such a manner that it would be unlikely that an individual would assimilate in a critical organ, by inhalation, ingestion, or absorption, a quantity of a radionuclide or a mixture of radionuclides that would commit the individual to an organ dose that exceeds the limits specified in the above table. Dose commitment is defined as the dose equivalent (rem) received by specific organs during a period of one calendar year that was the result of uptakes of radionuclides by a person occupationally exposed (from DOE Order 5480.1).

[b]A beta exposure below a maximum energy of 700 kilo-electron volts (KeV) will not penetrate to the lens of the eye; therefore, the applicable limit for these energies would be that for the skin (15 rem/year).

D.2 PROGRAM REQUIREMENTS

D.2.1 ORGANIZATION AND STAFFING

The RAC had, on the site, a qualified person responsible for the health and safety of the workers and public. This person was provided with properly trained staff and adequate equipment to ensure that the work was done safely. The equipment, number of staff members, and staff member qualifications were commensurate with the scope of construction activities.

The person responsible for health and safety had adequate access to higher management, independent of construction operations management, which ensured that health and safety concerns were considered.

D.2.2 OPERATING PROCEDURES

Operating procedures were developed and documented for all activities where there was significant health or safety risk and for activities necessary to quantitatively assess radiological or industrial hygiene hazards. Examples are dosimeter issuance and control, air sampling and analysis, and control of personnel access.

D.2.3 WORKER TRAINING

A formal training program, including a discussion of the biological effects from exposure to radiation, was provided to all site workers. The program was of sufficient duration to include discussions of industrial and radiological safety procedures, emergency procedures, and instructions concerning prenatal radiation exposure. Practical demonstrations were given, when appropriate. Each worker passed a written or oral examination with the results documented. The instructor had available for distribution literature on the biological effects of radiation. The instructor also provided each worker with the information contained in U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 8.13, "Instruction Concerning Prenatal Radiation Exposure." Initial training sessions required approximately two hours. Subsequent training sessions were scheduled at a frequency that ensured continuous health and safety protection for the workers.

D.2.4 RECORDS AND REPORTING REQUIREMENTS

The RAC must notify the manager of the Uranium Mill Tailings Remedial Action (UMTRA) Project and the Environment, Safety, and Health Division of any fatality or serious accident as required by DOE Order 5484.1, "Environmental Protection Safety, Health Protection Information Reporting Requirements." Fatal accidents would be investigated by the state, Federal, or local office having environmental, health, and safety responsibilities. No fatal accidents have occurred to date.

A work-related radiation exposure history has been maintained as required. New employees completed a radiation exposure history form, and results of bioassays taken at termination shall be obtained from the last employer where exposure to radiation occurred. If previous bioassay information was not available, consideration was given to providing a whole-body count or other appropriate bioassay prior to permitting the employee to do radiation-related work.

The RAC was responsible for posting the OSHA applicability and employee reporting instructions, DOE Form F-5480.1. The RAC was also responsible for recording and reporting illnesses and injuries in accordance with OSHA requirements. Copies of these reports were forwarded to the UMTRA Project Manager. Recordable occupational accidents and illnesses are those defined in the Occupational Safety and Health Act of 1970, and set forth by the Occupational Safety and Health Administration in 29 CFR Part 1904.12(c), (d), (e), (f), and applicable part of 1904.12(g).

The RAC has been responsible for maintaining records of employee exposures to radioactive or toxic materials or other harmful physical agents. U.S. Department of Energy Form 5484.8, "Termination Occupation Exposure Report," was forwarded to the Contracting Officer's Representative (COR) within 30 days of termination of employment, or within 30 days of the determination of exposure, in accordance with Annex A of DOE Order AL-5484.1. Forms 5484.6, "Annual Summary of Whole Body Exposures to Ionizing Radiation," and 5484.7, "Summary of Exposure Resulting in the Internal Body Depositions of Radioactive Materials for CY__," were forwarded to the COR by March 15 of each year for the preceding calendar year, in accordance with Annex A of DOE Order AL-5484.1. In addition, all radiation exposure records or a copy of all radiation exposure records were transferred to DOE upon employee termination or completion of the contract.

The RAC notified the UMTRA Project Manager of any unusual occurrence. An "unusual occurrence" is any unusual or unplanned event having programmatic significance such that it adversely affects or potentially affects the integrity of the site or the performance, reliability, or safety of the UMTRA Project. Examples of unusual occurrences are:

- Overflow of an evaporation pond.
- Tailings release into a stream or river.
- Tailings release beyond the site boundary.
- Tailings spill associated with a trucking accident.
- Any major fire or explosion on the site.
- Site flooding.

- o Breach of access by unauthorized personnel.
- o Acts of vandalism or major theft occurring at the site.
- o Any occurrence which could adversely affect the environment or the health and safety of the populace.

The RAC submitted DOE Form 5484.3, "Supplementary Record of Occupational Injury/Illness," 5484.5, "Property Damage," or SF91-A, "Investigation Report of Motor Vehicle Accident," to the UMTRA Project Manager and the DOE Environment, Safety, and Health Division for each property damage incident involving more than $1000 government loss and for each motor vehicle accident involving more than $250 government loss.

A central file of all enforcement inspections and reports, along with violations and abatement actions, is maintained by the RAC for inspection by the DOE.

A central file is maintained by the COR and by contractors of formal employee health and safety complaints and their disposition. Upon request, these shall be made available for inspection by affected employees or their authorized representatives.

D.2.5 COMPLAINTS

Employees were encouraged to report to the contractor, either directly or through their authorized employee representative, any conditions or practices which they consider detrimental to their health or safety, or which they believe are in violation of applicable health and safety standards. Such complaints could be made orally or in writing.

Any employee or representative of employees who believes that a condition or practice threatens physical harm or violates health or safety standards may request an inspection by filing a complaint directly with the local agency having health and safety responsibility.

Any employee or authorized representative of employees who believes that an imminent danger exists that threatens death or serious physical harm is encouraged to bring this matter to the immediate attention of the appropriate contractor, supervisor, or designated official for resolution. In the event of inadequate corrective action, the employee and/or authorized representative may also contact the local agency having jurisdiction and/or the UMTRA Project Office in Albuquerque (by telephone) and set forth with reasonable particularity the basis for the request for an immediate inspection.

The DOE, upon receipt of a complaint of inaction concerning alleged imminent danger, or upon receipt of notice of imminent danger, would immediately ascertain whether there is a reasonable basis for the allegation. If it appears to have merit, the DOE would dispatch an

inspector to the workplace involved. When an immediate inspection would not be made, the DOE contacted the contractor immediately, gather the pertinent details concerning the situation, and if necessary, hav affected employees removed from the danger area. The DOE will determine what steps, if any, the contractor intends to initiate in order to eliminate the danger. The DOE will conduct appropriate follow-up activities.

D.2.6 POSTING

Each contractor had posted DOE Form F-5480.1, "Occupational Safety and Health Protection," a poster outlining contractor responsibilities to provide safety and health protection. Each contractor also had available in the workplace DOE Form EV-628, "Occupational Safety and Health Complaint," a form to be used in reporting violations.

The required forms were posted in a sufficient number of places to permit employees to observe a copy on the way to or from their workplace.

D.2.7 INTERNAL AUDIT PROGRAM

An internal audit committee made up of the RAC's Health and Safety Manager, and others as appropriate, was established to periodically review the health and safety operations and safety-related procedures. A documented report of this review, recommendations, and follow-u actions shall be maintained by the RAC and made available for review b DOE.

D.2.8 RESTRICTIONS

No workers under age 18 were employed in or allowed to enter controlled areas where they could receive doses of radiation in amounts exceeding one-tenth the standards specified in Table D.1.2.

All women working in jobs involving possible radiation exposure were advised of the National Commission on Radiological Protection Report 39 recommendation to minimize exposure to embryos and fetuses because of the biological risks due to such exposure.

Administrative limits shall be used to assure that workers do not exceed the quarterly or annual limits specified in Table D.1.2. Workers whose exposure levels have exceeded administrative limits or standards shall be placed on work restriction until the end of the period of concern.

D.2.9 QUALITY ASSURANCE

Field radiological measurements, sample collections, and sample analyses were performed using procedures and methods meeting the requirements of the UMTRA Project Quality Assurance Program Plan (DOE, 1986). Quality assurance procedures and record keeping methods were submitted to the UMTRA Project Office for approval prior to beginning remedial actions.

Proof of calibration must be available for all laboratory radiation detection instrumentation; and field instruments must be calibrated a minimum of once each year, or more frequently if recommended by the manufacturer. Prior to each work shift, proper response of field instruments was ensured using check sources.

Appropriate training must be completed and documented for all personnel involved in sample collection or operation of radiation detection instruments. All records of calibration, training, sample collections, field measurements, and laboratory analyses were maintained in a clear and concise manner. Records were checked for accuracy and made available for auditor inspection at any time during the remedial action.

The UMTRA Project Office and/or the TAC conducted periodic surveys during the remedial action to ensure compliance with the UMTRA Project Quality Assurance Program Plan.

D.3 CONTAMINATION MONITORING AND CONTROL

D.3.1 CONTROLLED AREAS

Controlled areas have been established to protect the workers and the general public from unnecessary radiation exposure, and to prevent the spread of radioactive contamination. Controlled areas include, but are not limited to, any work areas in which:

- 10 millicuries (mCi) or more of contamination exist in the area, based on Ra-226 concentrations as determined by the initial radiological assessment.
- The estimated external gamma dose to any individual in that work area exceeds 500 millirems (mrem/yr).
- Airborne concentrations of radionuclides exceed quantities provided in DOE Order 5480.1A, Attachment II.
- Transferable surface contamination exceeds 600 disintegrations per minute per 100 square centimeters (dpm/100 cm^2).

Access to these areas was controlled for people, vehicles, and equipment by fencing the area or using other methods to prevent inadvertent exposure to contaminated material.

Smoking, drinking, and eating were prohibited in controlled areas.

Controlled areas were conspicuously marked at points of potential access with a sign or signs bearing the radiation caution symbol and the words

CAUTION
RADIOACTIVE MATERIAL

All other applicable posting and labeling requirements set forth in 10 CFR Part 20 were followed.

D.3.2 ACCESS CONTROL

An access control point was established and was operational during all normal periods of ingress or egress. The access control point was the only point at which personnel or equipment entered or left the controlled areas of the site. Personnel and equipment entering or leaving the controlled areas were controlled by the technician occupying the access control point, under the direction of the site health physicist. Restrictions exercised at the access control point are described in the following text.

A log of personnel and equipment entering and leaving the site was maintained at the access control point. The access control log functioned as a checklist at the end of each work shift to ensure that all contractor personnel were out of the controlled area before closing the access control point.

A log of personnel dosimeters assigned to contractor personnel at the site was maintained by the technician. Dosimeters were distributed to contractor personnel at the beginning of each work shift and collected at the end of each work shift. The technician provided general instructions and precautions to personnel and notified them of any changes in work restrictions which occurred as radiological monitoring data were collected.

Reference files were maintained at the site and contained the following information and documents:

- Records of attendance at orientation and training sessions conducted by the health physics staff.
- Records of bioassay samples submitted by the employee and analytical results from the samples.
- Records of dosimeters provided to the employee, and exposure accumulations as indicated by reports from the dosimeter service.

In addition to maintaining complete and current records as specified in Section D.3.2, the technician occupying the access control point ensured that contractor personnel were provided the appropriate protective clothing for the conditions present in the work environment. Protective clothing requirements were determined by the site health physicist based upon results of instrument surveys and sample analyses performed in the work environment. Additional guidelines for clothing requirements are provided in Section D.3.6.

Personnel were required to remove protective work clothing, such as coveralls and boot covers, before leaving the controlled area. The technician or workers then surveyed their clothing and exposed skin surfaces for contamination using instrumentation and methods described in Section D.3.3. Persons with detectable surface contamination had to undergo decontamination procedures as described in Section D.3.3 and be resurveyed before leaving the controlled area.

Equipment that was in contact with contaminated material was surveyed at the access control point before leaving the controlled area. Equipment exteriors were monitored for removable and fixed contamination, and were evaluated in accordance with procedures and limits described in Section D.3.4. Heavy equipment which was found to be contaminated was detoured to the decontamination pad, washed by contractor personnel, and re-surveyed by the access control technician.

D.3.3 PERSONNEL CONTAMINATION MONITORING

Protective clothing was removed at the access control point to minimize potential surface contamination detected during alpha frisking surveys. Any personnel contamination detected was removed to prevent dispersion of radioactive material to uncontrolled areas and to minimize exposure to subcontractor personnel. Employees leaving the controlled area were monitored before leaving at the access control point. Procedures for monitoring personnel and removing surface contamination are provided in the following text.

Instrumentation

Alpha scintillation detectors were used for personnel monitoring. The detector was connected to a ratemeter/scaler which has an audible and visual alarm with adjustable setting. An instrument with no alarm could have been used if it had a speaker over which the count rate could be heard. A portable counter was not required since monitoring was done at the entrance of the access control point, and AC power was available. A cable at least six feet long was used to connect the detector to the counter so the motions of the surveyor were not restricted.

Monitoring method

Due to the delicate nature of survey instruments and the importance of monitoring, the technician assured that personnel were properly trained prior to monitoring themselves. Standard procedures for alpha frisking were followed.

Tools and equipment carried off the site were also surveyed according to recommendations in American National Standards Institute N13.12, "Control of Radioactive Surface Contamination on Materials, Equipment, and Facilities to be Released for Uncontrolled Use."

Personnel monitoring procedures

In order to maintain personnel exposure to radiation at levels as low as reasonably achievable, the goal of personnel monitoring was to detect and remove all contamination. Thus, the preferred level was no detectable radioactivity above background. Any levels of activity detected during the survey which were noticeably above normally fluctuating background were considered an indication of the presence of radioactive contamination. To ensure accurate measurements, a monitor must be able to reliably detect a minimum of 500 dpm/100 cm^2 total activity.

Most cases of personnel contamination involved loose surface contamination on protective clothing or skin. If clothes were contaminated, the preferred procedure was to remove them, monitor the skin under the affected area, and supply clean clothes for the employee.

The contaminated articles were then washed in the laundry area. Clothing was returned to the employee after decontamination.

In the event of surface contamination detected on skin, the contaminated area was washed and monitored again. If decontamination procedures were not effective, the site health physicist was consulted.

D.3.4 EQUIPMENT MONITORING

As vehicles and equipment were used in the controlled area, radioactive material tended to accumulate on all surfaces in contact with the contaminated material. Instrument surveys and decontamination procedures ensured that radioactive materials were not transported to uncontrolled areas. The following instructions applied to vehicles and equipment leaving the controlled area.

Instrumentation

Two instrument sets were required for equipment monitoring. A portable instrument was necessary for field monitoring, and a swipe counter was used for areas where background radiation levels were high enough to interfere with field monitor readings. The following characteristics were required for the two types of instruments:

Field monitor:

- Hand-held pancake G-M tube, proportional counter detector, or alpha scintillator.
- Large detector area.
- Thin detector window capable of detecting three milli-electron volts (MeV) or greater alpha energies.
- Detector window protected from puncture by wire screen.
- Battery-powered ratemeter/scaler.
- Speaker attached for audible indication of radiation levels detected.
- Meter display for exact indication of radiation levels in counts per minute (CPM).

Swipe counter:

- Slide tray to accept two-inch diameter samples.
- Alpha scintillation detector.
- Adjustable timer for counting circuit from about five seconds to one minute, to a maximum of one hour.

Monitoring methods

The health physics technician monitored equipment and vehicles which were in contact with the contaminated material before allowing them to leave the controlled area.

Vehicles and heavy equipment were driven to the decontamination pad for monitoring and cleaning, if necessary. All vehicles were cleaned to remove all visible soil prior to leaving a contaminated site. The following criteria were then applied.

- For vehicles potentially in contact with material having radium-226 (Ra-226) concentrations of 200 picocuries per gram (pCi/g) or greater, the tires (and cab interior, if potentially contaminated) were monitored and decontaminated to meet the limits described below. Appropriate spot checks were made of other potentially contaminated truck surfaces.

- For vehicles potentially in contact with material having Ra-226 concentrations less than 200 pCi/g, the tires and cab interior were periodically monitored to meet the limits described below. If contamination in excess of the limits was found, the guidelines in the preceding paragraph were used.

Background radiation could cause such high instrument readings that instrument surveys of vehicles were not feasible. When instrument surveys were inadequate, swipe surveys were performed as an alternative. Results of swipe surveys were recorded in the Removable Contamination Log, in units of dpm/100 cm^2.

Vehicle surfaces which exceeded the limits below were washed on the decontamination pad, and additional swipe samples collected and counted.

Contamination limits

Release criteria for vehicles and equipment leaving the controlled area were:

- 3300 dpm/100 cm^2 total activity, as detected by the instrument survey.

- 600 dpm/100 cm^2 dpm per 100 sq cm, as indicated by swipe samples.

In all cases, an extensive effort was made to reduce contamination to levels as low as reasonably achievable.

Decontamination procedures

In the event that equipment or vehicles required extensive decontamination, they were washed using high-pressure washers or other decontamination methods in the decontamination area. Vehicles were driven onto the pad for cleaning so that runoff could be contained.

Proper measures were used to protect the workers and environment during decontamination. Coveralls, boot covers, gloves, and eye protection were worn to prevent transfer of contamination to clothing, skin, or eyes. Caution was exercised to prevent spray from splashing back onto workers.

The equipment was monitored again for surface contamination. If contamination was still evident on the equipment after two washings, the site health physicist was consulted for additional decontamination procedures.

The inside of a truck bed did not have to meet decontamination standards. If visible contaminated material was brushed from the truck bed, the truck could return from an alternate site to the tailings site empty or with clean fill if a tarp was covering the truck bed.

D.3.5 BUILDING DECONTAMINATION AND DEMOLITION

Loose or removable contamination in buildings was removed, affixed to the surfaces prior to demolition, or controlled to prevent dispersion to the environment during demolition. Decontamination was performed by crews supplied with adequate protective equipment (coveralls, respirators, gloves, boots, and eye protection as necessary) under the supervision of the RAC health physicist. The decontamination involved the following:

- Contaminated water from washdown activities was used as a tailings dust suppressant or monitored and disposed of in compliance with Section D.5.4.

- Decontamination, if performed using of nuclear grade industrial vacuum cleaners, required strict maintenance of the filter and proper disposal of contents and filters.

- Dosimetry and special urinalysis samples were specified. If asbestos had been present in buildings, monitoring would have been initiated as described in Section D.4.1 of this document. No asbestos was identified during relocation of the tailings pile.

- Application of contamination fixants prior to demolition was done under the supervision of health physicists who specified protective clothing and equipment.

- Use of cutting torches, jack hammers, or other equipment for demolition of building structures would have required protective equipment for personnel. Appropriate engineering controls would have been used to prevent dispersion of contaminated dust or smoke during such activities. Demolition of buildings for cleanup of the Lakeview site was not necessary.

D.3.6 PROTECTIVE CLOTHING AND CHANGE FACILITIES

Protective clothing was available to contractor personnel to minimize surface contamination of personal clothing. Change facilities were provided and stocked to accommodate workers in compliance with the following requirements.

Protective clothing requirements

Clothing items were stocked at the access control point in a variety of sizes to fit contractor personnel and included coveralls, rubber shoe covers, knee-high rubber boots, leather gloves, and cotton gloves.

Additional items were stocked as considered necessary by the site health physicist.

Coveralls, boot covers, and gloves were worn by all personnel working in areas having significant quantities of soils or contaminated material containing 200 pCi/g or greater concentrations of Ra-226. Additional work areas having lesser amounts of contamination also required use of protective clothing, and were so designated by the site health physicist.

Use of change facilities

Change facilities were located at or near the access control point. These facilities were intended for use by contractor personnel working in controlled areas who were unable to meet surface contamination limits when leaving through access control. Change facilities included showers and sinks, lockers and benches, soap and towels, and toilets.

Change facilities were supplied with hot and cold running water to the sinks, showers, and the laundry. Wastewater from sinks, showers, and the laundry was collected in a sump and sampled prior to spraying on the tailings, or routed to an evaporation pond for treatment and discharge, where applicable.

Workers were required to shower only if widespread contamination was found on the skin. Localized contamination was washed off in the sinks. Contaminated areas were resurveyed after washing.

D.3.7 DOSIMETRY AND BIOASSAY

The dosimetry and bioassay programs provide measurements of personnel external and internal exposure to radiation. These programs were conducted in the following manner.

D.3.7.1 Personnel dosimetry

Thermoluminescent dosimeters (TLDs) or film badges were used to provide accurate measurements of personnel exposures

to external sources of radiation during remedial actions. All contractor personnel who worked at least 120 hours per calendar quarter in a controlled area (as defined in Section D.3.1) were issued a dosimeter. Visitors were not given badges unless it was deemed necessary by the site health physicist.

Dosimeters were worn by contractor personnel while working in controlled areas, and returned to the technician at the access control point at the end of each work shift. The technician properly stored the TLDs to minimize non-occupational exposures due to elevated levels of background radiation.

Employees wore dosimeters on the front of the body between the neck and waist unless directed otherwise by health physics personnel. The same dosimeter was retained by an employee for the entire quarter, unless deemed otherwise by health physics personnel.

Dosimeters were exchanged quarterly and read by the dosimeter service which supplied them. The resulting data were reviewed, recorded, and initialed by the site health physicist and retained on the site until remedial actions had ceased. The site health physicist noted any increases in personnel exposures above the levels usually expected at the site, investigated potential causes of elevated exposure rates, and, when possible, eliminated the source.

Whole-body dose equivalent rates were maintained bel three rems/quarter and five rems/yr. Whenever possible, engineering controls or work procedures were initiated to maintain worker exposures at levels which were as low as reasonably achievable.

D.3.7.2 Bioassay

Two methods of measuring internal deposition of radioactive materials in workers were used. Urinalysis provided information concerning potential uptake of radioactive material by contractor personnel, and whole-body counting provided an indication of an individual's body burden.

All personnel who worked at least 120 hours per calendar quarter in a controlled area submitted a urine sample prior to beginning work on the project. An exit sample was collected upon termination of the individual's work activities at the project and interim samples were collected at intervals as required by the health physics staff. Non-routine samples were required whenever a situation resulted in a potential overexposure to airborne radionuclides. Additional bioassay was required for personnel performing jobs where exposures to high airborne radionuclide concentrations were encountered.

Typically, urine samples were analyzed for thorium-230 (Th-230) concentrations. Thorium-230 was selected as the limiting isotope due to its solubility, radiotoxicity, and its presence in tailings in concentrations comparable to those of Ra-226. At the discretion of the site health physicist, additional analyses were required based on data obtained from material in specific work areas.

Analytical results had a lower limit of detection at least equal to the concentration at which resampling was indicated. Action levels (in picocuries per liter, or pCi/l) are provided below for thorium and radium.

- o Th-230:
  - 0.05 pCi/l - resample.
  - 0.1 pCi/l - investigate work conditions.
  - 0.2 pCi/l - prohibit employee from working in controlled areas.

- o Ra-226:
  - 0.5 pCi/l - resample.
  - 0.7 pCi/l - investigate work conditions.
  - 1.0 pCi/l - prohibit employee from working in controlled areas.

Analytical reports from the laboratory were retained at the project site while remedial actions were in progress; copies will be retained thereafter by the U.S. Department of Energy (DOE). Reports were reviewed by the site health physicist and results which exceeded the limit for resampling were discussed with the employee involved. The employees initialed the laboratory reports to indicate that they had been informed of the potential overexposure.

Whole-body counts were required for contractor personnel who frequently exhibited excessive radionuclide concentrations in the urine. Personnel whose work was confined to uncontrolled areas due to elevated urinalysis results were considered by the Radiological Support Contractor for whole-body counting upon termination of employment at the project site. Copies of records of whole-body counts were retained by the UMTRA Project Office.

D.3.8 AIR SAMPLING

An air sampling program was initiated during the preoperational phase and continued during the operational phase of the project. Radionuclide concentrations in the work environment were monitored and potential occupational health hazards were evaluated in determining the need for respirators and bioassay.

D.3.8.1 Air particulate sampling

Engineering controls and dust suppression techniques were used to minimize levels of airborne particulates. Methods such as vehicle speed control and water spray were commonly used. However, to ensure that the work environment was not hazardous to workers, air samples were collected and analyzed in accordance with the following requirements.

Representative work area air particulate samples were collected using lapel and work area samplers in all work areas where excavated soils average 50 pCi/g of Ra-226 or greater. Additional air particulate samples were collected during the work shift in the predominant downwind direction relative to excavation activities using high volume samplers. At the end of each shift, air particulate samples were stored in containers and marked with the following information:

- o Location of sample.
- o Date sampled.
- o Flow rate and identification number of sampler.
- o Start time and stop time of sample period.

After a delay of at least 24 hours, air filters were counted for gross alpha levels, using instrumentation described in Section D.3.4 for counting swipe samples. Gross activity levels were compared to the limit for Th-230. Air concentrations which exceeded the limit for soluble Th-230 in the work environment, as given in 10 CFR Part 20 (2×10^{-12} microcuries per milliliter), indicated the need for additional analyses and mandatory use of respirators by contractor personnel.

After counting, filters were stored in closed containers for future analyses. Samples may be stored together, according to sample location, as long as data regarding the volume of air sampled are retained. At the end of each quarter, the composited filters were analyzed for concentrations of Th-230 and Ra-226 to provide precise data on radionuclide concentrations in the work environment and potential levels of internal exposure. Results of isotopic analyses were compared to limits provided in 10 CFR Part 20 Appendix B, Table 1, and used to provide guidance on the use of respirators.

D.3.8.2 Radon daughter sampling

A sampling program for short-lived particulate radon decay products was conducted in all confined work areas where contamination might have been present. The greatest potential for elevated radon daughter concentrations (RDCs) exists in enclosed areas such as buildings where ventilation is limited. Radon daughter samples were collected and evaluated for all

buildings expected to contain elevated concentrations of radium, radon, or radon daughters before construction personnel entered such work areas.

If buildings were closed between work shifts, RDCs were re-evaluated before workers were permitted to enter the buildings to resume work. Additional samples were collected in the buildings during the work shift as deemed necessary by the site health physicist.

During periods of calm winds or inversions, RDCs may exceed limits in outdoor work areas which contain very high concentrations of Ra-226 in the soil. Such work areas were evaluated for RDCs on a daily basis.

The modified Kusnetz (1956) method of measuring RDCs was recommended as a quick and accurate procedure. Portable instruments were utilized for sample collection and counting. Other comparable methods were substituted at the discretion of the site health physicist.

Radon daughter concentrations were limited to 0.33 working level (WL) in the work environment. Any work area which exceeded 0.33 WL averaged over the work period was evacuated until engineering controls could be effected or respiratory protection provided. The primary methods of alleviating excessive RDCs in the work environment were increased ventilation or decreased exhalation of radon gas into the area. Respiratory protection was used only when other methods were not feasible.

D.3.8.3 Respiratory protection

The respiratory protection program was administered in such a manner as to provide assurance that all workers were properly protected. Personnel were determined physically fit for wearing respirators through the use of medical history information and, in some cases, a medical examination. A careful evaluation and documentation of the use of respirators was accomplished by knowledgeable professional personnel.

Respirators, either cartridge types or supplied-air types, were the last resort in attempting to provide a safe work environment for contractor personnel. Engineering controls such as spraying water on dry contaminated materials were used before relying on respiratory protection. However, when airborne particulate radionuclide concentrations reached applicable regulatory limits, respirators were used and the following requirements met:

- Employees required to use respirators were instructed in their use, and informed of the conditions under which they were required.

- o Personnel required to use a respirator were beardless to ensure a good seal between the face and the respirator.

- o Each worker required to wear a respirator was qualitatively fit-tested for a specific type of respirator before being issued that type of respirator.

- o Respirators were only used at the request of the site health physicist. Respirators were only required after exhausting all measures for alleviating the conditions requiring respirator use.

- o Cartridge-type respirators were issued for use in atmospheres containing respirable quantities of oxygen, but which were contaminated with excessive concentrations of harmful substances such as radionuclides, chemicals, or particulates.

- o Self-contained breathing apparatus (SCBAs) were required in atmospheres which contained less than respirable quantities of oxygen, high concentrations of hazardous gases, or short-lived radon decay products in excess of the administrative or regulatory limit. No occasion arose at Lakeview requiring the use of SCBA-type respirators.

- o Respiratory protection factors and respiratory program details were taken from "Practices for Respiratory Protection," ANSI Z88.2-1980 (ANSI). Further guidance may be obtained from Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection."

D.3.9 TRANSPORT OF CONTAMINATED MATERIAL

The DOE has complied with the applicable state or Federal regulations regarding the transportation of contaminated material. Site-specific determination of the levels of radioactivity associated with tailings and tailings-contaminated material were made. If levels do not exceed 2000 pCi/g, the material does not meet the U.S. Department of Transportation's definition of "Radioactive Material," and trucks are not required to be placarded.

As a minimum, all trucks or train cars hauling contaminated material were tarped for transit. All visible contaminated material was removed from the exterior. The vehicles were monitored according to guidance provided in Section D.3.4.

D.4 INDUSTRIAL HAZARDS CONTROL

D.4.1 NONRADIOACTIVE AIRBORNE MATERIAL

Monitoring for respirable dust and toxic gases and fumes was required when the average eight-hour loading was expected to reach 50 percent of the Threshold Limit Value (TLV) adopted by the American Conference of Governmental Industrial Hygienists (ACGIH). Representative samples of tailings materials were taken and a weekly composite made and analyzed for lead, arsenic, selenium, quartz, and other toxic or hazardous materials. If limits were exceeded for these toxic and hazardous materials, and concentrations of radionuclides did not require respiratory protection, then exposure to levels below the TLV were maintained by wearing respirators approved by the National Institute of Occupational Safety and Health (NIOSH).

If asbestos was suspected to be present in soils or in buildings to be decontaminated, then an asbestos monitoring, protection, and record keeping program would have been initiated in accordance with 10 CFR Part 1910.1001. The eight-hour time-weighted average airborne concentrations of asbestos fibers to which any employee may be exposed shall not exceed 2.0 fibers longer than five micrometers, per cubic centimeter of air. Asbestos concentrations were determined by the membrane filter method at 400 to 450x (magnification), four millimeter objective, with phase contrast illumination. No asbestos was encountered during remedial action.

D.4.2 NOISE

Threshold Limit Values for workers were limited to that specified by the DOE Prescribed Standard, AF161-35: 85 decibels on the A-weighted scale (dBA) for an eight-hour work day, and 80 dBA for a 16-hour work day. Noise suppression devices were used where appropriate, and the use of hearing protective devices was mandatory for levels above the TLV and encouraged for levels below the TLV. All other guidance in "Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment with Intended Changes for 1982," ACGIH, related to noise exposure was followed.

D.4.3 PERSONAL PROTECTIVE EQUIPMENT

Plans for the use of personal protective equipment were developed based on projected need. Training was provided to employees on the use of such equipment. Such apparatus included respirators, safety eye glasses or goggles, coveralls, hard hats, gloves, shoe covers, rubber boots, and safety shoes.

D.4.4 FIRE SAFETY

Contractors maintained a fire prevention and control effort appropriate for the needs at the site. Fire extinguishers were provided and maintained and employees instructed in their use. Good housekeeping practices and proper storage of flammable and combustible liquids were also required.

D.4.5 CONSTRUCTION SAFETY

Management ensured that all provisions of 29 CFR Part 1926 were addressed prior to initiating any construction activity. Particular attention was paid to Excavations, Trenching, and Shoring (Subpart P); Signs, Signals, and Barricades (Subpart G); and Motor Vehicle, Mechanized Equipment, and Marine Operations (Subpart O). All managers were familiar with the requirements and directed the workers accordingly.

D.4.6 SANITATION

Toilet facilities were provided in accordance with 29 CFR Part 1926.51.

Potable water for drinking and for washing prior to eating was provided for all employees.

D.5 ENVIRONMENTAL MONITORING

An environmental monitoring program was conducted at the project site and surrounding area. The program proceeded through three phases: preoperational, operational, and post-operational. During the preoperational phase, data was accumulated to characterize background and unimproved radiation levels in the region. Operational data provided documentation of off-site contamination generated by remedial activities at the project site. Post-operational data documented the reduced levels of contamination which occurred after the contaminated materials were properly stabilized. The intent was to document the anticipated reduction in levels of contamination after pile disturbance has ceased.

The environmental monitoring program was designed to monitor non-radioactive particulate concentrations in air, radionuclide concentrations in air, and contaminants in surface water and groundwater, where applicable. Monitoring requirements are described in the following sections. Additional requirements may result from the permitting processes outlined in Section 6.0 of the Remedial Action Plan.

D.5.1 PARTICULATES IN AIR

Continuous air particulate sampling was required at points around the site boundary, commencing at least one month before remedial actions at the site. Samples were collected at eight locations: three along the site boundary in the predominant downwind directions, one at the site boundary upwind, one at the nearest residence, one at the nearest downwind residence, one at the Precision Pine Lumber Company office building, and one at a background location which was distant enough not to be influenced by site activities.

Filters were exchanged, analyzed, and evaluated in accordance with the U.S. Environmental Protection Agency (EPA) regulations (40 CFR Appendix B). Additional radiological parameters were also evaluated as required by the site health physicist. The following information was recorded when used filters were collected:

- Sample location.
- Sampler flow rate, or volume of air sampled.
- Start and stop time and date of sample.
- Sampler identification number.

After a minimum delay period of 24 hours, samples were counted for long-lived gross alpha activity using instruments required for swipe samples. Data from gross alpha measurements were compared to the appropriate limit for soluble Th-230 given in 10 CFR Part 20 Appendix B, Table II. Filters which counted above the limit were recounted five days later to allow for the decay of any remaining short-lived isotopes. Any filters that still exceeded the limit would have been sent to the radiochemistry laboratory for isotopic analysis of Th-230 and Ra-226. Total particulates would have been determined and compared

to 10 CFR Part 20 Appendix B, Table II limits. No occasion occurred requiring filters to be sent to a radiochemistry laboratory for isotopic analysis of Th-230 or Ra-226.

D.5.2 RADON IN AIR

Environmental radon monitors (either PERM or film type detectors) were placed to provide measurement of periodic average radon concentrations in air and the data made available within two weeks. In order to provide immediate information, one real-time, continuous radon monitor was placed at the Precision Pine Lumber Company office building and at one of the downwind site boundary locations.

A guideline was set to restrict increases in off-site radon-222 (Rn-222) in air to 3.0 pCi/l, which equals one MPC (maximum permissible concentration). A weekly average of three pCi/l resulted in one MPC-week. Average annual concentrations of radon were limited to 52 MPC-weeks. During periods of remedial action, measures were employed to maintain airborne radionuclide concentrations at levels which were as low as are reasonably achievable.

D.5.3 GROUNDWATER

At least one set of preoperational groundwater samples was collected and archived from monitoring wells located in hydrologically upgradient and downgradient directions. The locations of these wells were determined by the TAC after evaluation of recently collected water data. Additional sample sets were collected quarterly throughout the construction period. Sampling collection and sample analyses procedures conformed to the UMTRA Project Quality Assurance Program Plan (DOE, 1986). Samples were analyzed for Th-230, Ra-226, uranium, and nonradioactive elements and compounds agreed to by the UMTRA Project Office and the State of Oregon.

D.5.4 SURFACE WATER

During remedial action, evaporation ponds collected all non-domestic wastewater at both the processing site and the disposal site. The retention ponds were designed for evaporation of runoff from at least the 10-year 24-hour storm, so minimal discharge was expected during remedial action. It was necessary to construct additional holding ponds to control the water generated by snowmelt and equipment decontamination.

All potentially contaminated water at the processing site retention pond was sampled and analyzed at a frequency specified in the National Pollutant Discharge Elimination System permit to ensure compliance with effluent standards. Samples were analyzed for dissolved and total Th-230 and Ra-226, as a minimum. Other parameters were included as required. Radionuclides not specifically mentioned in the

permit were controlled in accordance with standards given in 10 CFR Part 20 Appendix B, Table II.

Surface water in catch basins, shower water in catch tanks, and water retained after vehicle decontamination operations was sampled prior to reuse on the site. Water was treated after settling, as necessary, to meet acceptable Federal and Oregon Department of Environmental Quality standards before discharge from the site.

D.6 EMERGENCY PROCEDURES

D.6.1 SEVERE WEATHER ACTION PLAN

A severe weather action plan was developed by the RAC to prevent extensive off-site dispersion of contamination during periods of high winds or heavy rains. The plan identified a responsible individual to be available to direct activities previously defined to mitigate the effects of the severe weather. Action levels to limit work and environmental contamination were specified.

D.6.2 MEDICAL EMERGENCIES

An emergency medical assistance plan was also developed by the RAC. Approved first-aid kits and equipment were made available to the supervisors in the field and at the access control point.

Although high levels of contamination on workers were not expected, special care was taken to decontaminate superficial cuts and abrasions.

Arrangements were made for the transport and admission of accident victims to medical facilities should the need arise. A medical emergency plan was developed, and arrangements made with local medical facilities to ensure the availability of medical assistance. Medical emergencies involving life-threatening circumstances would have been reasonable cause for waiving the contamination monitoring procedures at the access control point. If practical, a health physicist would have accompanied the injured person and performed a contamination survey using a portable monitoring instrument while in transit to the medical facility. Life-saving procedures would have taken precedence over contamination monitoring.

No life-threatening situation occurred during the transportation of the mill tailings to the Collins Ranch site.

D.6.3 OPERATIONAL PROCEDURES

The RAC established operational procedures to be used in conjunction with environmental monitoring results to ensure the health and safety of the general public. Environmental monitoring records were updated on a weekly basis and any upward trends in radon concentrations identified. Control levels were 6.0 pCi/l for a six-month average and 3.0 pCi/l for an annual average. Activities were reviewed at any time the releases exceeded 3.0 pCi/l radon above background and administrative action taken at any point where releases were more than 6.0 pCi/l above background. Increases in radon concentrations which indicated that limits were exceeded resulted in implementation of one of the following procedures, as appropriate:

I. Continue normal construction activities:

- o Wet down active working areas.
- o Wet down unprotected contaminated areas.

II. Modified work stoppage:

- o Continue wet-down procedures.
- o Employ wet-down procedure for vicinity property material coming on the site.
- o Stop work in contaminated areas.
- o Continue work in clean areas.

III. Total work stoppage

- o Stop work, including bringing vicinity property material on the site.
- o Wet down, use covers, or otherwise secure contaminated portions of the site.
- o Notify the public of the reasons for work stoppage.

Airborne particulate radionuclide concentrations were monitored and maintained below limits provided in 10 CFR Part 20 Appendix B, Table II, Column 1, using similar procedures. The DOE/UMTRA Project Office would have been notified immediately in the event that modified or total work stoppage became necessary. No event requiring the stoppage of work due to an exceedance of airborne particulate radionuclide concentrations occurred at the Lakeview site.

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Environmental Assessment of Remedial Action at the Lakeview Uranium Mill Tailings Site, Lakeview, Oregon Volume I: Text, and Appendix D: Hydrology April 1985

This subsection consists of Volume I of the Environmental Assessment (Surface EA) and the hydrologic data. These sections discuss the quality of ground water and the local hydrologic system at the former millsite and at the two proposed locations for the disposal cell. The Surface EA indicates that the uppermost aquifer is of naturally poor quality and that arsenic concentrations in samples from Hunters Hot Springs exceed all values in ground water samples at the former millsite. The document suggests that additional ground water characterization should be performed at the site before an adequate compliance strategy could be proposed. The Surface EA also discusses the high sulfate concentrations in ground water beneath and downgradient of the site. The high concentrations probably resulted from use of sulfuric acid during the milling operations.

DOE/EA-0271

ENVIRONMENTAL ASSESSMENT
OF
REMEDIAL ACTION AT THE LAKEVIEW
URANIUM MILL TAILINGS SITE
LAKEVIEW, OREGON

VOLUME I - TEXT

APRIL 1985

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

230

ENVIRONMENTAL ASSESSMENT OF REMEDIAL ACTION AT THE LAKEVIEW URANIUM MILL TAILINGS SITE LAKEVIEW, OREGON

U.S. DEPARTMENT OF ENERGY

ABSTRACT

This document assesses and compares the environmental impacts of various alternatives for remedial action at the Lakeview uranium mill tailings site located one mile north of Lakeview, Oregon. The site covers 256 acres and contains 30 acres of tailings, 69 acres of evaporation ponds, and 25 acres of windblown materials. The Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA), Public Law 95-604, authorizes the U.S. Department of Energy to cleanup the site to reduce the potential health impacts associated with the residual radioactive materials remaining at the site and at associated vicinity properties off the site. The U.S. Environmental Protection Agency promulgated standards for the remedial actions (40 CFR Part 192). Remedial actions must be performed in accordance with these standards and with the concurrence of the Nuclear Regulatory Commission. Three alternatives have been addressed in this document. The first alternative (the proposed action) is relocation of all contaminated materials to the Collins Ranch site. The contaminated materials would be consolidated into an embankment constructed partially below grade and covered with radon protection and erosion protection covers. A second alternative would relocate the tailings to the Flynn Ranch site and dispose of the contaminated materials in a slightly below grade embankment. A radon protection and erosion protection cover system would also be installed. The no-action alternative is also assessed. Stabilization in place is not considered due to potential seismic and geothermal hazards associated with the current tailings site, and the inability to meet EPA standards.

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GLOSSARY

ABBREVIATIONS AND ACRONYMS

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1.0 SUMMARY

1.1 PROJECT SUMMARY

The Lakeview mill tailings site is located approximately one mile north of the city limits of Lakeview in Lake County, Oregon (Figure 1.1). The site is situated on the alluvium of Goose Lake, with the existing shoreline of the lake approximately eight miles south of the existing tailings pile. Major topographic features of the area consist of Goose Lake valley and the surrounding mountains that rise over 3000 feet above the valley floor.

The Lakeview area has a high desert climate with annual precipitation averaging 16 inches. Snowfall averages 61 inches per year. Vegetation ranges from the grassy plains of the valley floor to Ponderosa pine trees on the mountain slopes surrounding the valley.

The dominant land uses are agriculture and livestock grazing. Lakeview is the major urban center in Lake County with an estimated 1983 population of 2750.

The existing Lakeview site consists of an almost square tailings pile, evaporation ponds, and decontaminated mill buildings currently used for industrial purposes. The pile covers approximately 30 acres and contains approximately 239,000 cubic yards (cy) of tailings. The total volume of contaminated materials including the tailings, contaminated soils beneath and around the tailings pile, existing pile cover, evaporation ponds, windblown soils and vicinity properties is estimated to be 628,000 cy. Six vicinity properties have been identified as possibly needing remedial action (DOE, 1985). They contain an estimated 600 cy of contaminated materials. Additional properties may be identified for possible remedial action before the end of the project.

The principal hazard associated with the tailings results from the production of radon, a radioactive decay product of the radium contained in the pile. Radon, a radioactive gas, can diffuse through the pile and be released into the atmosphere where it and its radioactive decay products may be inhaled by humans. Increased exposure to radon and its decay products may increase the possibility of cancer in persons living and working near the pile. If the tailings are not properly stabilized, erosion or human removal of the contaminated materials could spread the contamination over a much wider area and increase the potential public health impacts.

The Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA), Public Law 95-604, authorizes the U.S. Department of Energy (DOE) to perform remedial action at the Lakeview tailings site (as well as at many other sites) to reduce the potential public health impacts from the residual radioactivity remaining in the pile. The U.S. Environmental Protection Agency (EPA) promulgated standards (40 CFR Part 192) for this remedial action.

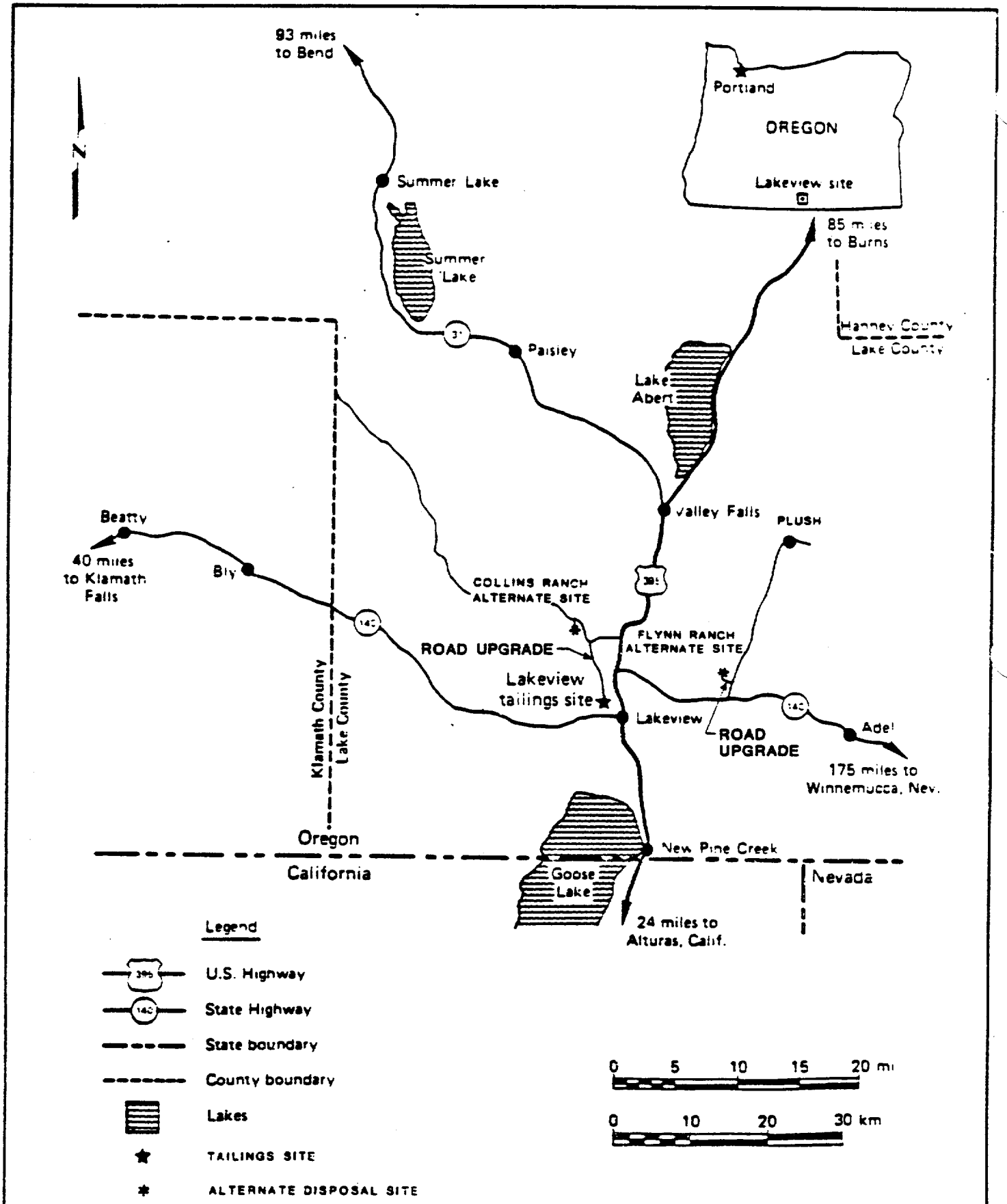


FIGURE 1.1
LAKEVIEW SITE LOCATION MAP

A geotechnical evaluation of the current Lakeview tailings site determined that stabilization in place is not feasible. Details of this evaluation are found in Appendix E, Seismic and Geothermal Hazards. Briefly, this evaluation identified seven active faults or fault zones with the potential to affect the existing tailings site. The area is also characterized as having a high subsurface heat flow with three hot springs and over 40 geothermal wells in the general vicinity of the existing tailings site. The identification of these potential hazards and the project's required design life of 200 to 1000 years dictated that the mill tailings be relocated. An in-depth alternate site selection process was implemented to identify suitable disposal sites and the Collins Ranch and Flynn Ranch sites were selected (Figure 1.1).

The proposed action, disposal of the tailings and contaminated materials at the Collins Ranch site (Alternative 1) would involve relocating all of the contaminated materials to land seven road miles northwest of the tailings site. This site has recently been burned by a fast moving range fire, but was previously used primarily for livestock grazing. The contaminated materials would be consolidated into an embankment constructed partially below grade and covered with radon protection and erosion protection covers. A rock-soil matrix would be placed on the protective covers and the site would be revegetated. The finished embankment would blend into the surrounding terrain and would cover approximately 13 acres. A total of 20 acres would be Federally owned, and restricted from all uses except livestock grazing. The original tailings site would be decontaminated and released for any uses consistent with Lake County zoning ordinances.

The no-action alternative (Alternative 2) would consist of taking no remedial action at the tailings site or vicinity properties. The tailings pile and contaminated materials at the vicinity properties would remain in their present locations and would continue to be susceptible to erosion and unauthorized human removal (and thereby present an increased health risk).

Disposal of the mill tailings and contaminated materials at the Flynn Ranch site (Alternative 3) would be similar to Alternative 1, except that the site is approximately 26 road miles northeast of the existing tailings site. The site is now privately owned and also used primarily for grazing of livestock. The contaminated materials would be consolidated into an embankment constructed slightly below grade and covered with radon protection and erosion protection covers. A rock-soil matrix would be placed on top of the protective covers and the site would be revegetated. The finished embankment would rise approximately 35 feet above the surrounding terrain and cover approximately 17 acres. A total of 25 acres would be federally owned, and restricted from all uses except livestock grazing. The original tailings site would be decontaminated and released for any uses consistent with Lake County zoning ordinances.

All the alternatives, except Alternative 2 (no action), include remedial action at the off-site vicinity properties.

1.2 PUBLIC PARTICIPATION

Since the enactment of UMTRCA, the DOE has held numerous meetings in Lakeview to ascertain public interests and opinions regarding remedial action at the Lakeview site. These meetings have been held with city and county officials, various agencies, and an active citizens task force during the pre-planning stages and throughout DOE's site characterization and alternate site selection process. Several public meetings have been held with widespread notification of the event, and interested citizens were encouraged to express their concerns and receive answers to their questions regarding plans for the Lakeview site.

In 1982, a Lakeview task force, made up of private citizens and local officials, was formed to serve as a major communication link between DOE and the community. The DOE has met several times with this group to provide information on and obtain input about DOE's efforts. From time to time, the DOE has also issued press releases regarding activities taking place at the Lakeview site. On October 3, 1984, a Scoping Meeting was held in Lakeview to gather local input as to what issues the people wanted to see addressed in the EA.

The types of concerns and comments expressed during these meetings and other consultations include the following:

- Exposure to radiation that the public and the workers on the project will receive from routine operations.
- Exposure to radiation from hypothetical accidents that release radioactive material.
- Effects on surface and ground waters.
- Effects on transportation networks, including changes in traffic patterns and volumes.
- Effects of accidents excluding those arising from release of radioactive materials.
- Changes in land use.
- Effects on scenic, historic, and cultural resources.

These concerns and comments have been addressed in this EA.

1.3 IMPACT SUMMARY

This section contains a quantitative comparison of the impacts of the various alternatives (Table 1.1 at the end of this section) and a brief discussion of the major differences between the alternatives. The impacts presented in Table 1.1 and the remainder of this chapter are based on conservative impact assessment methods and represent a realistic upper limit of the severity of the potential impacts of each alternative.

Collins Ranch (Alternative 1) - the proposed action

The primary impacts of this alternative are:

- The Collins Ranch alternative would reduce the radiological hazards to a level consistent with the EPA standards and would ensure the long-term stability and containment of the tailings.
- The Collins Ranch site is a relatively remote location, approximately seven road miles north-northwest of the existing tailings site and eight road miles from the northern city limits of Lakeview.
- The Collins Ranch alternative would result in fewer predicted total health effects per year (0.000019) following remedial action in comparison to no action (0.00081).
- The Collins Ranch alternative would have a low impact on remedial action worker health, water consumption, population, and employment.
- The Collins Ranch alternative could result in temporary exceedence of Federal particulate (dust) standards.
- The Collins Ranch alternative would consume 963,000 gallons of fuel and require 19,847,000 gallons of water. A total of 418,000 cy of uncontaminated fill are required from the disposal site excavation for restoration of the processing site.
- The Collins Ranch alternative would cost $12,250,000, including restoration of the existing mill site.
- Twenty acres at the Collins Ranch site would be permanently restricted from all uses except livestock grazing.
- The 258-acre Lakeview site would be released for any uses consistent with Lake County zoning ordinances.

No action (Alternative 2)

Selection of the no-action alternative would not be consistent with the intent of Congress in UMTRCA (PL95-604) and would not result in DOE's compliance with the EPA standards (40 CFR Part 192). This alternative would result, in time, in the dispersion of the tailings over a wide area by wind and water erosion. Ground water could be contaminated, and tailings would not be protected against unauthorized removal by humans. Unauthorized removal and use of the tailings could cause significant radiological contamination of other areas and result in significant public health impacts.

Flynn Ranch (Alternative 3)

The major differences between the Flynn Ranch and Collins Ranch alternatives are:

- The Flynn Ranch site is a more remote location, approximately 26 road miles northeast of the existing tailings pile.

- The Flynn Ranch alternative would result in the fewest predicted total health effects per year (0.0000006) following remedial action as compared to the Collins Ranch alternative (0.000019) and the no-action alternative (0.00081).

- The Flynn Ranch alternative would have a slightly greater impact on remedial action worker health, population, and employment.

- Public roads would be used to relocate the tailings and a greater number of traffic related injuries and possibly fatalities are predicted.

- Federal air quality standards would not be exceeded.

- The Flynn Ranch alternative would cost $13,700,000 including restoration of the existing mill site.

Table 1.1 Quantitative comparison of alternatives

Environmental component/ alternative	Collins Ranch Proposed Action	No Action	Flynn Ranch
Water resources	Uranium to reach ground water in 10^3 to 10^6 years. Eliminate source of contamination at Lakeview processing site. Additional study needed to determine need for aquifer restoration at processing site.	Potential for degradation of local surface and ground waters - reduced use of water.	No impact at Flynn Ranch site. Eliminate source of contamination at Lakeview processing site. Additional study needed to determine need for aquifer restoration at processing site.
Water consumption	19,847,000 gallons	None	13,264,000 gallons
Air quality (non-radiological) (24 hr maximum)	492 ug/m^3 increase in TSP - slight increase in fuel combustion pollutants - potential approach to or exceedence of Federal primary air quality standards for particulates.	None	277 ug/m^3 increase in TSP - slight increase in fuel combustion pollutants - no violation of Federal primary air quality standards.
Wildlife	Negligible	None	Negligible
Vegetation	Negligible	None	Negligible
Site worker health	0.0027 projected deaths from cancer; 21.9 projected equipment use injuries	None	0.0032 projected deaths from cancer; 30.5 projected equipment use injuries

Table 1.1 Quantitative comparison of alternatives
(Continued)

Environmental component/ alternative	Collins Ranch Proposed Action	No Action	Flynn Ranch
*Public health	0.00019 projected deaths in 10 years and 0.019 projected deaths in 1000 years from cancer.	0.0081 projected deaths in 10 years and 0.81 projected deaths in 1000 years from cancer - assumes no dispersion of tailings; see Section 4.1.4.	0.000006 projected deaths in 10 years and 0.0006 projected deaths in 1000 years from cancer.
*Health impacts are calculated for a constant population (see Section 4.14).			
Mineral resources	Consumption of 66,000 cy of cover material (silty clay, pit run rock).	None	Consumption of 84,000 cy of cover material (silty clay, pit run rock).
Soils	245 acres disturbed during construction.	Potential increase in area of contaminated soils.	282 acres disturbed during construction.
Threatened and endangered species	None	None	None
Archaeological resources	None	None	None
Aesthetic resources	Pile not visible to road traffic on east side of Augur Hill - not visible from town of Lakeview.	None	Pile may be visible to small area of County Road 3-13, northeast of site. Pile not visible to populated area.

Table 1.1 Quantitative comparison of alternatives
(Continued)

Environmental component/ alternative	Collins Ranch Proposed Action	No Action	Flynn Ranch
Cultural/historic resources	Limited historical value - Ft. Bidwell Indians expressed some concern for historical value.	None	Ft. Bidwell Indians consider area to be significant to historical and religious practices of Northern Paiute Indians.
Noise	Nearest sensitive receptor 1.5 miles away; close enough to be affected - isolated disturbance to residence near roadways.	None	Nearest sensitive receptor 4.75 miles; close enough to be affected - isolated disturbance to residence near roadway.
Land use	Tailings pile confined to 13 acres; restricted use of 20 acres.	Restricted use of 258 acres. Potential for continuously increasing restricted area	Tailings pile confined to 17 acres; restricted use of 25 acres.
Population	Short-term increase of 14 persons; 0.5 percent of Lakeview's population.	None	Short-term increase of 14 persons; 0.5 percent of Lakeview's population.
Employment	Direct employment: average of 70 persons for 24 months; peak of 81 workers - indirect employment of 31 workers.	None	Direct employment: average of 73 persons for 30 months; peak of 79 workers - indirect employment of 32 workers.

Table 1.1 Quantitative comparison of alternatives
(Concluded)

Environmental component/ alternative	Collins Ranch Proposed Action	No Action	Flynn Ranch
Social services	Negligible	Negligible	Negligible
Transportation networks	Average 290 trips per day on private, 2-lane road during 24-months; 0.44 traffic fatalities; 21.9 traffic injuries.	None	Average 100 trips per day on U.S. Highway 140 and County Road 3-13. Two lane paved road of moderate use during 30 months - 0.14 traffic fatalities; 30.5 traffic injuries.
Energy resources	Consumption of 963,000 gallons of fuel and 489,000 kwh electricity.	None	Consumption of 1,279,000 gallons of fuel and 620,000 kwh electricity.
Cost ($)	$12,250,000	None	$13,700,000

REFERENCES FOR SECTION 1.0

DOE (U.S. Department of Energy), 1985. Programmatic Environmental Report for Remedial Actions of UMTRA Project Vicinity Properties, UMTRA-DOE/AL-150327.0000, prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

2.0 THE PROPOSED ACTION AND THE ALTERNATIVES TO IT

2.1 NEED FOR THE ACTION

2.1.1 Background

In response to public concern over the potential public health hazards associated with uranium mill tailings and the associated contaminated material left abandoned or otherwise uncontrolled at inactive processing sites throughout the United States, Congress passed the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA), Public Law 95-604, which was enacted into law on November 8, 1978. In UMTRCA, Congress acknowledged the potential health hazards associated with uranium mill tailings and identified 22 sites that were in need of remedial action. The Lakeview site is one of these 22 sites.

Title I of UMTRCA authorizes the U.S. Department of Energy (DOE) to enter into cooperative agreements with affected states and Indian tribes to clean up those inactive designated mill sites contaminated with uranium mill tailings, requires the Secretary of the DOE to designate sites to be cleaned up, requires the U.S. Environmental Protection Agency (EPA) to promulgate standards for these sites, and defines the role of the U.S. Nuclear Regulatory Commission (NRC).

Effective June 29, 1984, the DOE and the State of Oregon entered into a cooperative agreement under UMTRCA. The cooperative agreement set forth the terms and conditions for the DOE and State cooperative remedial action efforts including the DOE's development of a remedial action plan (with the concurrence of the State), the preparation of an appropriate environmental document, real estate responsibilities, and other concerns.

The EPA published an Environmental Impact Statement (EIS) (EPA, 1982) on the development and impacts of the standards (40 CFR Part 192) and issued final standards (48 FR 590-604) on January 5, 1983, to become effective on March 7, 1983. In developing these standards, the EPA determined "that the primary objective for control of tailings should be isolation and stabilization to prevent their misuse by man and dispersal by natural forces" and that "a secondary objective should be to reduce the radon emission from the piles." A third objective should be "the elimination of significant exposure to gamma radiation from tailings piles." Appendix A, EPA Standards, contains a detailed discussion of the EPA standards.

All remedial actions performed under the UMTRCA must be done in accordance with these standards and with the concurrence of the NRC. The NRC has not and does not intend to issue regulations applicable to the remedial actions at the inactive uranium processing sites but will issue licenses for the long-term surveillance and maintenance (including monitoring) of the disposal site after the cleanup work is complete. These licenses may require the DOE

or other Federal agency having custody of the site to perform such surveillance, maintenance, and contingency measures as necessary to ensure continued compliance with the EPA standards.

2.1.2 The remedial action process

The remedial action process for the Lakeview site began with site characterization and will conclude with a long-term maintenance and surveillance program. Preliminary radiological investigations and engineering assessments have been completed and published. Currently, a series of related studies that address the site-specific engineering concepts, maintenance and surveillance requirements, and licensing are under preparation. The anticipated publication schedule for each of these documents is shown in Table 2.1.

Table 2.1 Document publication schedule - Lakeview

Document	Scheduled publication date
Processing Site Characterization Report	October, 1985
Remedial Action Plan (including Health and Safety Plan, Radiological Support Plan, and Site Conceptual Design)	October, 1985
Final Design and Specifications	June, 1986
Site Licensing Plan	April, 1987
Site Surveillance and maintenance Plan	April, 1987

2.1.3 The Lakeview site

The Lakeview site is located approximately one mile northwest of Lakeview, Oregon, west of U.S. Highway 395, on private land owned by the Precision Pine Company (Figures 2.1 and 2.2). More specifically, the site is in portions of Sections 3, 4, 9, and 10 of Township 39 South, Range 20 East of Lake County, Oregon. The existing tailings pile is located on the alluvium of Goose Lake, which is approximately eight miles south of the tailings site.

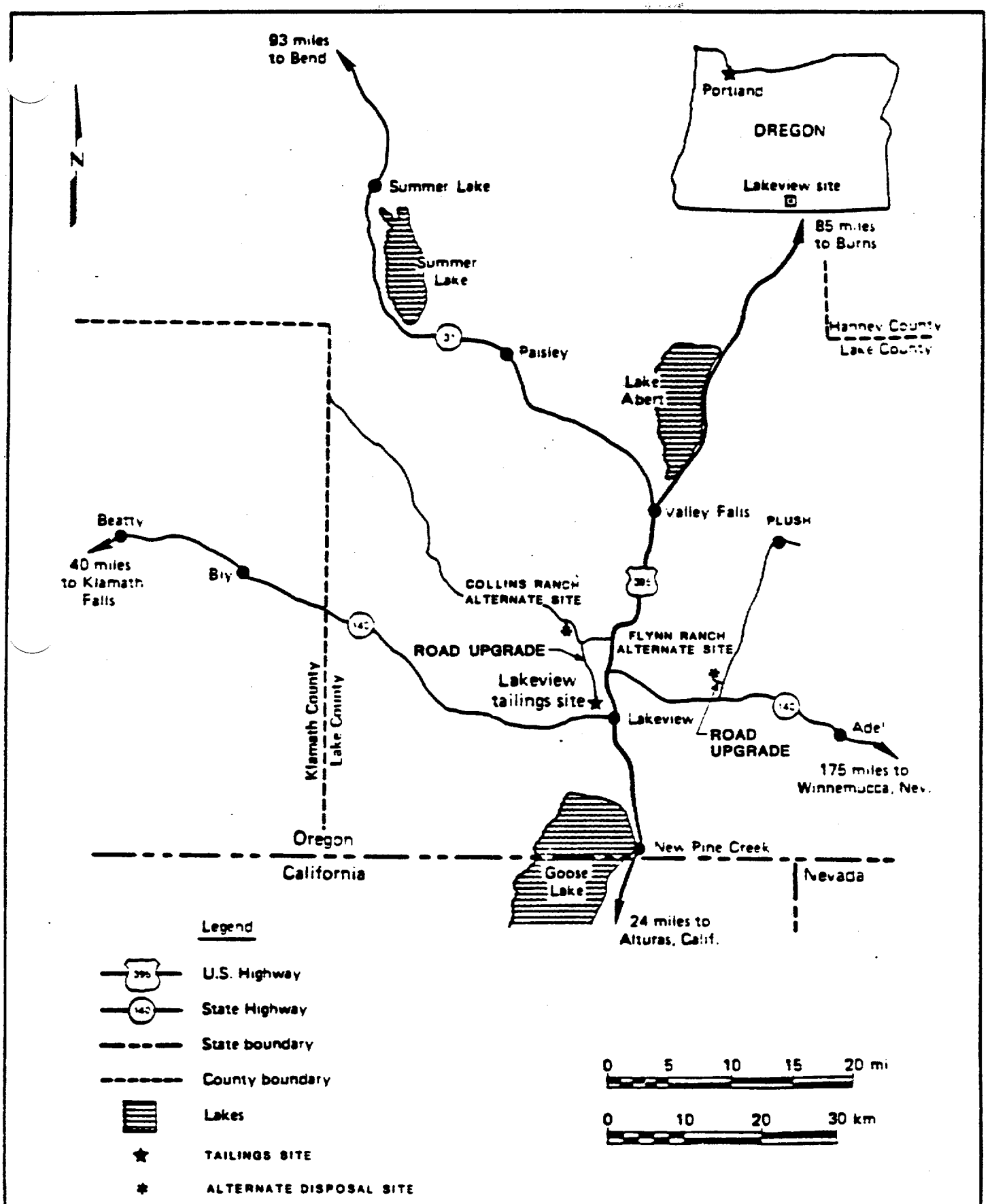


FIGURE 2.1
LAKEVIEW AREA MAP

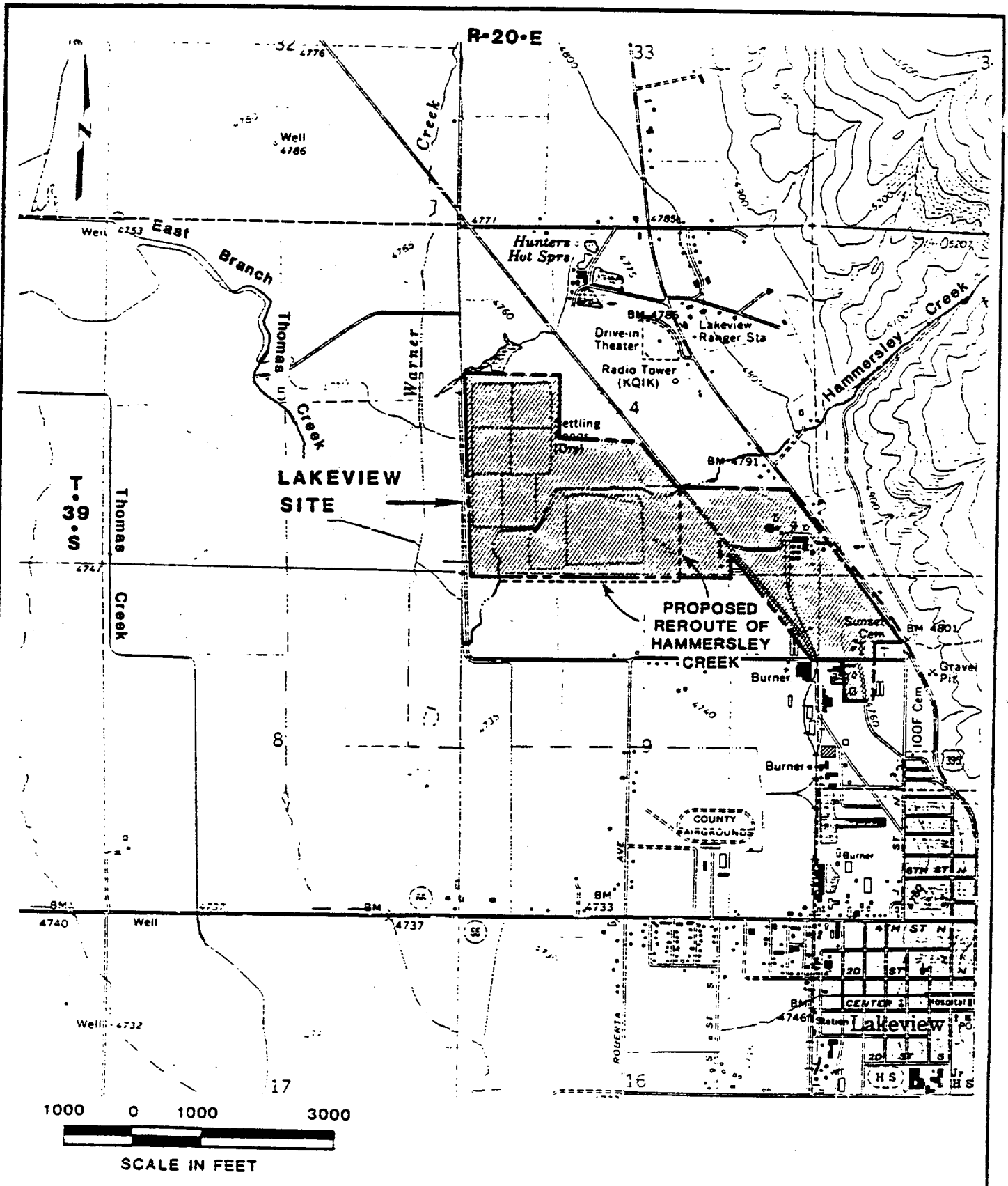


FIGURE 2.2
LAKEVIEW SITE MAP

The Lakeview site is in the basin and range physiographic province and is bounded on the east by the Warner Mountains and on the west by the mountains of the Fremont National Forest. Goose Lake Valley is a large, flat mountain valley approximately 4,750 feet above sea level. Mountain peaks in the surrounding ranges to the east and west reach elevations over 8000 feet. The higher mountains are pine covered, with sage and scrubbrush on the foothills. The valley consists of many grassy meadows and improved areas seeded for use as grazing lands for cattle.

Surface water flows through the site from east to west in Hammersley Creek which discharges into Thomas Creek. Thomas Creek drains the major portion of Goose Lake Valley and discharges into Goose Lake, eight miles south of the tailings site.

The areas of the tailings pile and to the north have high subsurface heat flows and local surficial expression of this phenomenon. Hunters Hot Springs lies about 0.4 mile north of the tailings pile. Three hot springs and over 40 geothermal wells are in the Known Geothermal Resource Area (KGRA) with many of these wells within 1.5 miles of the UMTRA site.

The area immediately surrounding most of the site is well-vegetated ranchland with occasional ranch homes and barns. Two lumber mills are located to the southeast of the site and comprise most of the industrial facilities in the immediate area.

The uranium mill was built in 1958 by the Lakeview Mining Company. The mill was operated for three years until 1961, during which time 130,000 tons of ore were processed and 171 tons of uranium oxide were produced by an acid leach process. The resulting tailings, the residue left over from the milling process, consist of finely ground rock, much like sand.

Partial stabilization of the existing tailings pile began in 1974 under the direction of Atlantic Richfield Company, the former owner of the site, and the Oregon State Health Division. Efforts to bring the site into compliance with the existing Oregon Regulations for the Control of Radiation were completed by 1977 and the property was subsequently sold to the Precision Pine Company on March 8, 1978.

The total designated site covers 258 acres. This includes the active sawmill area, the tailings pile (30 acres), the evaporation ponds (69 acres), and on-site windblown areas (25 acres).

The existing stabilized tailings pile measures approximately 1000 feet by 1100 feet and has an earthen cover ranging from 18 to 24 inches thick. The existing pile cover and pile subbase contain approximately 424,000 cubic yards of tailings and contaminated materials. Additionally, 204,000 cubic yards of contaminated materials have been identified in the evaporation ponds and around the tailings. The total estimate of the contaminated materials is 628,000 cubic yards.

The principal hazard associated with the tailings pile results from the production of radon, a radioactive gas, from the radioactive decay of the radium contained within the tailings. Radon can move through the tailings into the air. Inhalation of radon and its radioactive decay products can cause lung cancer if the concentrations of radon are high enough and the time of exposure long enough.

Cancers can also occur in other organs as a result of exposure to gamma radiation and from the consumption of contaminated food and water. If the tailings and the associated contaminated materials are not properly stabilized, natural processes such as wind and water erosion or removal of the material by man could spread the contamination and increase the potential public health hazard.

2.1.4 Purpose

This environmental assessment is prepared pursuant to the National Environmental Policy Act, which requires Federal agencies to assess the impacts that their actions may have on the environment. This environmental assessment examines the short-term and long-term effects of the DOE proposal to perform remedial action at the Lakeview site. Various alternatives to the DOE proposal are also examined.

DOE will use the information and analyses presented herein to determine whether the proposed action will have a significant impact on the environment. If the impacts are determined to be significant, a more detailed document called an "Environmental Impact Statement," will be prepared. If the impacts are not judged significant, the DOE may issue an official "Finding of No Significant Impact," and implement the preferred alternative. These procedures and documents are defined in regulations issued by the Council on Environmental Quality (CEQ) in Title 40, Code of Federal Regulations, Parts 1500 through 1508.

This environmental assessment addresses three alternatives: relocation and stabilization of the tailings and contaminated material at the Collins Ranch site, no action, and relocation and stabilization of the tailings and contaminated material at the Flynn Ranch site (Figure 2.1). As discussed in Section 2.6, stabilizing the tailings and contaminated materials in place is not a viable alternative.

Section 2.0 describes the remedial action alternatives. Section 3.0 discusses the present conditions of the environment. Section 4.0 assesses the environmental impacts of each of the remedial action alternatives. This document does not contain all of the details of the studies on which it was based. These details are contained in the appendices at the end of this document and in the referenced supporting documents.

In summary, remedial action at the Lakeview site is needed to minimize or eliminate the potential health hazard produced by the radioactive materials in the tailings piles and associated off-site materials. The U.S. Congress has mandated that remedial action be performed, and EPA has issued standards applicable to such actions.

2.2 RELOCATION AND STABILIZATION AT THE COLLINS RANCH SITE - THE PROPOSED ACTION

The Collins Ranch site is located on private land seven road miles northwest of the Lakeview site (Figures 2.1 and 2.3). The area surrounding the site has recently been burned but was previously used for the grazing of livestock. The nearest residence is 1.5 miles away.

The design for the Collins Ranch site was developed to comply with the EPA standards (Appendix A, EPA Standards). The following are summaries of the design objectives, major construction activities, and construction estimates. Additional details of the designs are contained in Appendix B, Site Conceptual Design, and the Draft Remedial Action Plan and Site Conceptual Design for Stabilization of the Inactive Uranium Tailings Site at Lakeview, Oregon (DOE, 1985).

Appendix B also contains a discussion of the major assumptions used for the preparation of the remedial action designs and the measures that would be used to control radon emanation, erosion, and ground-water contamination.

Design objectives

- Reduce the average radon flux from the site to 20 pCi/m^2sec or 0.5 pCi/l outside the disposal site.
- Design controls to remain effective for up to 1000 years, to the extent reasonably achievable, and, in any case, for at least 200 years. Appendix B contains details concerning the stability of the design.
- Prevent inadvertent human intrusion into the stabilized tailings.
- Minimize burrowing by animals into the stabilized tailings.
- Ensure that existing or anticipated beneficial uses of ground and surface water are not adversely affected.
- Reduce contaminant levels of Ra-226 in areas released for unrestricted use and at vicinity properties to 5 pCi/g averaged on the first 15 cm of soil below the surface, and 15 pCi/g averaged on 15-cm-thick layers of soil more than 15 cm below the surface.
- Undertake reasonable efforts to reduce radiation levels in habitable buildings (including vicinity properties) to 0.02 WL or in any case to 0.03 WL (includes background; gamma will not exceed background by more than 20 microR/hr).

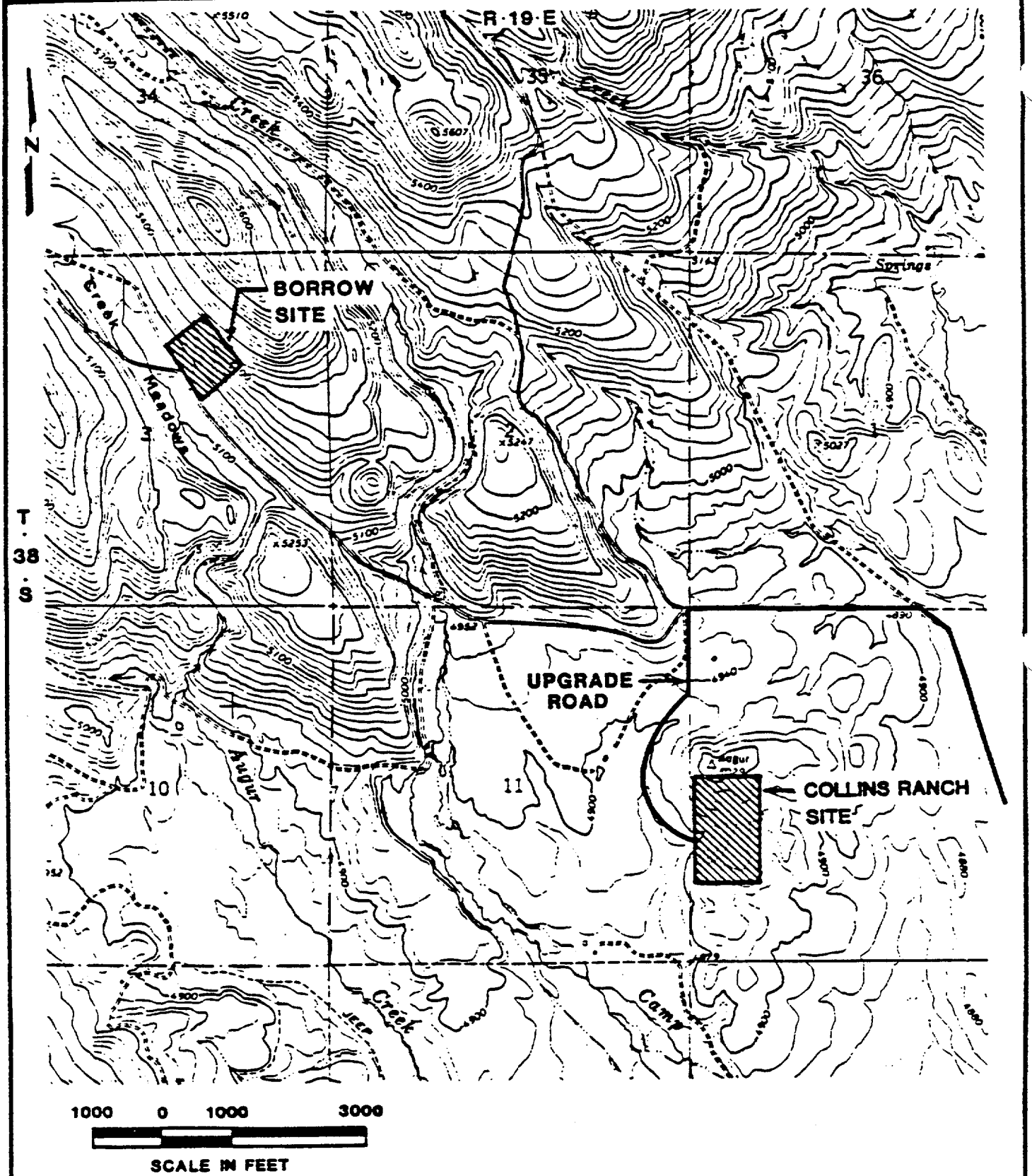


FIGURE 2.3

COLLINS RANCH ALTERNATE DISPOSAL SITE AND BORROW SITE

- o Minimize the land area to be utilized by the final disposal area.
- o Protect against releases of contaminants from the site during construction.
- o Minimize areas disturbed during construction and minimize human exposure to contaminated materials.

Major construction activities

The proposed action consists of relocating the tailings and contaminated materials from the Lakeview site and adjacent areas, and consolidating the materials into a gently contoured embankment at the Collins Ranch site.

A disposal area would be constructed partially below grade at this site. The surface materials removed from the area would be stockpiled and used later as a part of the cover system. Material for erosion protection would be obtained from borrow site B located approximately two miles northwest of the Collins Ranch site. Section 2.5 contains additional details on borrow site B.

The contaminated materials from the Lakeview site and vicinity properties would be covered with a one-foot-thick compacted earthen cover to inhibit radon exhalation and water infiltration. Only one foot of radon protection cover is necessary because the tailings would be covered by 20 feet of lesser contaminated materials (average Ra-226 concentration of 14 pCi/g). This then would be capped with a two-foot-thick layer of rock to protect the cover from wind and water erosion. A rock-soil matrix would be placed on the erosion protection covers and the stabilized pile would be revegetated. A description of a rock-soil matrix is contained in Section B.2.5.1 of Appendix B, Site Conceptual Design. This alternative would involve the following major construction activities.

At the Lakeview tailings site:

Site preparation

- o Grubbing and clearing (as necessary), erection of a temporary security fence, construction of access roads, and upgrading of seven miles of existing road between the tailings site and the disposal site (Figures 2.1 and 2.3).
- o Relocation of approximately 4000 linear feet of Hammersley Creek to flow south of the designated site boundary (Figure 2.2).
- o Relocation of uncontaminated on-site wood chips to an uncontaminated area.
- o Construction of a waste-water retention pond(s) to protect against the release of contaminants from the site during construction.

- o Construction of drainage control measures to direct all generated waste-water and storm-water runoff to the retention pond(s) during construction activities.

- o Installation of measures to control erosion and sediment from all disturbed areas during construction.

- o Installation and operation of a waste-water treatment facility to protect against inadvertent contaminant release during construction.

Tailings relocation

- o Excavation of all tailings and contaminated materials from the existing tailings pile, the evaporation ponds, windblown areas, mill site, ore storage area, and vicinity properties, and relocation by truck to the Collins Ranch disposal site.

Site restoration

- o Restoration of all excavated areas at the existing tailings site to at or near natural contours with uncontaminated fill and final grading to provide suitable drainage control.

- o Revegetation of all disturbed areas as required.

At the Collins Ranch site:

Site preparation

- o Construction of an access road (approximately 0.5 miles) to the haul road and any necessary upgrading of the existing road to the borrow area (2.0 miles) (Figure 2.3).

- o Grubbing and clearing (as necessary) and erection of a temporary security fence.

- o Construction of a waste-water retention pond to protect against the release of contaminants from the site during construction.

- o Construction of measures to control erosion and sediment from all disturbed areas during construction activities.

Tailings pile construction

- o Below-grade excavation of the disposal area and stockpiling of surface materials required for restoration at the existing site; remaining materials excavated to be placed directly on the tailings as a radon cover.

- o Construction of a capillary break layer consisting of a two-foot layer of graded sand and gravel (if necessary). The need for a capillary layer will be determined following the collection of ground-water level data in the spring and summer of 1985.

- o Placement and consolidation of the tailings and contaminated materials into the partially below-grade disposal area to form a gently contoured pile.

- o Even distribution of the demolition debris within the tailings pile.

Radon cover

- o Placement of the lesser contaminated material (with an average radium-226 concentration of 14 pCi/g) as the upper 20 feet of the stabilized pile.

- o Placement of a one-foot thick, compacted, earthen cover over the tailings to inhibit water infiltration, and radon exhalation.

Erosion protection

- o Emplacement of two feet of rock (including filter layer) over the radon cover for erosion protection and to inhibit burrowing by animals.

- o Emplacement of a rock-soil matrix layer to promote revegetation of the site.

Site restoration

- o Backfilling, final grading for drainage control, and revegetation, as required, of all areas disturbed during remedial action.

- o Construction of an unpaved access road and drainage ditch looping the toe of the stabilized tailings pile.

Description of final condition

The stabilized tailings embankment would cover an area of approximately 13 acres of the disposal site, and the entire disposal area would cover approximately 20 acres.

The below-grade excavation of the disposal area would extend to an average depth of 25 feet. The upper 20 feet of the stabilized embankment would consist of the lesser contaminated materials from the mill site. The tailings and contaminated material would be covered with a one-foot thick, compacted, earthen cover obtained from the surface materials excavated from the disposal area. The stabilized tailings pile would have maximum sideslopes of 20 percent and top slopes of three percent. The entire

embankment would be covered with a two-foot layer (including filter layer) of graded rock for erosion protection and a rock-soil matrix layer. The site would then be revegetated. The final stabilized pile would be a maximum of approximately 20 feet above the surrounding terrain (Figures 2.4 and 2.5).

The rock erosion barrier would tie into an unpaved access road which would loop the toe of the stabilized tailings embankment. Drainage ditches would divert surface runoff around and away from the pile. Monuments would be established at set intervals designating the site as Federally owned property.

After completion of the stabilized tailings pile at the disposal site and decontamination of the present tailings site, the disturbed areas of each site (as necessary) would be restored with uncontaminated fill to conform with the surrounding terrain, recontoured as necessary for surface drainage, and revegetated.

The decontaminated Lakeview site would be released for any purposes consistent with Lake County zoning ordinances.

The Collins Ranch site would be released for grazing purposes but ownership and control of the site would remain with the Federal Government. A long-term surveillance and maintenance program, as described in Section 4.0, would be conducted.

Personnel, consumptions, volumes, and cost estimates

Estimates of personnel requirements, energy and water consumption, earthwork volumes, and costs and schedules are contained in Section 2.4. Additional details are contained in Appendix B, Site Conceptual Design.

2.3 ALTERNATIVES TO THE PROPOSED ACTION

2.3.1 No action

This alternative consists of taking no steps towards remedial action at the tailings site or the vicinity properties. The tailings pile and vicinity properties would remain in their present condition and would be subject to dispersion by wind and water erosion and unauthorized removal by man. The selection of this alternative would not be consistent with the intent of Congress in UMTRCA (PL95-604) and would not result in DOE's compliance with the EPA standards (40 CFR Part 192).

2.3.2 Relocation and stabilization at the Flynn Ranch site

The Flynn Ranch site is located on private land 26 road miles northeast of the Lakeview site (Figures 2.1 and 2.6). The Flynn Ranch site and the surrounding area are used for livestock grazing. The nearest residence is 4.7 miles away.

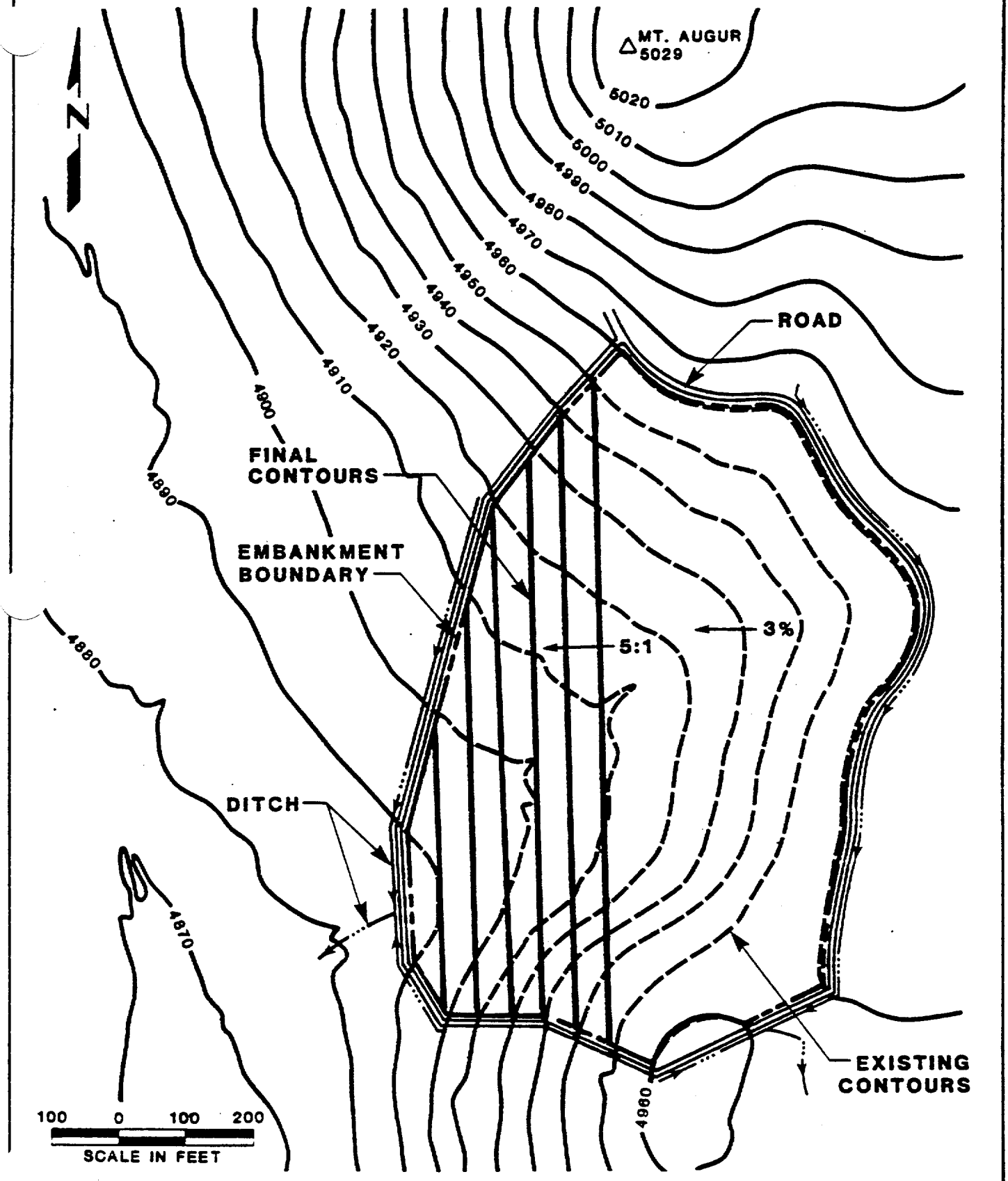


FIGURE 2.4
FINAL CONDITION - COLLINS RANCH ALTERNATE DISPOSAL SITE

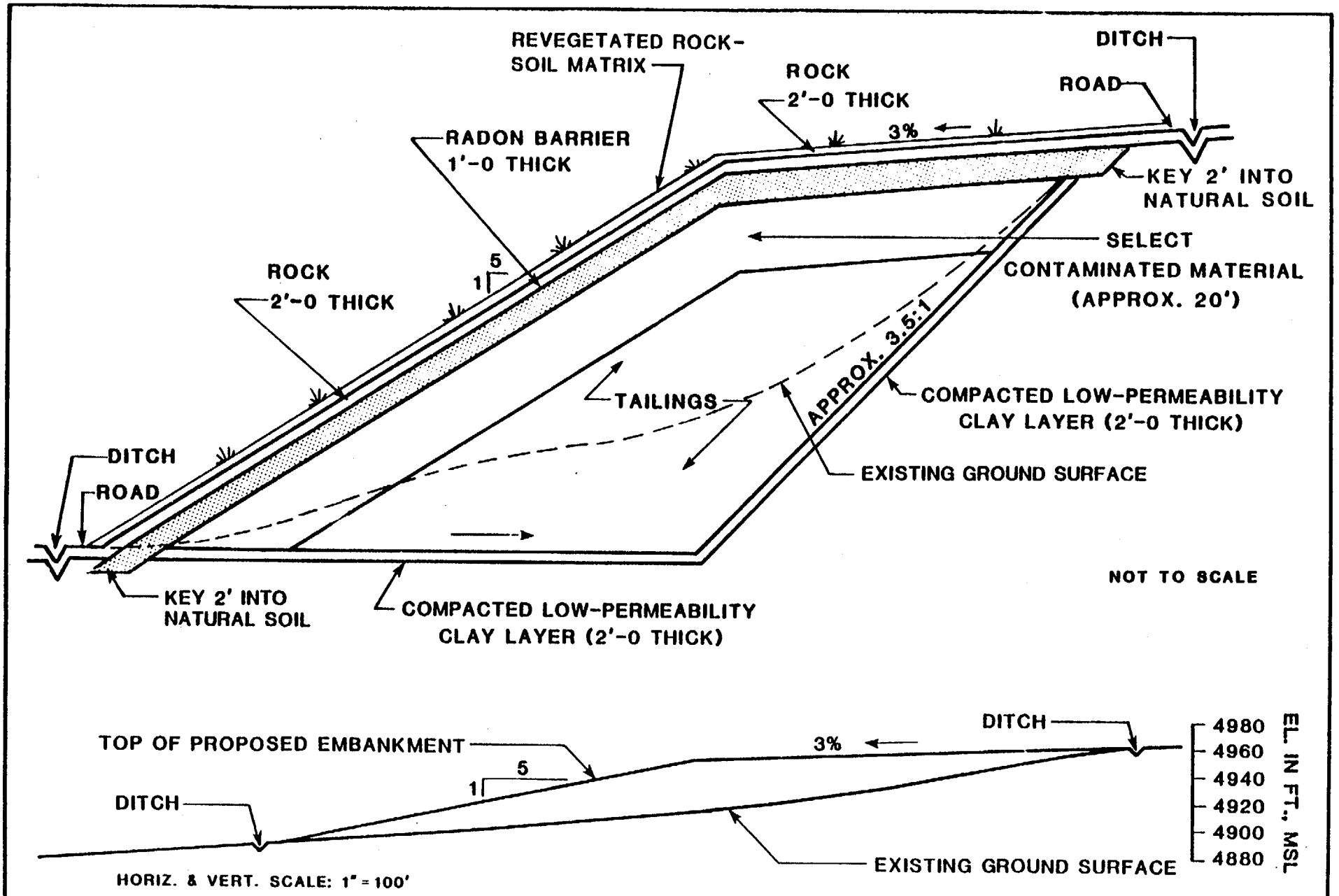


FIGURE 2.5
COLLINS RANCH DISPOSAL SITE
TYPICAL CROSS-SECTION

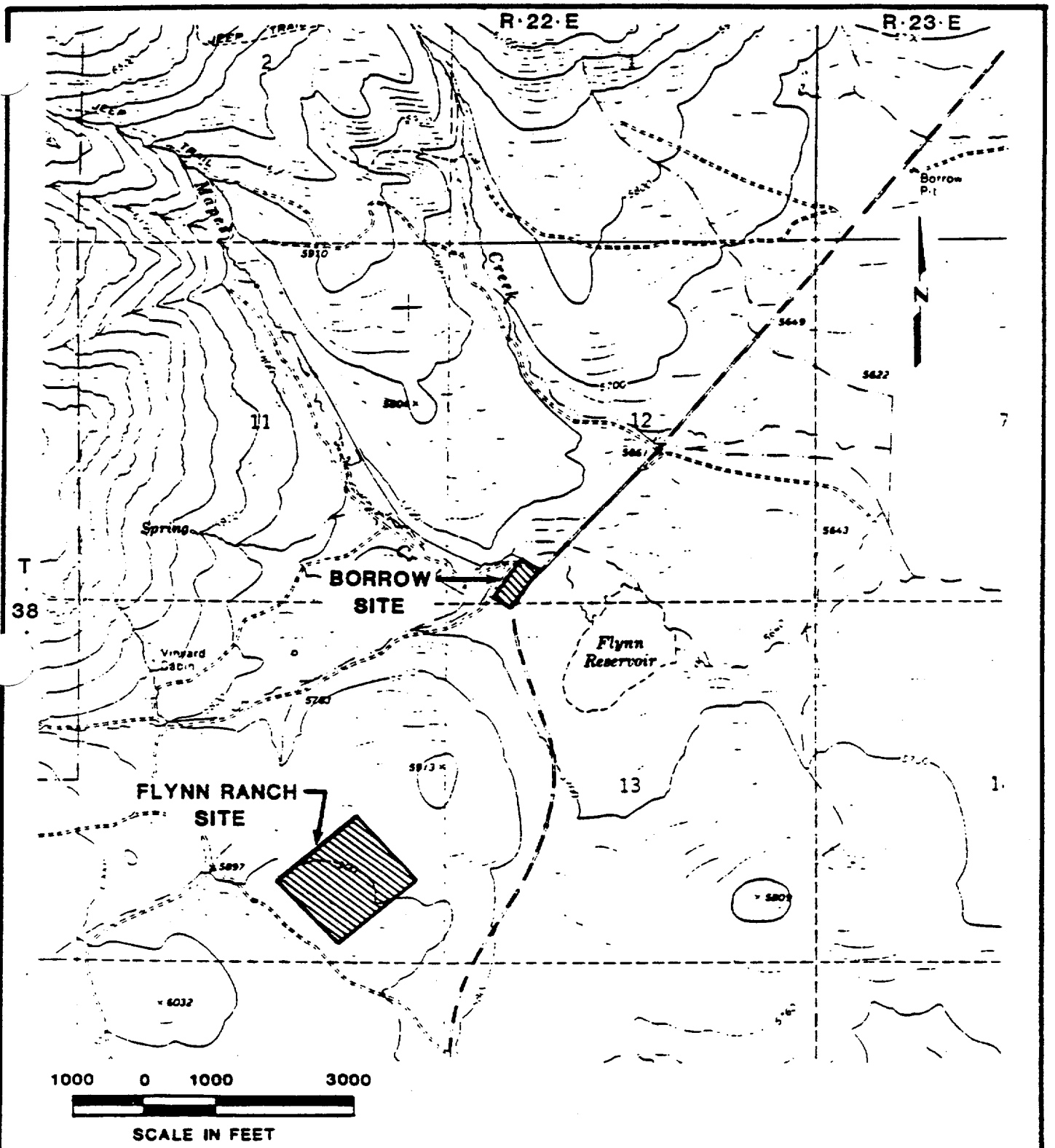


FIGURE 2.6

FLYNN RANCH ALTERNATE DISPOSAL SITE AND BORROW SITE

The remedial action design for the Flynn Ranch site was designed to comply with the EPA standards (Appendix A, EPA Standards).

The design objectives for the Flynn Ranch site are the same as those stated in Section 2.2 for the Collins Ranch site. The following are summaries of the major construction activities for the Flynn Ranch alternative. Additional details of the design and a discussion of the measures that would be used to control radon emanation, erosion and ground-water contamination are contained in Appendix B, Site Conceptual Design.

Major construction activities

The Flynn Ranch alternative consists of relocating the tailings and contaminated materials from the Lakeview site to the Flynn Ranch site and consolidating them into a gently contoured embankment at the Flynn Ranch site. A disposal area would be constructed partially below grade at this site. The surface materials removed from the area would be stockpiled and used later for the cover system. Restoration material for the existing site would be obtained from borrow site G located approximately two miles from the disposal site. Section 2.5 contains additional details on borrow site G.

The contaminated materials would be covered with a one-foot-thick compacted earthen cover to control radon exhalation and inhibit water infiltration. The cover would be capped with a two-foot-thick layer of rock to protect the cover from wind and water erosion. A rock-soil matrix layer would be placed to promote revegetation of the stabilized pile. This design would require the following major construction activities:

At the Lakeview tailings site:

- The Flynn Ranch alternative would require the same activities at the Lakeview site as discussed in Section 2.2 for the Collins Ranch site.

At the Flynn Ranch site:

- The Flynn Ranch alternative would require the same construction activities at the disposal site as discussed in Section 2.2 for the Collins Ranch site, with the following exceptions. Construction of an access road (approximately 1.5 miles) from the Flynn Ranch site to the haul road and upgrading of the existing road to the borrow area (2.0 miles) would be necessary. No capillary break layer would be constructed.

  The layer of lesser contaminated material (with an average radium-226 concentration of 14 pCi/g) in the upper portion of the stabilized embankment would be 15 feet thick at the Flynn Ranch site.

Description of final condition

The stabilized tailings embankment would cover an area of approximately 17 acres of the disposal site and the entire disposal area would cover approximately 25 acres.

The below-grade excavation of the disposal area would extend to an average depth of five feet. The upper 15 feet of the stabilized embankment would consist of the lesser contaminated soils from the mill sites. The tailings and contaminated material would be covered with a one-foot-thick, compacted, earthen cover obtained from the surface materials excavated from the disposal area. The stabilized tailings pile would have maximum sideslopes of 20 percent and top slopes of three percent. The entire embankment would be covered with a two-foot layer (including filter layer) of graded rock for erosion protection and a rock-soil matrix layer to promote revegetation of the site. The final stabilized pile would be a maximum of approximately 35 feet above the surrounding terrain (Figures 2.7 and 2.8).

The rock erosion barrier would tie into an unpaved access road which would loop the toe of the stabilized embankment. Drainage ditches would divert surface runoff around and away from the pile. Monuments would be established at set intervals designating the site as Federally owned property.

After completion of the stabilized tailing pile at the disposal site and decontamination of the present tailings site, the disturbed areas of each site (as necessary) would be restored with uncontaminated fill to conform with the surrounding terrain, recontoured as necessary for surface drainage, and revegetated.

The decontaminated Lakeview site would be released for any purposes consistent with Lake County zoning ordinances.

The Flynn Ranch site would be released for grazing purposes but ownership and control of the site would remain with the Federal Government. A long-term maintenance and surveillance program, as described in Section 4.0, would be conducted.

Personnel, consumption, volumes and cost estimates

Estimates of personnel requirements, energy and water consumption, earthmoving volumes, and costs and schedules are contained in Section 2.4. Additional details are contained in Appendix B, Site Conceptual Design.

2.4 PERSONNEL, CONSUMPTION, VOLUMES, AND COST ESTIMATES AND SCHEDULES

Estimates of personnel requirements, energy and water consumption, major earthwork volumes, and costs, for all alternatives are contained in Tables 2.2 through 2.6. Schedules are shown in Figures 2.9 and 2.10.

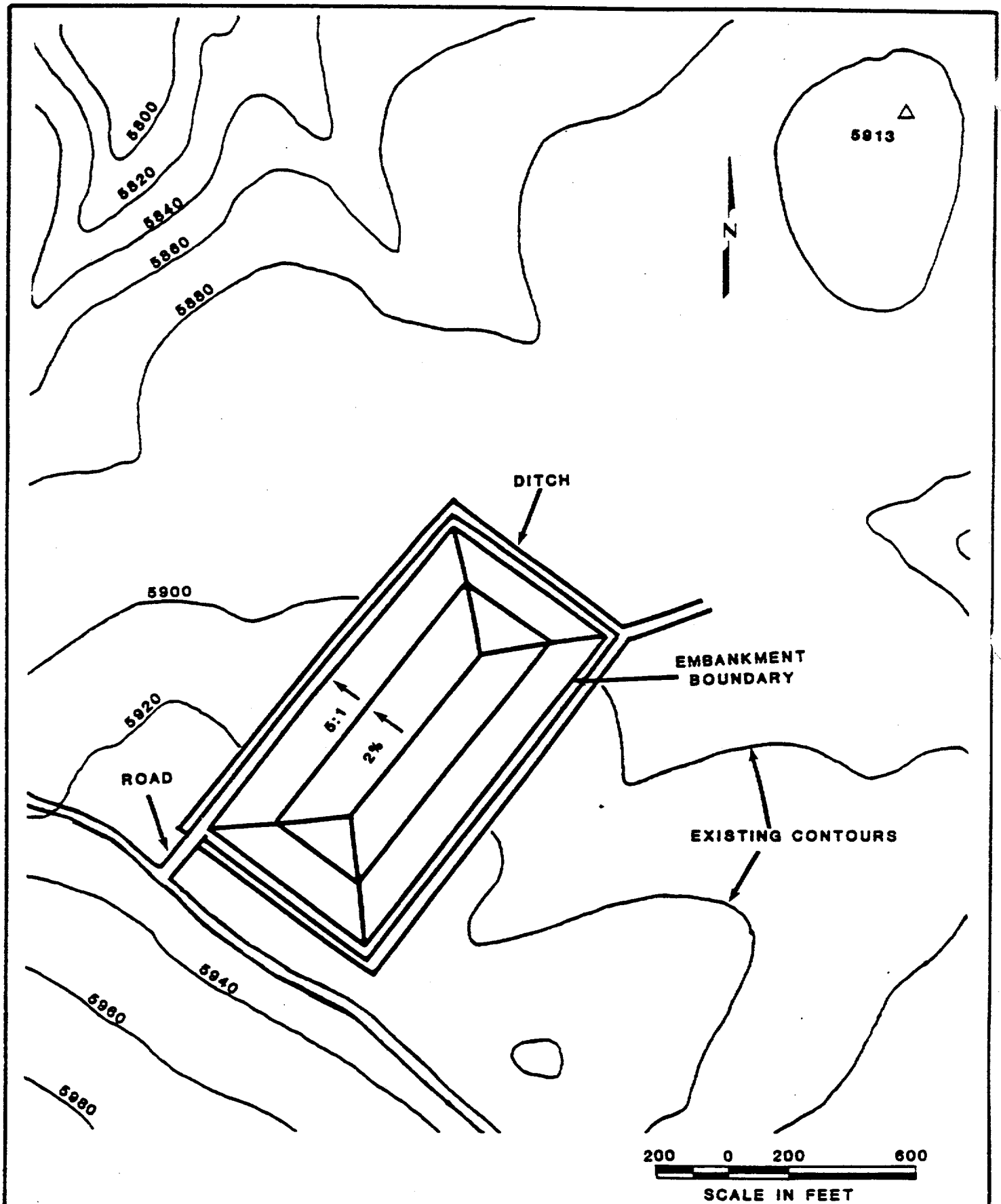


FIGURE 2.7

FINAL CONDITION - FLYNN RANCH ALTERNATE DISPOSAL SITE

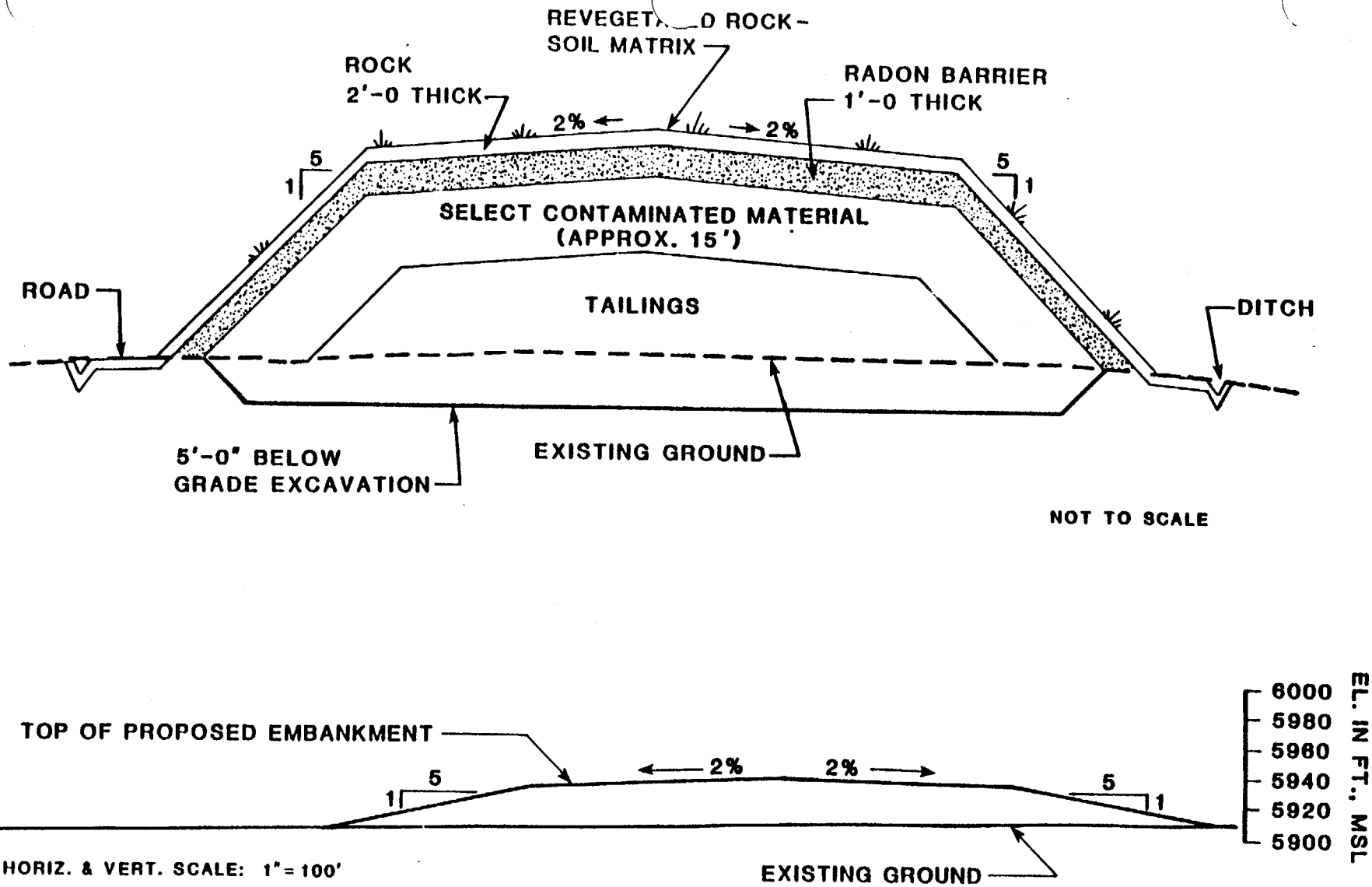


FIGURE 2.8
FLYNN RANCH ALTERNATE DISPOSAL SITE
TYPICAL CROSS-SECTION

Table 2.2 Personnel requirements - Collins Ranch

Type of personnel	Number of personnel per month of project schedule																								Total man months per type of personnel
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
Truck drivers	0	7	7	3	29	29	29	29	30	30	30	30	30	30	30	30	30	30	30	30	30	2	2	1	528
Equipment operators	0	15	15	11	17	11	11	11	16	16	16	16	16	16	16	16	16	16	16	16	16	9	7	7	322
Operator supervisors	0	2	2	2	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	2	2	2	93
Laborers	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	66
General supervision and field services	32	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	653
Total man months per month of project time	32	54	54	46	80	74	74	74	81	81	81	81	81	81	81	81	81	81	81	81	81	42	40	39	1662

Peak employment = 81.
Average employment = 1662 total man months/24 months = 70.

Table 2.3 Personnel requirements - Flynn Ranch

Type of personnel	Number of personnel per month of project schedule																														Total man months per type of of personnel
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
Truck drivers	0	5	5	30	30	30	30	30	30	30	30	30	30	30	30	30	30	32	32	32	32	32	32	32	32	32	32	32	32	1	815
Equipment operators	0	13	14	15	15	8	8	8	11	11	11	11	11	11	11	11	11	12	12	12	12	12	12	12	12	12	12	8	7	6	321
Operator supervisors	0	2	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	110
Laborers	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	84
General supervision & field services	33	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	845
Total man months per month of project time	33	51	52	80	80	73	73	73	76	76	76	76	76	76	76	76	76	79	79	79	79	79	79	79	79	79	79	74	73	39	2175

Peak employment = 80.
Average employment = 2175 total man months/30 months = 73.

Table 2.4 Energy and water consumption

Item	Collins Ranch	No action	Flynn Ranch
Fuel (gallons)	963,660	0	1,279,000
Electricity (Kwt)	489,000	0	620,000
Water (gallons)	19,847,000	0	13,264,000

Table 2.5 Summary of major earthwork volumes - Lakeview relocation alternatives

Activity item	Estimated in-place volume (cubic yards)[a] Collins Ranch	Flynn Ranch
Site preparation		
o Haul roads		
1. Base course	51,000	13,000
2. Gravel	35,000	12,000
o Strip and stockpile topsoil	18,000	34,000
o Relocate creek		
1. Excavate and stockpile	15,000	15,000
2. Clay liner	4,000	4,000
3. Gravel	3,000	3,000
o relocate on-site wood chips	144,000	144,000
Tailings relocation		
o Excavate, haul, spread, and compact	628,000	628,000
Capillary break (if required)		
o Sand	19,000	--
o Gravel	19,000	--
Radon cover		
o Excavation & stockpile for site restoration	442,000	442,000
o Excavate, haul, spread, and compact	24,000	31,000
Erosion protection	42,000	53,000
Site restoration		
o Backfill excavations	465,000	452,000
o Replace stripped topsoil	18,000	34,000

[a]Includes work performed at processing site, disposal site, and borrow site.

Table 2.6 Summary of construction costs - Lakeview relocation alternatives

Activity item	COST (x $1000)	
	Collins Ranch	Flynn Ranch
Site preparation	2,170	2,210
Capillary break (if required)	400	--
Tailings relocation	2,640	4,550
Radon cover	590	170
Erosion protection	470	530
Decontamination	120	120
Site restoration	1,550	1,600
Supervisory & field services	4,310	4,520
Total:	12,250	13,700

These estimates do not include the costs of:

- Property acquisition.
- Engineering design.
- Construction management (except for field supervision).
- Overall project management.
- Long-term maintenance and surveillance.
- Vicinity properties

FIGURE 2.9 REMEDIAL ACTION SCHEDULE. DISPOSAL AT COLLINS RANCH SITE

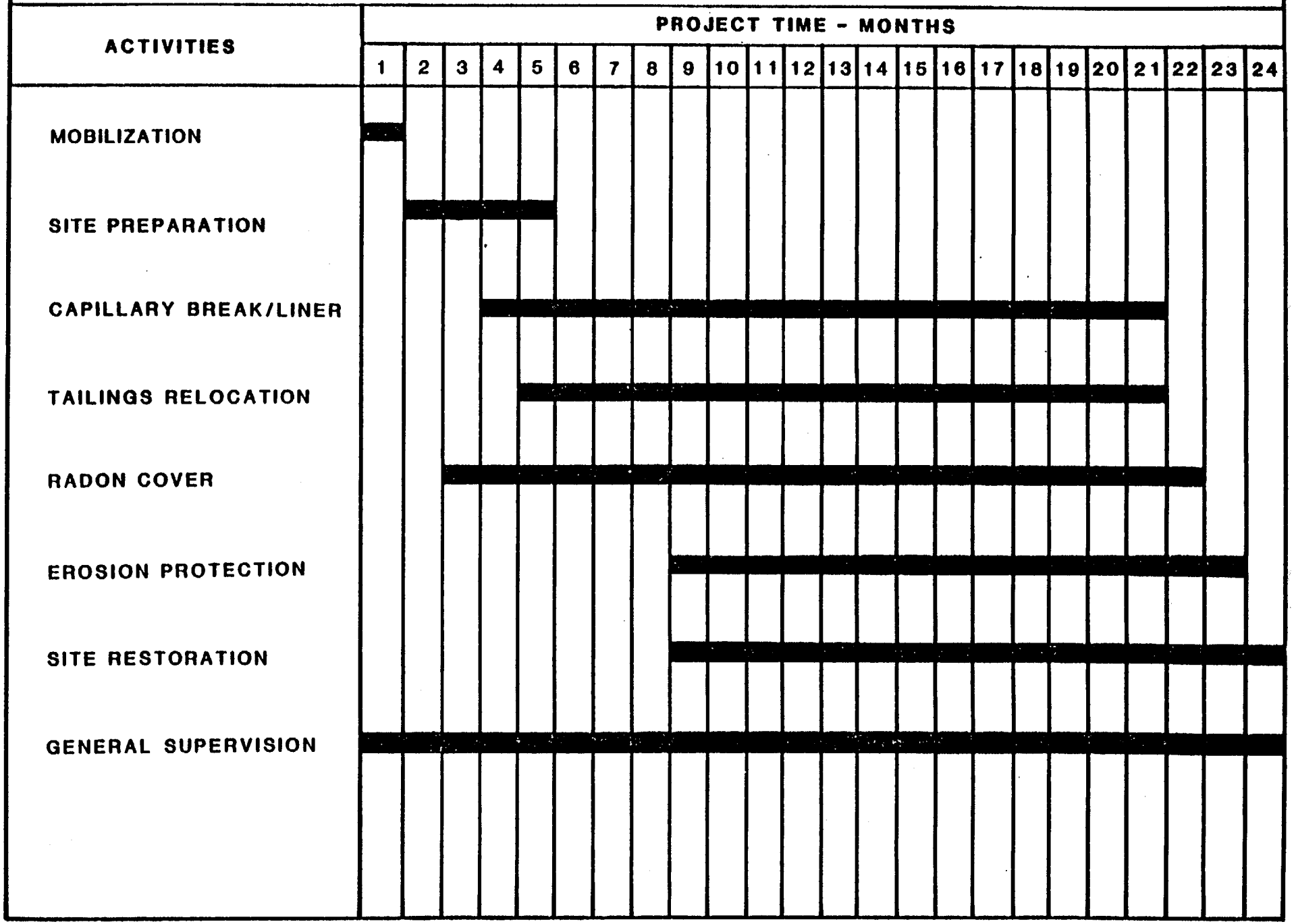
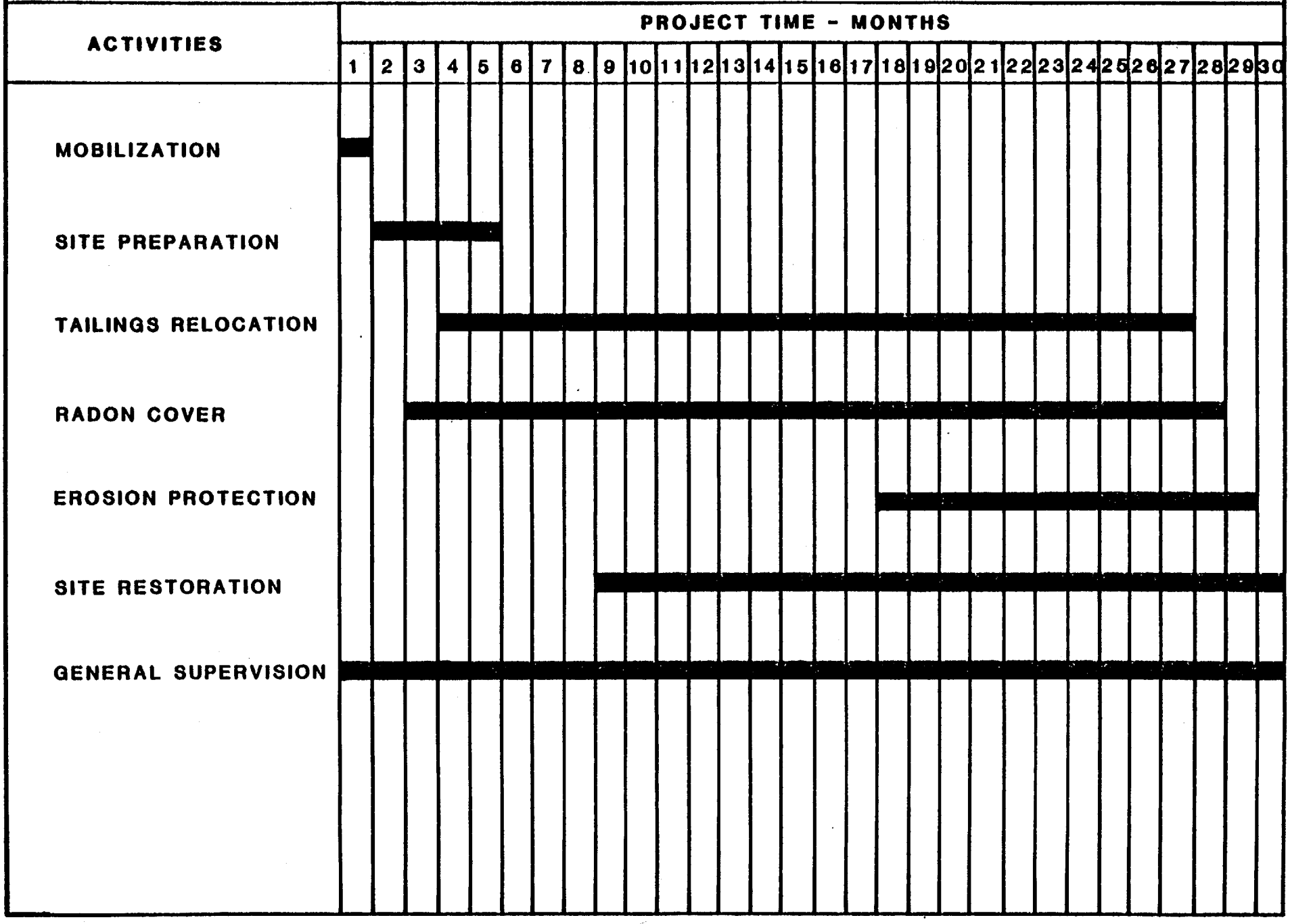


FIGURE 2.10 REMEDIAL ACTION SCHEDULE: DISPOSAL AT FLYNN RANCH SITE



2.5 BORROW SITES

During the alternate site selection process (Section 2.6) potential borrow sites for coarse and fine grained materials were also evaluated. One borrow site was identified for each alternative.

For the Collins Ranch alternative, borrow site B (Figure 2.3) was selected as the source of random fill for the areas to be excavated at the existing mill site and for the rock cover at the Collins Ranch site. Borrow site B was selected because it contains the needed material and has been used as a borrow source for other projects. The use of borrow site B would also enable trucks returning from the Collins Ranch site to the existing mill site to haul the random fill needed at the existing mill site and thereby provide for efficient earth moving activities. Material for the radon cover and the rock-soil matrix would be obtained from the Collins Ranch disposal site.

For the Flynn Ranch alternative, borrow site G (Figure 2.6) was selected as the source of random fill for the areas to be excavated at the existing mill site. Borrow site G was selected because it contains the needed material and has been used as a borrow source for other projects. The use of borrow site G would also enable trucks returning from the Flynn Ranch site to the existing mill site to haul the random fill needed at the existing mill site and thereby provide for efficient earth moving activities. Material for the radon cover, rock erosion protection, and the rock-soil matrix would be obtained from the Flynn Ranch disposal site.

Gravel and rock needed at the Lakeview site may be obtained from local commercial sources instead of borrow sites B or G depending on the costs of obtaining the gravel and rock from commercial sources when remedial action is performed.

2.6 REJECTED ALTERNATIVES

Stabilization in place

A geotechnical evaluation of the current Lakeview tailings site determined that stabilization in place is not feasible. Details of this evaluation are found in Appendix E, Seismic and Geothermal Hazards. Briefly, the geotechnical evaluation identified seven active faults or fault zones with potential for hazard at the existing tailings site. The area is also characterized as having a high subsurface heat-flow with three hot springs and over 40 geothermal wells in the vicinity of the existing tailings site. Many of the geothermal wells are within 1.5 miles of the site. Hunters Hot Spring lies about 0.25 mile north of the northernmost evaporation pond.

The presence of surface water (Hammersley Creek) and shallow ground water at the existing site increases the complexity of stabilization in place. It is believed that further study into the geothermal conditions at the existing Lakeview site will not change the conclusions or recommendations (Appendix E, Seismic and Geothermal Hazard, page 46). The identification of potential hazards to long-term stability, together with the project's required design life of 200 to 1000 years, dictates that the mill tailings are relocated.

Alternate site selection

As a result of the existing tailings' site instability, an alternate site selection process was instituted to identify suitable relocation alternatives. Details of this study are presented in Appendix J, Lakeview Alternate Site Selection. The program examined a 15-mile radius (700 square miles) around the existing mill site and seven sites were selected for further evaluation. Each site was evaluated and ranked for suitability as a disposal site based on geotechnical, hydrological, environmental, and engineering characteristics. The alternate sites were evaluated on 23 separate technical factors, with each factor given a degree of importance. Alternate sites B (the Collins Ranch site) and G (the Flynn Ranch site) were the sites preferred as a result of this study. These two sites were then subjected to an in-depth field evaluation that provided the site characterization included in this environmental assessment.

The Collins Ranch and Flynn Ranch sites were characterized during intense field studies in the summer and fall of 1984. Geotechnical drilling, hydrological modeling and testing, archaeological field surveys, and threatened and endangered species field surveys were all conducted during this period. The information gathered from these field studies was then applied to a refined ranking system for the two sites. The sites were then compared only to each other and given a score of zero or one, depending on the ranking of each site. The Collins Ranch site scored the higher.

Returning the tailings to the original mine sites

Returning the tailings to the mines from which the ore was obtained (the Lucky Lass and White King mines) was determined to be undesirable. The Lucky Lass and White King mines are located 13 miles northeast of the existing tailings pile in the mountains of the Fremont National Forest. The area is characterized as having shallow ground water, excessive slopes (greater than 33 percent grade), and subject to seasonal flooding from Augur Creek. A drilling program to identify the hydrogeotechnical characteristics of the area was conducted during the winter of 1984. This field study confirmed the unsuitability of the mines site as a disposal alternative. Meeting the EPA longevity design standards for remedial action at this site would be extremely difficult.

Returning the tailings to the mines would also preclude any further mining development at the mines and eliminate further recovery of known mineral resources.

The mines were included in the Lakeview alternate site selection process (DOE, 1984) and received the lowest ranking of the seven sites evaluated (see Appendix J, Lakeview Alternate Site Selection). The mines site was therefore eliminated from further consideration.

Reprocessing the tailings

The feasibility of reprocessing the tailings to recover the residual uranium was evaluated. At the Lakeview site, a limited number of samples

were obtained for characterization of the tailings to examine the feasibility of reprocessing the tailings pile. Two principal methods for reprocessing were examined: heap leaching and reprocessing at a new conventional mill.

The cost of recovering the uranium would be over $450.00/lb of U_3O_8, whether processed by heap leaching or a conventional processing plant (FBDU, 1981). The spot market for uranium in 1981 was $25.00/lb and has dropped to $17.00/lb in 1985.

Reprocessing of the tailings would not reduce the radium content of the tailings. Since radioactive decay of the radium is the source of the radon gas, there would be no reduction of the hazard from radon daughters; hence, the reprocessed tailings would require remedial action to meet EPA standards. Reprocessing was therefore eliminated from further consideration.

REFERENCES FOR SECTION 2.0

DOE (U.S. Department of Energy), 1985. Draft "Remedial Action Plan and Site Conceptual Design for Stabilization of the Inactive Uranium Tailings Site at Lakeview, Oregon," prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

DOE (U.S. Department of Energy), 1984. Draft "Lakeview Alternate Site Selection Process," prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

EPA (U.S. Environmental Protection Agency), 1982. Final Environmental Impact Statement for Remedial Action Standards for Inactive Uranium Processing Sites, EPA 520/4-82-013-2, Volume 1, Office of Radiation Programs, Washington, D.C.

FBDU (Ford, Bacon, and Davis, Utah, Inc.), 1981. Engineering Assessment of Inactive Uranium Mill Tailings, Lakeview Site, Lakeview, Oregon, DOE/UMT-0110 (360-18), prepared by FBDU, Salt Lake City, Utah, for the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

3.0 AFFECTED ENVIRONMENT

3.1 BRIEF DESCRIPTION OF THE AFFECTED AREAS

The Lakeview tailings site and the alternate disposal sites are located in Lake County, Oregon, in the general vicinity of the city of Lakeview. Figure 3.1 shows the location of each site and the major demographic features of the area. The major urban center in Lake County is the city of Lakeview with an estimated 1983 population of 2750. Most of this population is concentrated within the Lakeview city limits. The former mill site is approximately one mile north of the northern city limits of Lakeview.

The area has a cool high desert climate with an average annual precipitation of 16 inches. The predominant winds are out of the south (35 percent) with calm winds occurring most frequently (32 percent).

The tailings site is located on the floor of Goose Lake Valley. Vegetation ranges from ponderosa pine on the mountains surrounding Goose Lake Valley to shrubs and grasses on the valley bottom. In 1977, Atlantic Richfield stabilized the tailings pile to the then existing Oregon Department of Health standards, including revegetation of the pile. Introduced grasses, dominated by oats, are found covering the existing tailing pile as a result of stabilization completed in 1977. Total vegetation cover is approximately 50 to 75 percent (WRD, 1984a).

The tailings pile is approximately one mile north of the Lakeview city limits on property owned by Precision Pine Company (Figure 3.2). Two lumber mills are located south of the existing site and comprise most of the industrial facilities in Lake County outside of farming. Land to the north and west is used predominantly for grazing horses and cattle, with a few scattered dwellings. Sunset cemetery is located southeast of the site.

The Collins Ranch alternate disposal site is located seven road miles northwest of the existing tailings site in a sloping, bowl-shaped area on the western edge of Section 12, Range 19E, Township 38S (Figure 3.3). The land is privately owned and subleased for cattle grazing purposes. The site is approximately 1.5 miles from the nearest residence.

The Flynn Ranch alternate disposal site is located approximately 26 road miles east of the existing tailings pile, across the Warner Mountains toward the Warner Valley (Figure 3.4). The land is part of the Flynn Brothers Ranch, owned and operated by the Flynn family. The site is approximately 4.75 miles from the nearest residence.

Implementation of either of these alternatives would require additional fill and cover materials to be obtained from designated borrow sites. Identified as borrow sites B and G, these areas are illustrated in Figures 3.3 and 3.4.

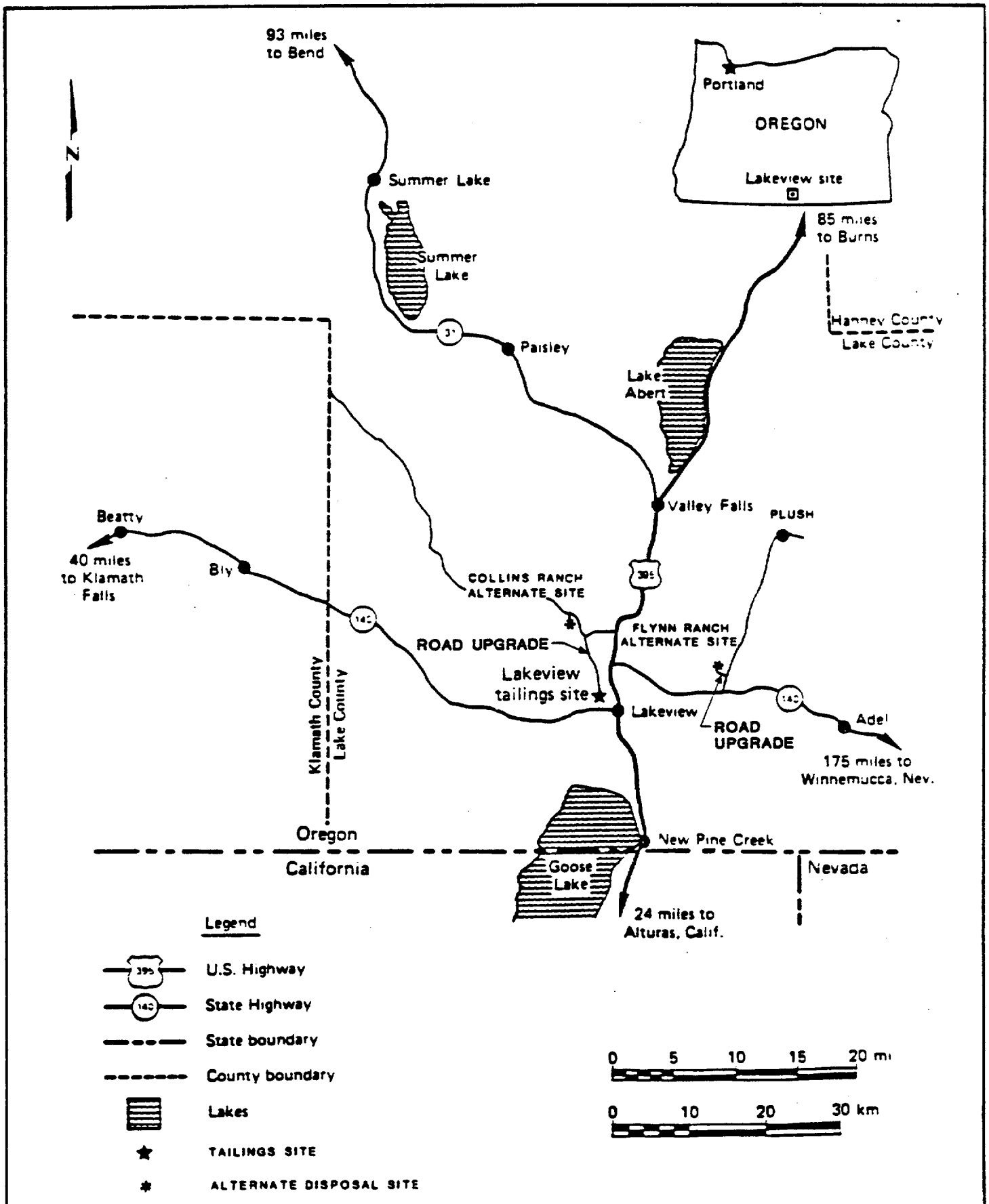


FIGURE 3.1
LAKEVIEW AREA MAP

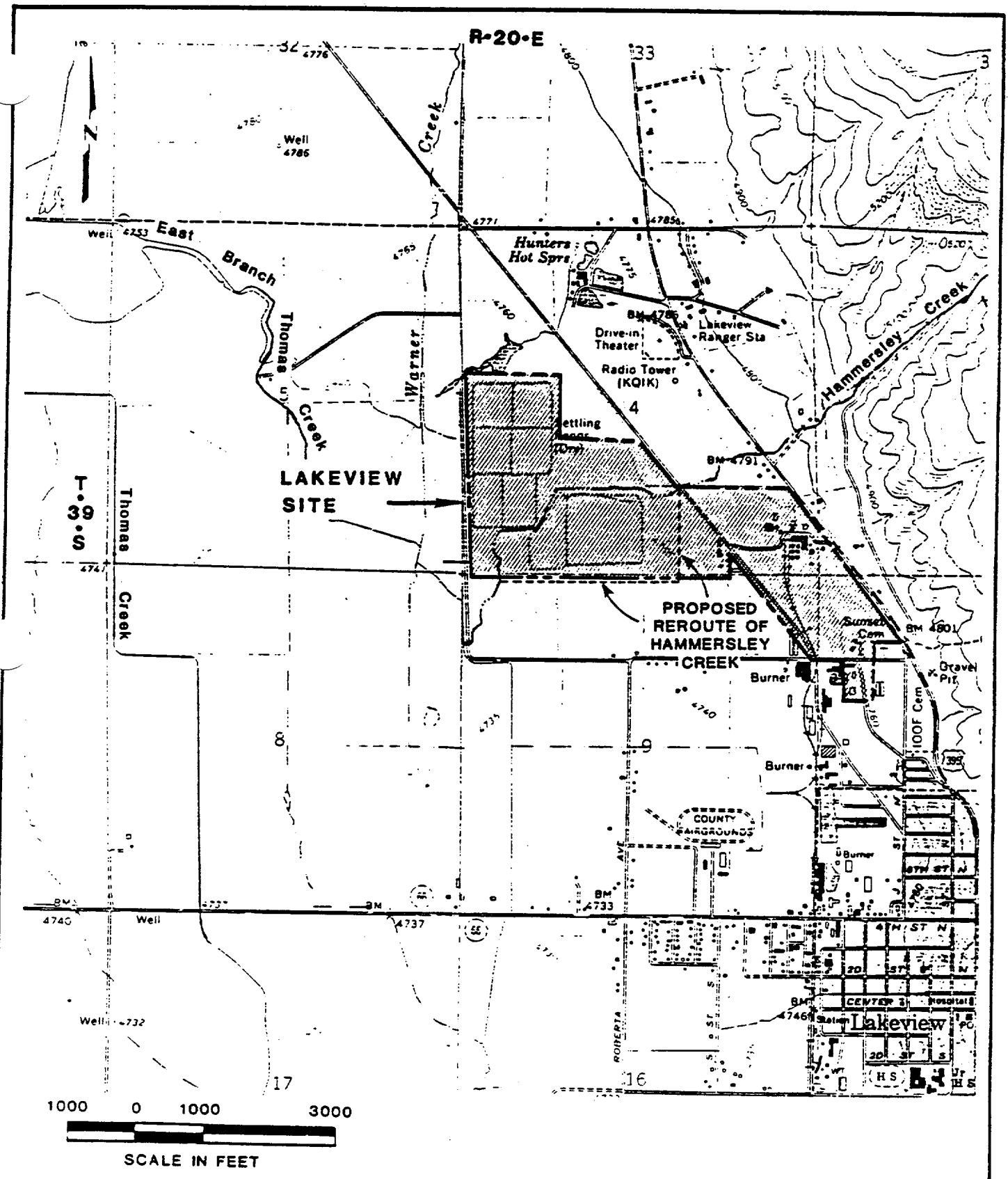


FIGURE 3.2
LAKEVIEW SITE MAP

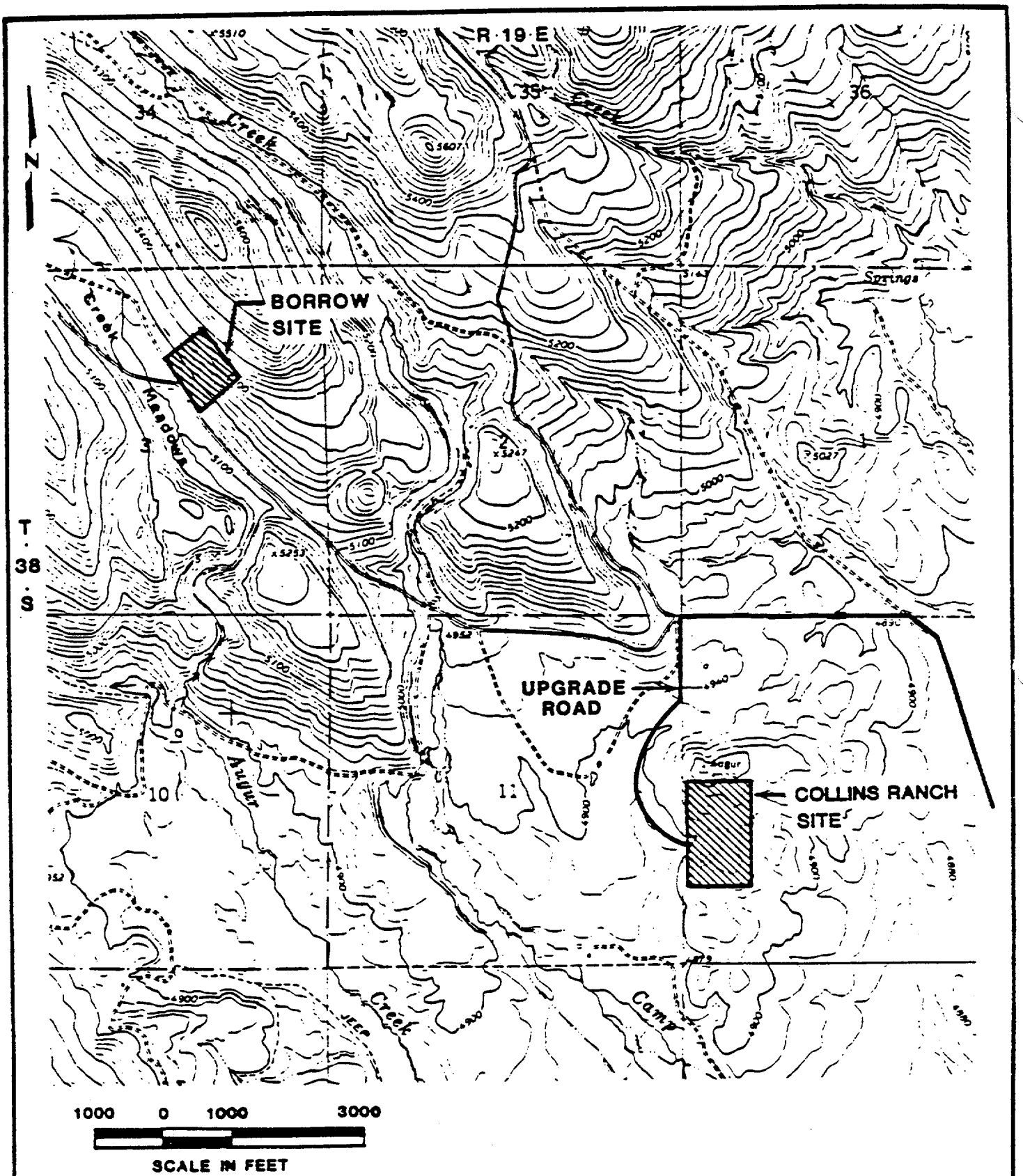


FIGURE 3.3

COLLINS RANCH ALTERNATE DISPOSAL SITE AND BORROW SITE

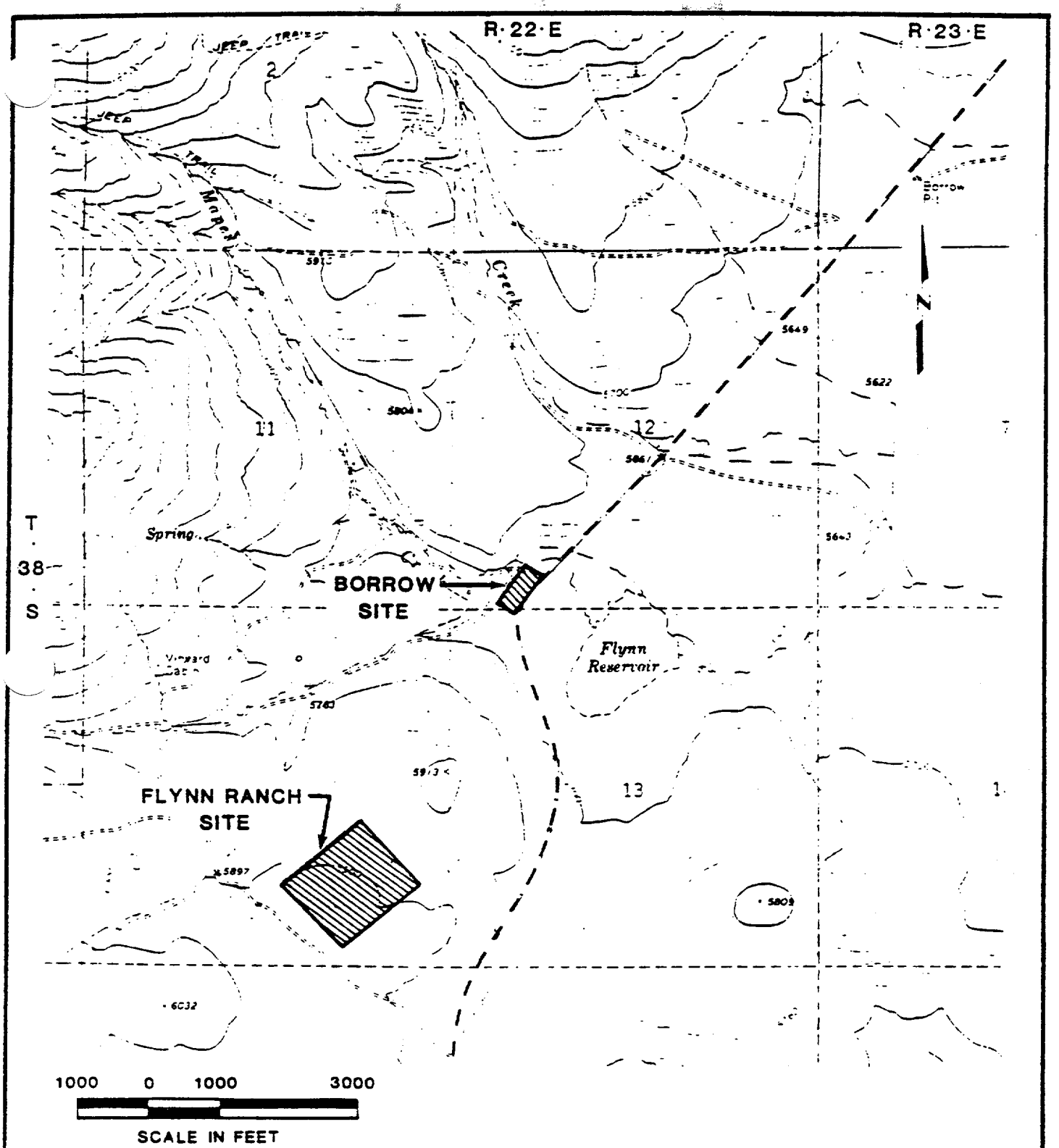


FIGURE 3.4
FLYNN RANCH ALTERNATE DISPOSAL SITE AND BORROW SITE

3.2 DESCRIPTION OF THE EXISTING TAILINGS SITE

The Lakeview uranium mill was built by the Lakeview Mining Company in 1958 to produce uranium oxide for sale to the Atomic Energy Commission (AEC). The mill was operated by the Lakeview Mining Company until it was acquired by Kermac Nuclear Fuels Corporation, a division of Kerr-McGee Oil Industries in 1961. Feed stock for the mill came from the Lucky Lass and White King Mines, located in the mountains approximately 16 road miles northwest of the mill site.

The Lakeview mill had a capacity of 210 tons of ore per day. The ore was ground and then leached with sulfuric acid and sodium chlorates. A solvent extraction process was applied to the uranium-bearing solutions, producing uranium oxide and solids. The solids were sent to the tailings pile and yielded approximately 130,000 tons of tailings waste. The mill produced 171 tons of uranium oxide concentrates (yellowcake) which it sold to the AEC.

Between 1960 and 1968, the Lakeview mill property had five owners. In 1968, the Lakeview site was obtained by Atlantic Richfield Company (ARCO). ARCO initiated cleanup efforts at the former Lakeview mill in 1974, under a plan approved by the Oregon State Health Division. By 1977, the mill buildings and their immediate surroundings had been decontaminated to meet the then existing requirements of the Oregon Regulations for the Control of Radiation.

The total designated site area covers 258 acres. This includes the active sawmill area, the tailings pile (30 acres), the evaporation ponds (69 acres), and on-site windblown areas. A general site layout is presented in Figure 3.5.

During cleanup efforts, the mill buildings and other structures were decontaminated, along with the machinery and other salvageable items that have been removed. Materials from the final decontamination of the mill buildings and surrounding areas have been placed on the southeastern portion of the tailings pile and stabilized in the same manner as the remainder of the tailings.

The Lakeview tailings pile covers approximately 30 acres and is roughly 1000 feet by 1100 feet in size. Prior to the stabilization activities, an earthen dike was formed around the planned disposal area to contain the tailings. The mill tailings and other non-salvageable materials were placed within the earthen dike and spread to a depth of approximately two feet. An earthen cover caps the tailings pile and ranges from 1.5 to two feet thick. The average depth of the tailings, including cover, is 3.7 feet. The surface of the pile is flat. Pockets have developed in the cover which can trap moisture.

The tailings pile has been fenced with hog-wire, and radiation signs are posted. There is also a barbed wire fence around the entire site.

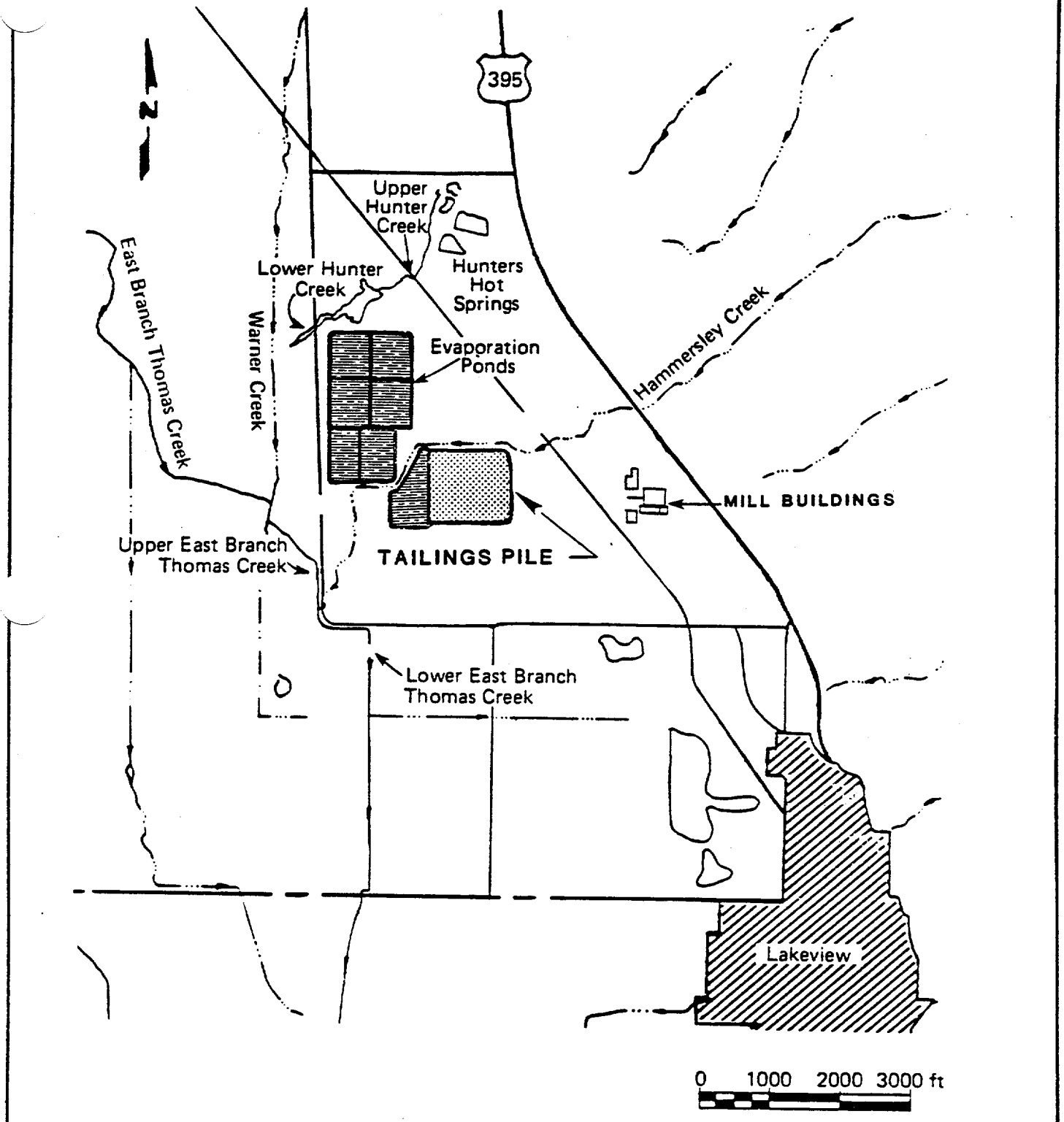


FIGURE 3.5
LAKEVIEW MILL SITE

3.3 WEATHER

Lakeview is located in part of Oregon's semi-arid, or high desert country, near Goose Lake. The area is characterized by cool temperatures, light precipitation, and moderate winds. Details of meteorological conditions in Lakeview are contained in Appendix C, Weather and Air Quality.

Immediately to the east of Lakeview are the Warner Mountains including Drake Peak (8407 feet), Rogger Peak (7302 feet), and Crane Mountain (8454 feet). This range is the southern continuation of Abert Rim, the largest exposed fault on the North American Continent. Twenty miles to the west of Lakeview are the Fremont Mountains in Fremont National Forest, which include Dog Mountain (6935 feet), Grizzly Peak (7768 feet), and Cougar Peak (7919 feet).

These two ranges have a major effect on surface wind patterns through the valley, virtually preventing easterly (four percent of the year) and westerly (two percent of the year) flows. Winds are predominantly from the southern quadrant (35 percent) at an average speed of 12 mph. Winds are calm 32 percent of the time.

Seasonal variation influences wind speed more than direction. In Lakeview, spring and fall mean wind speeds (10.5 mph) are slightly higher than winter (8.3 mph) or summer (7.8 mph). Speeds in excess of 25 mph occur only rarely (one percent of the year) and are from the south. Tables 3.1 and 3.2 provide specific windspeed and directional details.

Precipitation patterns in Lakeview include moderate amounts (2.5 inches each) in December and January, mostly in the form of sleet and snow; light amounts (one to two inches per month) during the spring and fall, often as snow, and minor rains (0.25 to 0.5 inch each) during summer. Average annual precipitation is 16 inches, with 61 inches of snow. There are about 100 days per year with precipitation levels of 0.10 inch or greater. Annual pan evaporation is approximately 63 inches.

Lakeview has an annual average of less than 250 cooling degree days, and more than 7000 heating degree days. Average daytime highs are 70 to 80°F during the summer and average nighttime lows during the winter are below 25°F. A record high temperature of 99°F was reached in 1955 and 1960, and a record low temperature of - 20°F occurred in December of 1972.

Collins Ranch alternate

No site-specific meteorological data are available for this alternate site. The proximity of the Collins Ranch site to Lakeview (7 road miles), however, yields similar wind patterns to those recorded at Lakeview. The prevailing winds are southerly with flows from the Collins Ranch site (i.e. from the northwest and north-northwest) occurring only three percent of the year, at an average speed of 8.3 mph.

Precipitation amounts for the Collins Ranch site appear to be similar to Lakeview as evidenced by the vegetation patterns and the short distance to the city limits.

Table 3.1 Average wind speed (miles/hour) for Lakeview, Oregon

Direction	Season			
	Winter	Spring	Summer	Fall
N	7.6	7.7	7.6	9.2
NNE	12.7	9.2	11.2	8.3
NE	11.2	10.0	9.7	10.8
ENE	7.7	7.9	7.3	10.6
E	7.5	6.8	7.0	9.6
ESE	7.1	8.3	6.1	7.7
SE	7.8	7.1	6.5	7.0
SSE	9.8	9.0	7.8	7.0
S	13.7	11.7	8.8	11.9
SSW	11.3	13.9	9.4	9.9
SW	12.4	10.6	8.7	8.1
WSW	11.9	9.5	9.6	7.3
W	12.7	7.8	10.0	9.2
WNW	8.6	9.6	9.4	7.8
NW	6.5	9.6	10.1	7.5
NNW	6.3	8.1	7.7	6.6

Ref. NOAA, 1982.

Table 3.2 Wind-frequency distribution for Lakeview

Direction (from)	Frequency of occurrence (%)
Calm	28.6
N	4.5
NNE	3.7
NE	4.7
ENE	3.9
E	4.0
ESE	1.6
SE	2.4
SSE	4.7
S	21.6
SSW	6.4
SW	3.8
WSW	2.6
W	2.4
WNW	2.1
NW	1.6
NNW	1.3

Ref. NOAA, 1982.

No-action alternative

The discussion on general meteorological conditions for the Lakeview area typifies conditions at the existing tailings site. Wind direction is predominantly out of the south with windspeeds varying seasonally.

The Flynn Ranch alternate

The Flynn Ranch site, located approximately three miles southeast of Drake Peak, is not affected directly by the wind patterns of Goose Lake Valley. The site is on a western terrace, above the Warner Valley, with wind patterns influenced by the Hart mountains to the east and the Warner mountains to the west. Similar to Goose Lake Valley, the predominant winds are from the southern quadrant.

The Flynn Ranch site is almost 1000 feet higher in elevation and is influenced by the orographic effects of the Warner Mountains. The U.S. Forest Service estimates annual precipitation for the Flynn Ranch site to be 20 to 22 inches per year (USFS, 1984).

3.4 AIR QUALITY

Lakeview and the two alternate disposal sites are within the jurisdiction of the Central Region of the Oregon Department of Environmental Quality (ODEQ), for monitoring and maintenance of air quality. The Central Region monitors 37 percent of Oregon's land area including all or part of seven wilderness areas and one national park. The entire region is classified as an attainment area (i.e., in compliance with National Ambient Air Quality Standards) for all air pollutants.

Most of the major pollutant sources in the region are associated with the wood products and rock-processing industries. Some suspended particulates are generated by slash and field burning. Windblown dust is sometimes visible from roads and barren fields. Forest and agricultural groups are working with the ODEQ to lessen the impacts of summer slash and field burning.

No air quality monitoring data were available for Lakeview and the immediate surrounding area. Two sources of data in the general vicinity, however, provide an insight into Lakeview's air quality. The State of Oregon maintains a high volume sampler at Klamath Falls, about 94 miles west of Lakeview. The Cedarville, California airport, located 50 miles south of Lakeview, also has an operating monitoring station.

In 1983 Lake County had an estimated total emission of 6352 tons of total suspended particulates (TSP); 98 percent from area sources, and two percent from point sources (ODEQ, 1984).

In the four-year period from 1979 to 1982, the highest yearly 24-hour TSP concentrations at Cedarville were 132, 63, 111, and 52 microg/m^3, respectively. The average annual geometric mean was 23 microg/m^3 during that time. TSP readings at Klamath Falls generally exceed 150 microg/M^3 more than once per year, with an average annual geometric mean of 66

microg/m^3 during the period 1974 to 1983. This compares to the State of Oregon standard of 150 microg/m^3 for the 24-hour average and 60 microg/m^3 for the annual geometric mean. Federal primary standards (Title 40, Code of Federal Regulations Part 50) are 260 microg/m^3 for a 24-hour average and 75 microg/m^3 for the annual geometric mean. The Federal secondary standards are identical to the Oregon standards.

Air quality at Lakeview and the alternate sites is more likely to resemble that of Cedarville, California, than Klamath Falls, due to the similarities of population size and land use between Lakeview and Cedarville. Randomness (i.e., variability) in the Cedarville data is twice as great as the randomness of the Klamath Falls data. This suggests that the Cedarville data are mostly a result of wind generated dust, whereas the Klamath Falls readings are caused by human activities.

3.5 SURFACE AND SUBSURFACE FEATURES

The project area lies in the southern part of the Fremont Mountains and the northern part of the Goose Lake Valley within the basin and range physiographic province. This province is characterized by north- to-northwest trending mountain ranges and ridges separated by oblong to long narrow valleys. The present topography of the area has resulted primarily from normal faulting. Intermittently during the Pleistocene epoch (10,000 to 1,000,000 years ago), lakes filled Goose Lake Valley to varying depths up to several hundred feet. Terraces and deltas were formed, and have since been dissected and eroded to produce the rolling, hilly terrain present along the flanks of the mountains to the north and west of Goose Lake. Elevations range from just over 4700 feet above sea level at Goose Lake to 8407 feet at the top of Drake Peak.

Underlying the area are a great variety of volcanic rocks of Tertiary and Quaternary Age. The rock units of the Warner Mountains (east of Lakeview) consist of interstratified andesitic flows, tuffs, lacustrine sediments, and basalt flows. These rocks are Miocene, Pliocene, and Pleistocene in age (10,000 to 25,000,000 years old) (FBDU, 1976). Overlying the volcanic rocks in the Goose Lake Valley is a Pleistocene unit (10,000 to 1,000,000 years old) consisting of fluvial terrace, and diatomaceous and lacustrine sediments ranging from silts to conglomerates (DOGAMI, 1970). Erosion of the surrounding mountains has provided the detritus for accumulation of valley fill to depths in excess of 5,000 feet in the vicinity of the tailings site (SHB, 1984a).

The dominant structural features in the region are normal faults. The north-south trending basin and range frontal fault separates the Goose Lake Valley from the uplifted Warner Mountains to the east (DOGAMI, 1980). In the Warner Mountains, topography and drainage are controlled by prominent fault sets that appear to be high-angle normal faults showing small displacements ranging from a few tens to a few hundred feet. Movement along the faults probably began contemporaneously in late Tertiary time and has continued up to the present (DOGAMI, 1959). The western border of the Goose Lake Valley is delineated by a series of short northwest- and northeasterly-trending normal faults (SHB, 1984a) (Appendix E, Seismic and Geothermal Hazard).

Southwestern Oregon is an area of moderate seismic risk (Figure 3.6). Historical seismicity in the region is characterized by moderate-sized earthquakes associated with normal faulting within the mountain and valley blocks of the basin and range province.

The area has a high subsurface heat flow. Three hot springs and over 40 geothermal wells exist in the Lakeview Known Geothermal Resource Area (KGRA). Seismic activity, both from earthquakes associated with geothermal anomalies and basin and range structure earthquakes, can affect the thermal and flow characteristics of existing hot springs (SHB, 1984a) (Appendix E, Seismic and Geothermal Hazard).

Known mineral deposits in Lake County are diatomite, stone, sand and gravel, mercury, and uranium. Mineral production in the project area is limited to sand and gravel, stone, and mercury (USDA, 1978). The White King and Lucky Lass deposits are the only economic occurrences of uranium discovered in Oregon to date. The mines were closed in 1965. In addition to known deposits, exploration is currently underway for gold and copper (DOGAMI, 1984). Geothermal resources exist in the Goose Lake Valley. Two areas with relatively shallow high-temperature (up to 173°F) geothermal resources have been identified. Low-temperature resources have been encountered in the valley fill aquifer throughout the basin (Allen, 1984).

Lakeview site

The existing tailings pile is located on the alluvium of Goose Lake. The valley fill beneath the uranium mill site property consists of lacustrine and fluviatile sedimentary rocks overlain by unconsolidated clay, sand, and gravel. The sediments near the surface are Quaternary in age (less than 1,000,000 years old) (FBDU, 1976). The lithologic log of a geothermal test well drilled about 1.4 miles southwest of the site indicates that valley fill underlies the site to depths in excess of 5,000 feet (SHB, 1984a).

Soils in the site area include Lakeview-Goose Lake-Ozamis and Scherrard-Stearns associations with zero to two percent slopes. These are mostly clayey soils with some silt and sands. In Scherrard-Stearns areas, hardpan is present at a depth of about 20 inches. This association is present beneath the evaporation ponds and under the western portions of the tailings pile (USDA, 1978). The soils have been disturbed by past milling activities on and near the site.

The Lakeview site is located in seismic risk Zone 2. Zone 2 areas have a moderate seismic risk in which the maximum predicted earthquake would result in moderate damage. Based on the current knowledge of the regional structural geology, the probable maximum horizontal acceleration in rock at the epicenter of an earthquake would be expected to be 10 percent of the force of gravity (0.10g) or less. There is a 90 percent probability that an earthquake of this magnitude would not be exceeded in 50 years (SHB, 1984a). Known earthquake epicenters from 1841 to 1970 are shown in Figure 3.7. During the period of record, four earthquakes were detected at or near the site. These events occurred in 1923, and were rated as having a maximum intensity of VI on the Modified Mercalli scale (SHB, 1984a).

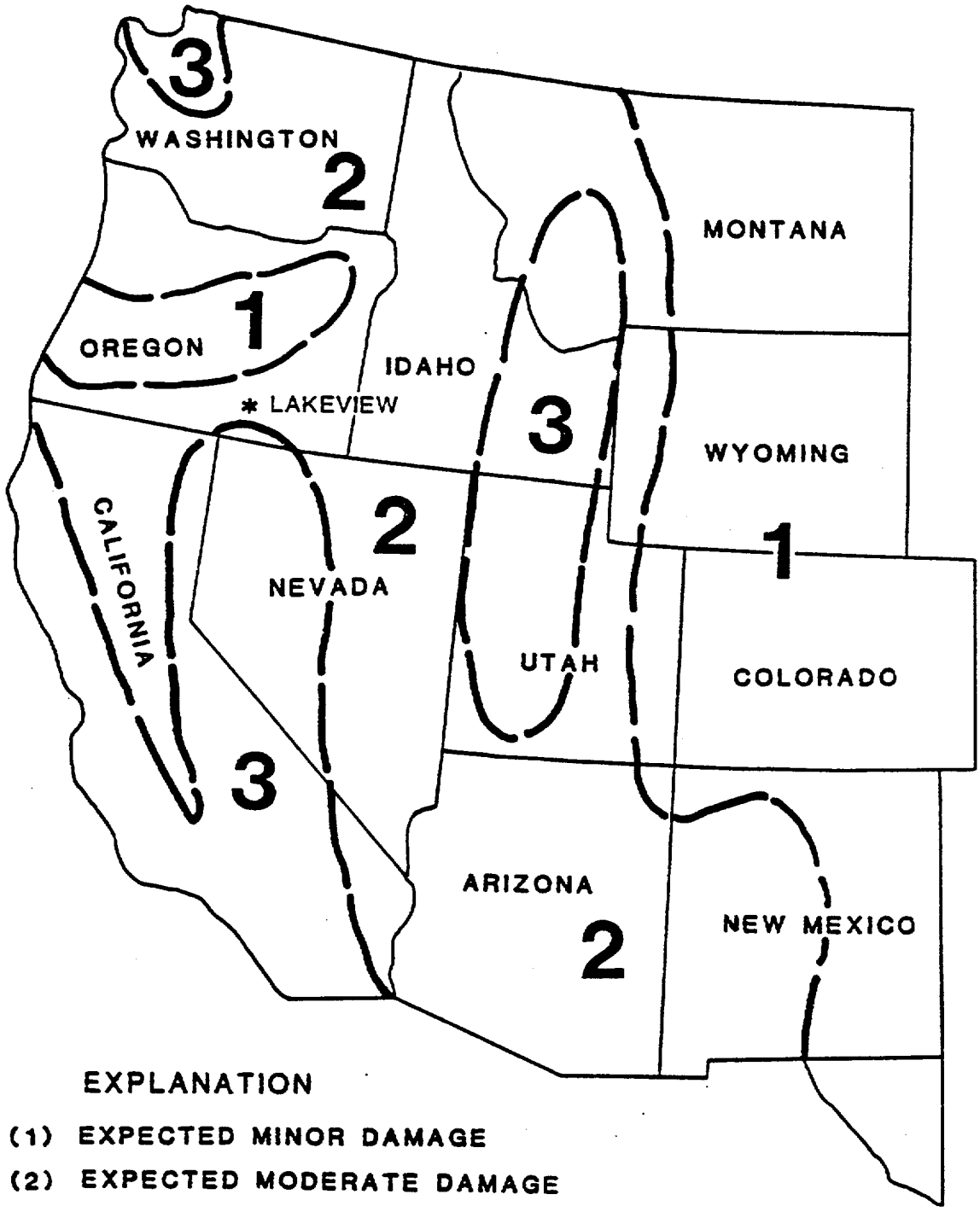
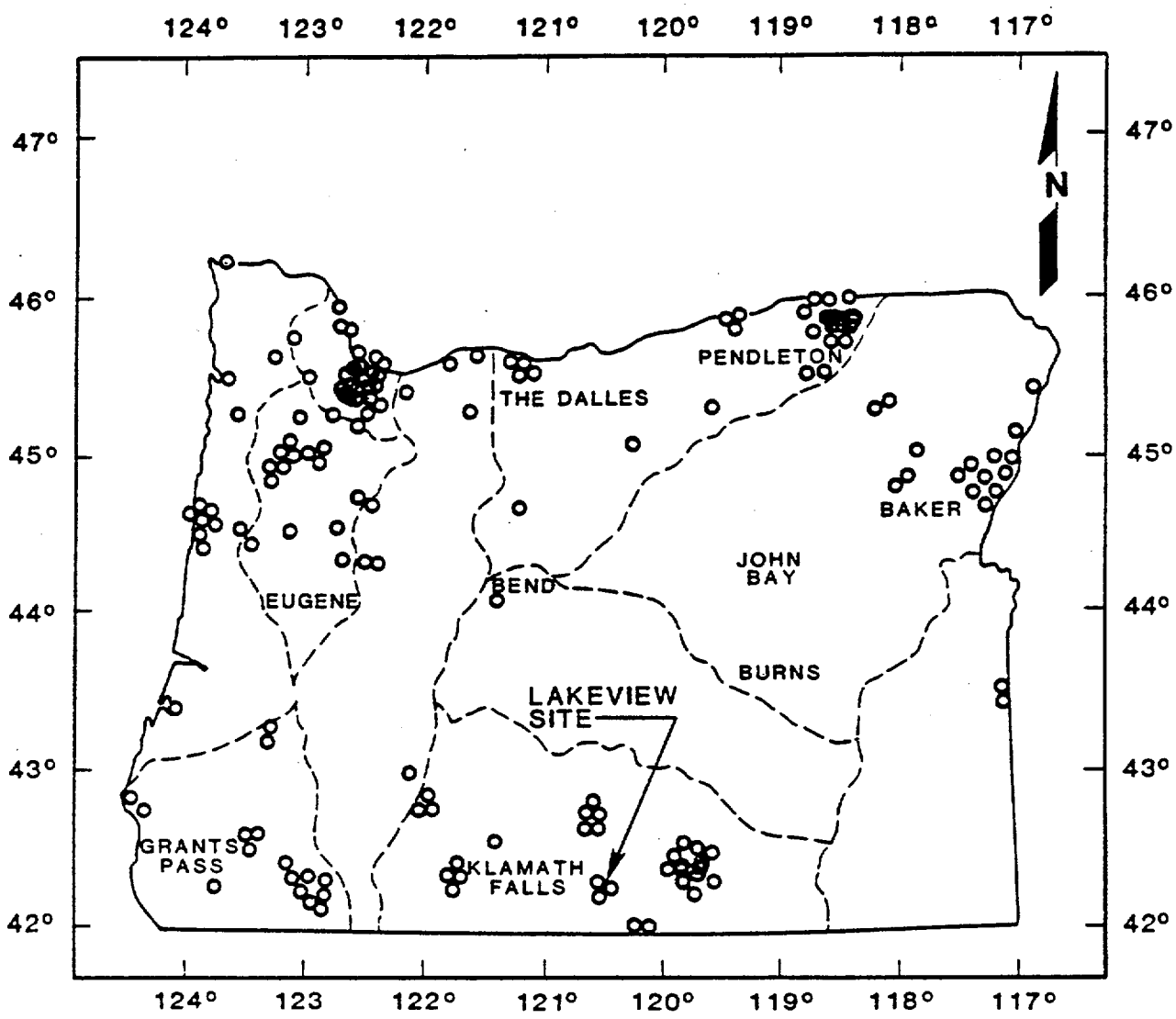


FIGURE 3.6
SEISMIC RISK MAP OF THE WESTERN UNITED STATES



NOTE: DASHED LINES DELINEATE PHYSIOGRAPHIC AREAS.

FIGURE 3.7
EARTHQUAKE EPICENTERS IN OREGON: 1841 THROUGH 1970

Because of their suspected activity in the last 11,000 years, seven active faults or fault zones nearby the site have been identified (SHB, 1984a). The Maximum Credible Earthquake (MCE) for these faults or fault zones was estimated to be 7.5 (Richter) and would generate a horizontal ground acceleration at the site of 0.70g (SHB, 1984a).

There are no known commercially marketable mineral resources at the Lakeview site. Geothermal resources are present beneath the site and in adjacent areas. Hunters Hot Springs lies about 0.4 mile northwest of the tailings pile (SHB, 1984a). A total of three hot springs and over 40 shallow geothermal wells (10 to 1700 feet deep) are located in the Lakeview KGRA (DOGAMI, 1982). The Lakeview KGRA, on the east side of Goose Lake Valley, is shown in Figure 3.8.

Collins Ranch site

The Collins Ranch disposal site is located on a remnant terrace adjacent to the Fremont National Forest northwest of Lakeview. The pediment has been separated from the mountain flank by erosional processes. The eastern portion of the site is underlain by a complete stratigraphy of interbedded sand and silt, with occasional lenses of clay. Boring logs from the western portion of the site indicate that sand and gravel comprise the sediments beneath this part of the site, reflecting a difference in depositional mode and age of sediments underlying the east and west portions of the site.

Soils developed at the site are loams of the Salisbury series. These soils consist of well-drained gravelly loams and sandy loams with medium to rapid runoff and moderate erosion hazard. Substrata exhibit a gravelly cemented hardpan resulting in low permeability (USDA, 1978). Ground surface slopes range from less than five percent to 20 percent.

The Collins Ranch site lies in seismic risk Zone 2. Moderate damage would be expected from a maximum predicted earthquake. The site is within the Goose Lake Graben fault zone (SHB, 1984a). There is no historical sesimicity assigned to faults in this area. The MCE was estimated to be 7.2 (Richter), and would generate a horizontal ground acceleration of 0.48g (SHB, 1984c).

Mineral resources present at the Collins Ranch site are limited to sand and gravel. There are no mining claims on file for this site.

Flynn Ranch site

The Flynn Ranch disposal site is located in the uplands between Warner Valley and Drake Peak along the eastern flank of the Warner Mountains. The site is underlain by rock formations consisting largely of volcanic tuffs, tuffaceous sedimentary rocks, pumicites, and silicic flows. These volcanic flows overlie thick basalts and tuffaceous sedimentary rocks of Miocene and Pliocene age (1,000,000 to 25,000,000 years old) (Sammel, 1984; DOI, 1977).

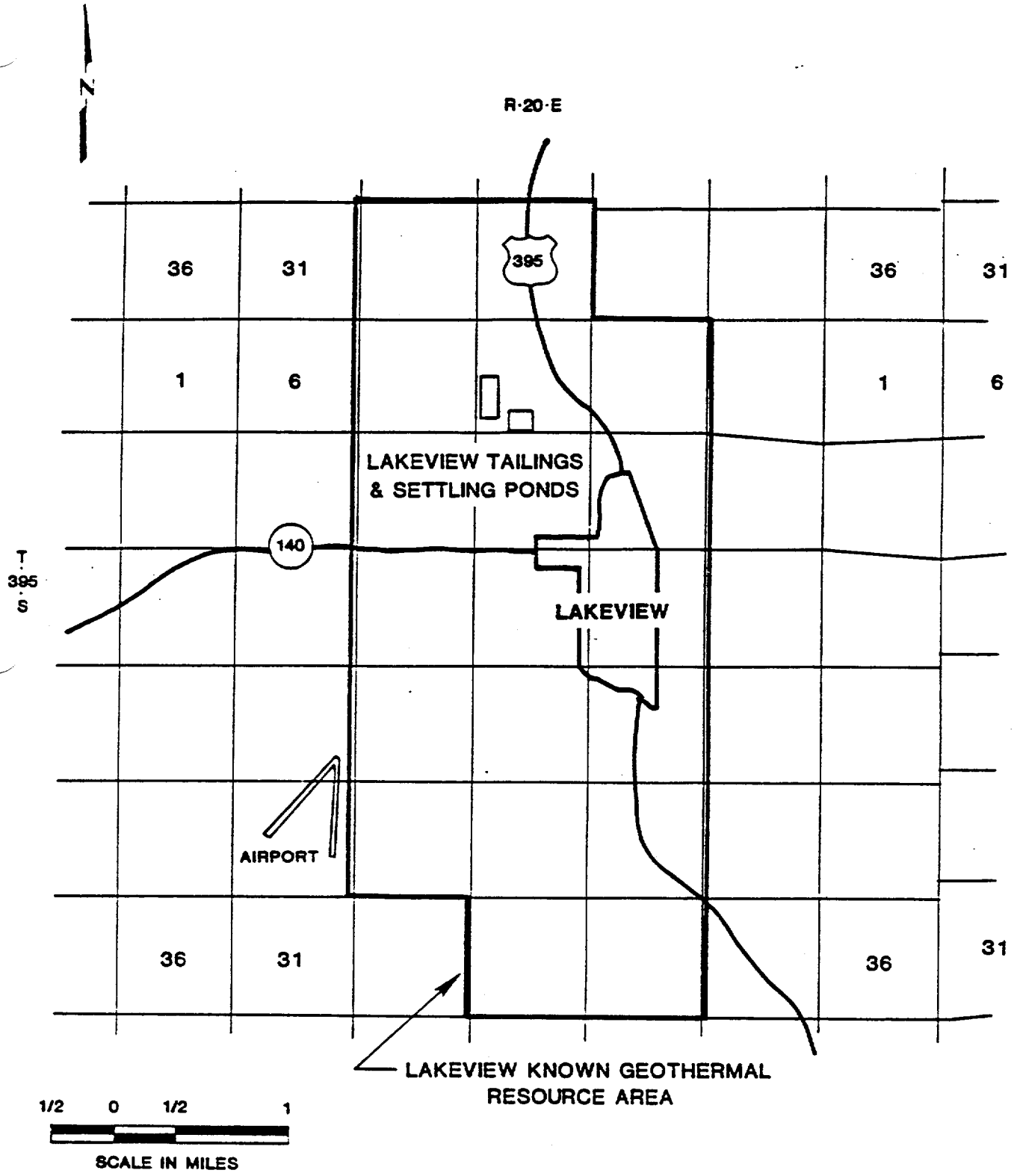


FIGURE 3.8

LOCATION MAP SHOWING BOUNDARY OF THE LAKEVIEW KGRA

Soils present at the site are very stony loams of the Bluejoint series. This shallow soil consists of colluvium, uncontaminated volcanic ash, and residual weathered basalt (SHB, 1984b) deposited on gently sloping terrain. The soil is well-drained, with moderately slow permeability, medium runoff, and moderate erosion hazard (USDA, 1978).

The Flynn Ranch site also lies in seismic risk Zone 2. The general area is cut by secondary faults extending from major north-south trending faults that form the western boundary of Warner Valley (DOI, 1973). A series of earthquakes with a maximum estimated magnitude of 5.1 on the Richter Magnitude Scale occurred in the Warner Valley in 1968 (DOGAMI, 1968). No historical seismic data are available for the immediate area of this alternate site. An MCE has not been calculated for the Warner Valley fault zone. Earthquake design parameters for this site are based on MCEs calculated for two fault zones not related to the seven fault zones in Goose Lake Valley. The maximum horizontal ground acceleration resulting from an MCE of an estimated magnitude of 7.2 (Richter) would be 0.35g (SHB, 1984c).

There are no mining claims on file for the Flynn Ranch alternate site.

Borrow sites

Two borrow sites are proposed as sources of materials for the remedial action. Borrow site B, located 2.1 miles northwest of the Collins Ranch site, has deposits consisting of sandy gravel, cobbles, silty clay, and coarse sand. Borrow site G, located 1.9 miles northeast of the Flynn Ranch site, consists of sandy clay, silty gravel, and cobbles.

3.6 WATER

Section 3.6.1 describes surface-water occurrence, flow patterns, uses, and water quality for the Lakeview tailings site, the Collins Ranch site, the Flynn Ranch site, and the borrow sites. Section 3.6.2 describes ground-water occurrence, use, and quality for each of the sites. Additional details on surface and ground waters are provided in Appendix D, Hydrology.

3.6.1 Surface water

Lakeview tailings site

The Lakeview tailings site lies within the drainage basin of Thomas Creek, a major tributary of Goose Lake. Located approximately one mile to the west of the tailings site, several creeks in the immediate vicinity of the tailings site indirectly feed Thomas Creek, a major tributary of Goose Lake. Figure 3.9 illustrates the surface drainage in the area.

Hammersley Creek, issuing from Hammersley Canyon (northeast of the site), flows across the tailings site in a northeast to

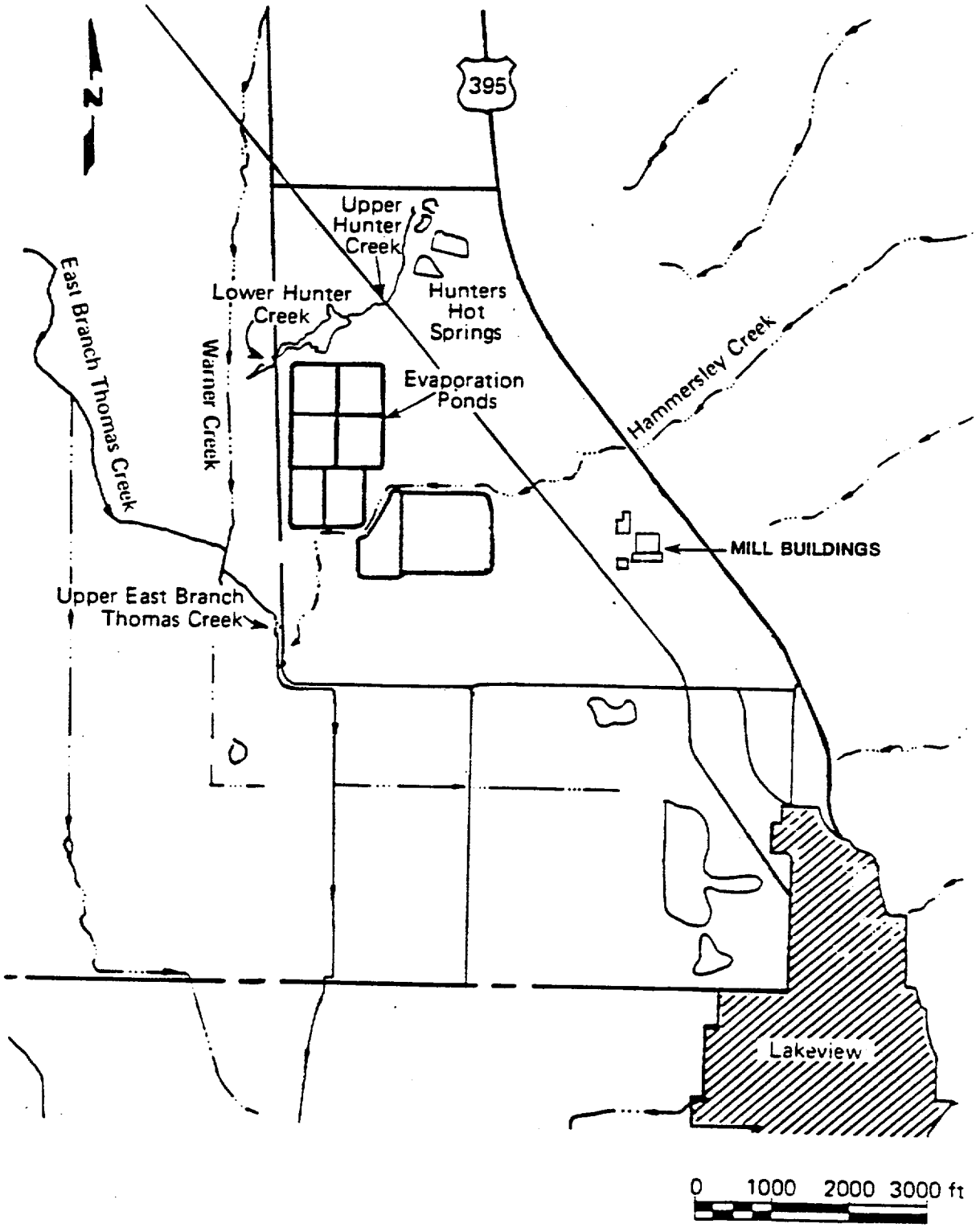


FIGURE 3.9
LAKEVIEW PROCESS SITE SURFACE DRAINAGE

southwesterly direction, between the tailings pile and former waste-water evaporation ponds. Hammersley Creek feeds into the East Branch of Thomas Creek. Surface-water flows are also visible from Hunters Hot Springs Creek, approximately 0.5 mile north of the tailings site. Hunters Hot Springs Creek originates at the geothermal Hunters Hot Springs and travels in a northeast to southwesterly direction, to Warner Creek, skirting the northern Lakeview site evaporation ponds. Warner Creek also drains into the east branch of Thomas Creek.

The drainage area for Hammersley Creek is about 3.34 square miles with a drop in elevation of 355 feet per mile. An area of approximately 30 square miles drains into Thomas Creek above the Lakeview site. The majority of this drainage basin is located in the wooded area of the Fremont National Forest, northwest of Lakeview. The drainage basin for Goose Lake is approximately 1,140 square miles including the surface area (approximately 175 square miles) of Goose Lake.

There are no USGS stream gaging stations in the Lakeview area. A former station on Thomas Creek, about 5.5 miles northwest of the site near the point where the stream issues from the mountains, recorded average flows of 9,480 acre-feet per year for the seven-year period of record before 1931.

Several investigations were conducted at the Lakeview site in order to characterize the existing hydrologic system. The results of the flood potential study for Hammersley Creek, which flows across the site adjacent to the north side of the tailings pile, indicated that a flood with a return period of 200 years would have a peak flow at the site of 520 cubic feet per second (cfs). The 1000-year peak flow would have an expected magnitude of 780 cfs. During either of these flood events the base of the pile would become inundated with flow velocities ranging from 5.6 to 8.4 feet per second adjacent to the pile.

No data are available for flooding of the East Branch Thomas or Warner Creeks, which flow 2500 and 1000 feet west of the tailings pile. Although the effects of a Probable Maximum Precipitation (PMP) over the drainage area above the Lakeview site have not been analyzed, it is expected that flow from all three of the above mentioned creeks would impact the pile with velocities sufficient to cause downstream migration of contaminants.

Analytical results on surface-water samples indicate that surface water in the Lakeview area is of two chemical types. Water flowing in the East Branch of Thomas Creek is dominated by sodium and bicarbonate ions, with a TDS concentration of 220 to 260 milligrams per liter (mg/l). Water flowing out of the Hunters Hot Springs area (termed Hunters Creek herein) is dominated by sodium and sulfate ions, with large amounts of chloride also present. The TDS concentration of Hunters Creek was found to be 800 to 850 mg/l. Hunters Creek also has elevated arsenic concentrations relative to the East Branch of Thomas Creek. No water was present in Hammersley Creek during the sampling effort (FBD, 1983).

Differences in the chemistry of the two streams are due to the presence of Hunters Hot Springs immediately upstream from the Hunters Creek samples. The discharge from the geyser at Hunters Hot Springs is rich in sodium, sulfate, and chloride, with TDS concentrations similar to that found in Hunters Creek. Arsenic concentrations are also high in the geothermal source relative to the East Branch of Thomas Creek. The lower concentrations of constituents in the East Branch of Thomas Creek compared to Hunters Creek result from dilution by the greater quantity of water flowing in the East Branch of Thomas Creek upstream from the confluence with Hunters Creek.

Even though surface water in the area is not used for domestic purposes, a comparison of the chemical condition of the water with drinking-water standards promulgated by the U.S. Environmental Protection Agency (40 CFR Part 141) is helpful in defining water quality. Except for the arsenic concentrations in Hunters Creek, no concentrations of trace metals or radioactive constituents were found in the surface waters that exceeded the National Interim Primary Drinking Water Regulations or National Secondary Drinking Water Regulations for public water supplies. As noted previously, the high arsenic concentration in Hunters Creek occurs naturally as discharge from the geothermal water at Hunters Hot Springs. No significant differences in constituent concentrations occurred in either stream between the upstream and downstream samples.

Surfaces waters are used for irrigating some croplands and for livestock tanks and watering areas.

Collins Ranch alternate disposal site

The Collins Ranch alternate disposal site (Figure 3.10) is located along the southwestern slopes of Augur Hill adjacent to a drainage divide. An area of approximately 15 acres above the proposed embankment area drains southwest towards Camp Creek, which flows approximately 3000 feet from the site at an elevation 50 feet below the site. Camp Creek has a drainage area of approximately 13 square miles above the location where it flows past this alternate disposal site.

Augur Creek flows 10 to 20 feet in elevation below Camp Creek, approximately 6000 feet from the Collins Ranch site. The confluence of these two perennial creeks is 1.5 miles south of the site and 110 feet below the site in elevation.

Flooding is not considered to be a hazard at the Collins Ranch site. About one mile upstream from the site, Camp Creek is restricted to a narrow valley which could create high flood levels. As it approaches the site, however, the valley opens into a broad basin which would lower flood levels and reduce velocities making it improbable that the site could be flooded by Camp Creek.

There are no surface-water-quality data available for any of the ephemeral or perennial streams in the Collins Ranch area.

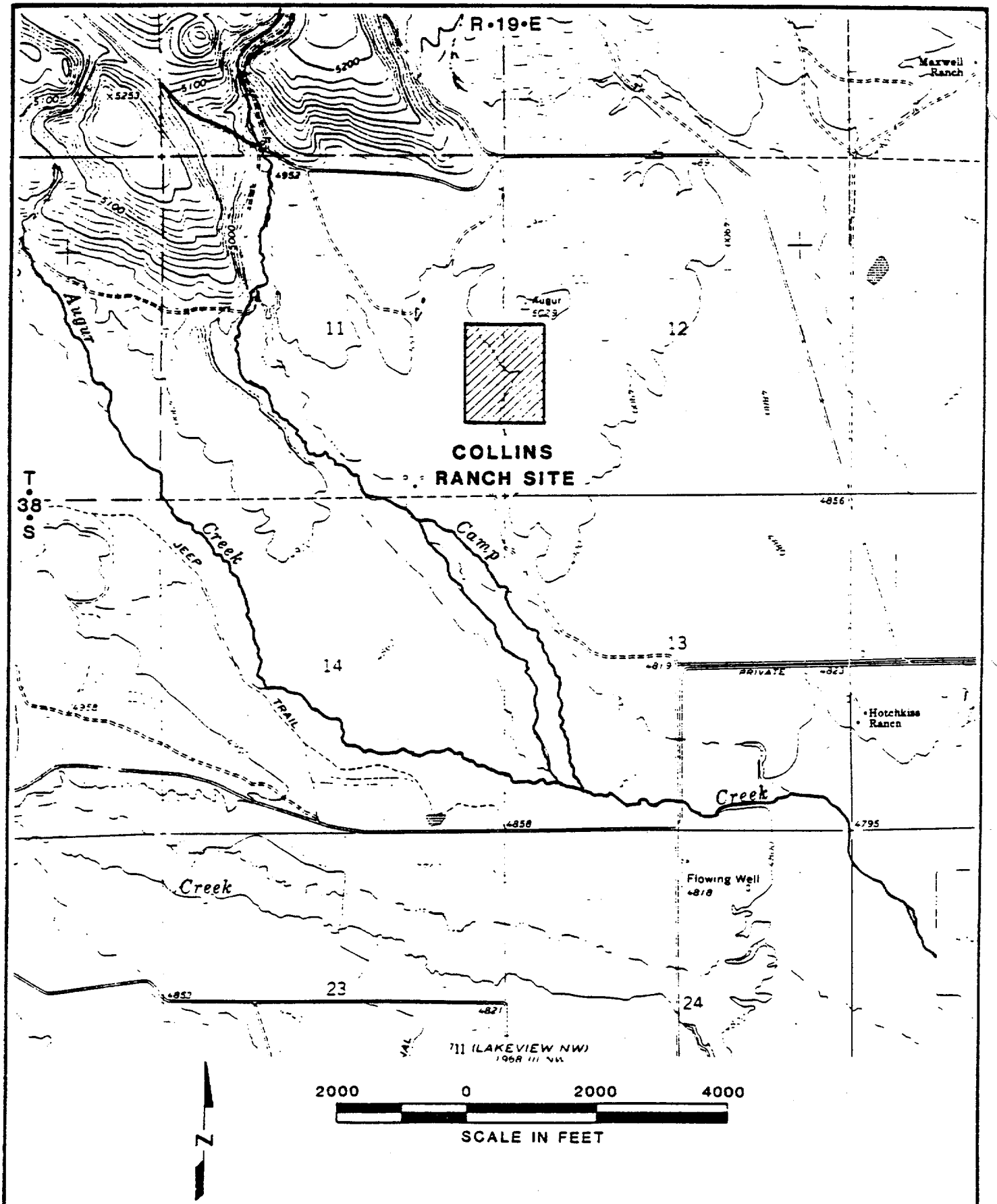


FIGURE 3.10
COLLINS RANCH SITE - DRAINAGE CHARACTERISTICS

Flynn Ranch alternate disposal site

The Flynn Ranch site (Figure 3.11) is also located on a drainage divide, with intermittent flows passing northeast and southeast of the site. Flows across the site drain to the northeast toward Flynn Reservoir. A dry, poorly incised channel drains the small area northwest of the site. Flows in this channel are rarely, if ever, encountered. The closest perennial stream is Mapes Creek, which flows into Flynn Reservoir approximately one mile northeast of the site. Mapes Creek has a drainage area of less than seven square miles above Flynn Reservoir. An ephemeral stream which flows north of the site joins Mapes Creek 1500 feet upstream of Flynn Reservoir at an elevation approximately 220 feet below the site. Peddlers Creek, a small ephemeral stream, flows to the southeast approximately 1.2 miles southwest of the alternate disposal site.

No flood flows are expected at this site because of its distance from and elevation above Mapes Creek. An area of approximately 0.14 square mile drains toward the Flynn Ranch site.

Surface water in this area is used predominantly for cattle watering. Flynn Reservoir is used primarily as a water source for cattle during the summer and fall months. The reservoir is drained in the winter.

There are no surface-water-quality data available for any of the streams in the Flynn Ranch area.

Borrow sites

The Collins Ranch site, located approximately two miles northwest of the Collins Ranch alternate disposal site, is within the Augur Creek drainage basin. The borrow area is approximately 1000 feet east of Augur Creek on the opposite side of the Fremont Lumber Company logging road. The borrow area elevation ranges from 30 to 100 feet above the streambed elevation.

The borrow site for the Flynn Ranch alternative is located approximately 1200 feet upstream of Flynn Reservoir, just below the point where Mapes Creek is joined by an ephemeral stream, which drains the area northwest of the Flynn Ranch site. The borrow area is separated from Flynn Reservoir by U.S. Highway 140 and from Mapes Creek by a dirt access road.

Both borrow sites may be affected by limited flooding. Augur Creek has the potential to affect the Collins Ranch borrow site and Mapes Creek could affect the Flynn Ranch borrow site. However, due to the small watersheds above the sites, flows resulting from high intensity rain storms would not be expected to cause damage.

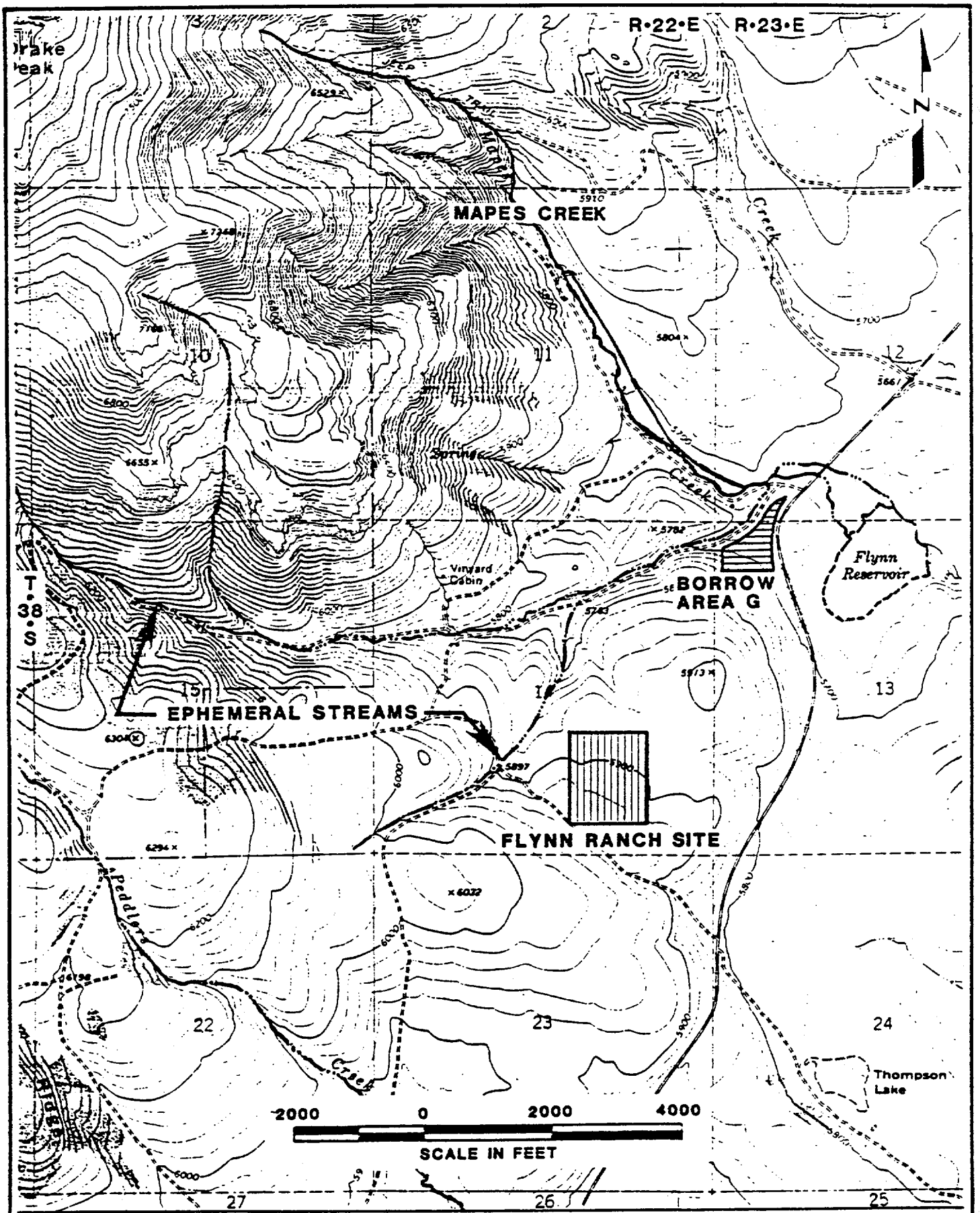


FIGURE 3.11 **FLYNN RANCH SITE - DRAINAGE CHARACTERISTICS**

There are no surface-water-quality data available for either Mapes Creek or Augur Creek.

3.6.2 Ground water

Existing ground-water conditions at the Lakeview tailings site, Collins Ranch alternate disposal site, Flynn Ranch alternate disposal site, and the proposed borrow sites are summarized in this section. Ground-water data from the sites and detailed analyses of these data are presented in Appendix D, Hydrology.

Lakeview tailings site

Shallow ground water occurs under unconfined and semi-confined conditions within the alluvial and lacustrine deposits in the Goose Lake valley. Beneath the site, ground water occurs in a series of interfingered silty sands and gravels separated by discontinuous lenses of moist clays and silty clays. Two ground-water zones have been investigated in the vicinity of the tailings pile; a shallow system, above 30 feet, and a deeper system between depths of 60 to 75 feet. Well pairs screened in each zone (one in the shallow zone and one in the deeper zone) showed generally less than seven feet difference in water levels. The result of these samples indicate a small potential for downward movement of water from the shallow to the deeper zone. Aquifer tests conducted in both screened zones show hydraulic communication between saturated zones and leakage occurring between semi-confining lenses.

The stratigraphy beneath the site is extremely heterogeneous. Correlations between lithologic units from borehole logs could not be made even for holes 20 feet apart. Directly beneath the pile are four to seven feet of moist to wet silty clay, underlain by 10 to 20 feet of saturated clayey sand and gravel, followed by three to six feet of moist silty clay. Beneath this silty clay layer are sequences of silty sands and gravel separated by interlayered silty to sandy clays to a depth of at least 2000 feet below the site (Brown et al., 1980). These sediments become somewhat more consolidated with depth. The total depth of this valley fill is about 5000 feet toward the center of the valley (Brown et al., 1980). In the upper 75 feet, borehole logs show the number and thickness of less permeable silty clay lenses decrease from the northeast to the southwest corner of the site.

Shallow ground-water flow is generally from the mountain flanks (the Warner Mountains to the east and the Fremont Mountains to the west) toward the center of the valley. Recharge to the unconsolidated sediments is from local precipitation, snowmelt, and upward movement from the underlying geothermal system. Discharge is to surface drainages, springs, and wells. The water table generally is shallow (five to 11 feet) below the land surface at the Lakeview site).

Ground water in the unconfined to semi-confined aquifers beneath the site moves from northeast to southwest under a hydraulic gradient of approximately 0.01 (Figure 3.12). Values of hydraulic conductivity from aquifer tests averaged 1.4 ft/day for the shallow zone and 4.4 ft/day for the deeper zone. Using the measured hydraulic conductivities, and a conservative estimate of effective porosity equal to 0.10, the calculated velocity of ground water is between 0.14 and 0.44 ft/day (50 to 160 ft/yr).

Ground water is characterized by four different geochemical facies: 1) evaporation pond seepage, 2) tailings pile seepage, 3) low temperature background water, and 4) high temperature upward moving geothermal water. Migration of evaporation pond and tailings pile seepage is generally confined to the shallow zone above 30 feet. Two source areas of contamination are distinguished by sulfate isopleths plotted for shallow ground-water samples (Figure 3.13). Leachate produced by the downward movement of water through the tailings pile and the evaporation ponds or by ground-water inundation of contaminated material is generating two plumes that merge in the area west of the tailings pile. The most significant source area is the southwest evaporation pond.

Samples of low temperature background waters exceed Oregon DEQ standards for zinc, manganese, and iron, with natural concentrations of 0.02, 2.2, and 0.28, respectively. Samples of high temperature geothermal water exceed EPA primary drinking water standards for arsenic, and secondary standards for boron and fluoride. Background values for each constituent are 0.11, 4.0, and 6.0 mg/l, respectively. High temperature (>20°C) geothermal water is manifest in domestic wells (deeper than 30 feet) north of a diagonal line cutting approximately northeast to southwest through the lower evaporation ponds, in TAC wells 523 and 524 directly north of the evaporation ponds, and in surface waters of Hunters and Warner Creeks. TDS in geothermal water ranged from 368 to 690 mg/l compared to values of about 200 mg/l in low temperature background waters.

Six constituents have elevated concentrations above state and or Federal standards in the shallow aquifer beneath and downgradient of the evaporation ponds and tailings pile. Measured concentrations of sulfate, antimony, chromium, iron, cadmium, and manganese were as high as 7300, 0.056, 0.08, 15.5, 0.006, and 16.6 milligrams per liter (mg/l), respectively. The maximum sulfate value is greater than the U.S. Environmental Protection Agency (EPA) secondary drinking water standard as well as State of Oregon water quality standards for the Goose Lake Basin. Maximum antimony and chromium values were greater than EPA primary drinking water standards and cadmium exceeded Oregon Department of Environmental Quality (DEQ) limits for natural waters of Goose Lake Basin in one sample from beneath the tailings pile. Iron and manganese values exceeded EPA secondary drinking water standards and State of Oregon standards.

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Jack Hoopes	Jacobs	Geology/Soils
Dave Lechel	Jacobs-Weston	Manager, Environmental Services
Carol Meyer	Jacobs-Weston	Document Preparation
Gail Sutton	Jacobs-Weston	Document Preparation
Margaret Cobnitz	Jacobs	Air Quality/Noise
Marc Nelson	Jacobs-Weston	NEPA Management
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Raoul Portillo	Jacobs-Weston	Surface Water
Kim Reis	Jacos-Weston	Ground Water
Jim Brinkman	Sergent, Hauskins & Beckwith	Ground Water
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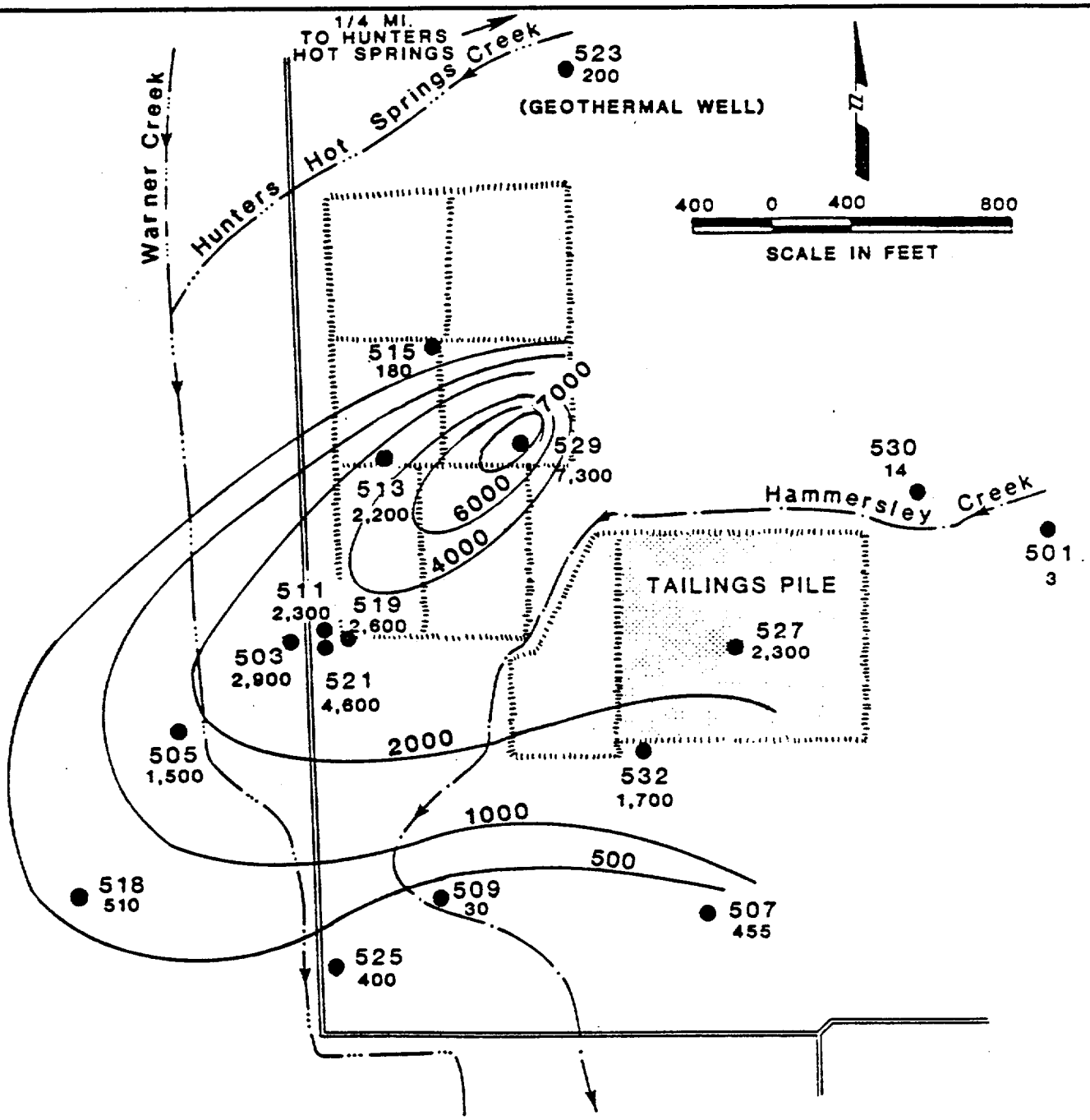
Denise Bierley	Jacobs-Weston	Permits
Steven Green	Jacobs-Weston	Radiological Source Term



LEGEND

505 - LOCATION ID

● - MONITOR WELL SCREENED IN SHALLOW ZONE

1,500 - SULFATE CONCENTRATION (mg/l)

EVAPORATION POND

INTERMITTENT FLOW

CONTINUOUS FLOW

FIGURE 3.13
SULFATE PLUME IN THE SHALLOW AQUIFER
LAKEVIEW SITE

Ground water sampled from the deeper zone (60 to 75 feet) beneath the ponds and downgradient from the site did not exhibit exceedence values of chromium, cadmium, or antimony above state standards and showed much reduced sulfate concentrations. However, Figure 3.14 shows TDS and sulfate isopleths increasing downgradient from the evaporation ponds and tailings pile. This may be an indication that shallow contaminated ground water is migrating downward as water moves downgradient of the site and that attenuation of metals and major ions occurs. This is consistent with well logs that show the number and thickness of less permeable layers decrease downgradient from the site. Aquifer test results also show communication between the two zones. Alternatively, this water may be of geothermal origin with naturally elevated sulfate and TDS concentrations.

Presently the shallow saturated zone above 30 feet is not used downgradient of the tailings site. Two deeper domestic wells, 7000 feet downgradient, show sulfate concentrations less than 20 mg/l and only zinc shows concentrations slightly above Oregon DEQ standards. Present data do not indicate seepage from tailings or evaporation ponds reaching privately owned domestic wells downgradient of the site.

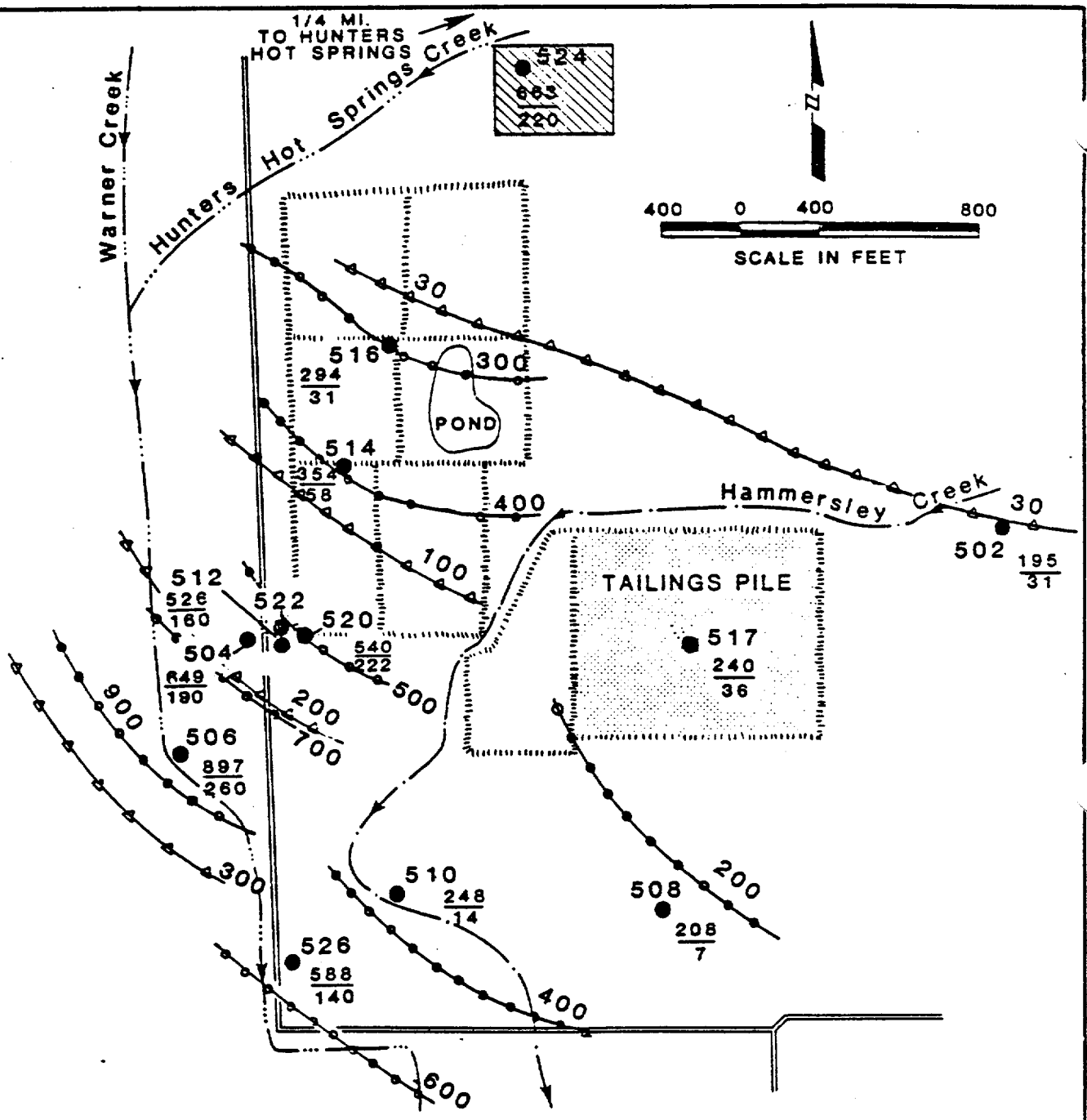
Collins Ranch alternate disposal site

Sixteen boreholes, from 22 to 127 feet deep, including nine completed as monitor wells, have been drilled at the Collins Ranch site. Ground water was encountered in four wells in the adjacent valley west of the proposed disposal area and in well No. 8 beneath the south end of the disposal area. Ground water moves from northwest to southeast under a hydraulic gradient of 0.018 (Figure 3.15). Measured depths to water range from seven feet in the valley to 75 feet beneath the south edge of the proposed disposal site. Seasonal fluctuations in water level will be monitored through at least June, 1985. Ground water occurs under unconfined and semi-confined conditions within unconsolidated lacustrine silty clays and sands. The average value of horizontal hydraulic conductivity based upon five slug tests is 0.86 ft/day.

The site is located just below a drainage divide with only a small recharge area. Surface drainage is to the south-southwest in the direction of Camp Creek, 60 feet in elevation below the site. Ground-water-quality data indicate recharge through volcanic deposits showing typically low TDS, high silica water with a high pH.

Flynn Ranch alternate disposal site

Sixteen boreholes, with one 150-foot hole completed as a monitor well, were drilled at the Flynn Ranch site (Figure 3.16); no ground water was encountered. The site is covered by two to six feet of clayey sands resting upon a complex series of basalt flows. Vesicular, highly weathered zones and unhealed cooling



LEGEND

508 – LOCATION ID

● – MONITOR WELL SCREENED IN DEEPER ZONE

208/7 – TOTAL DISSOLVED SOLIDS CONCENTRATION (mg/ℓ) / SULFATE CONCENTRATION (mg/ℓ)

GEOTHERMAL WELL

EVAPORATION POND

INTERMITTENT FLOW

CONTINUOUS FLOW

TDS

SO_4

FIGURE 3.14

TOTAL DISSOLVED SOLIDS AND SULFATE ISOPLETHS IN THE DEEPER AQUIFER LAKEVIEW SITE

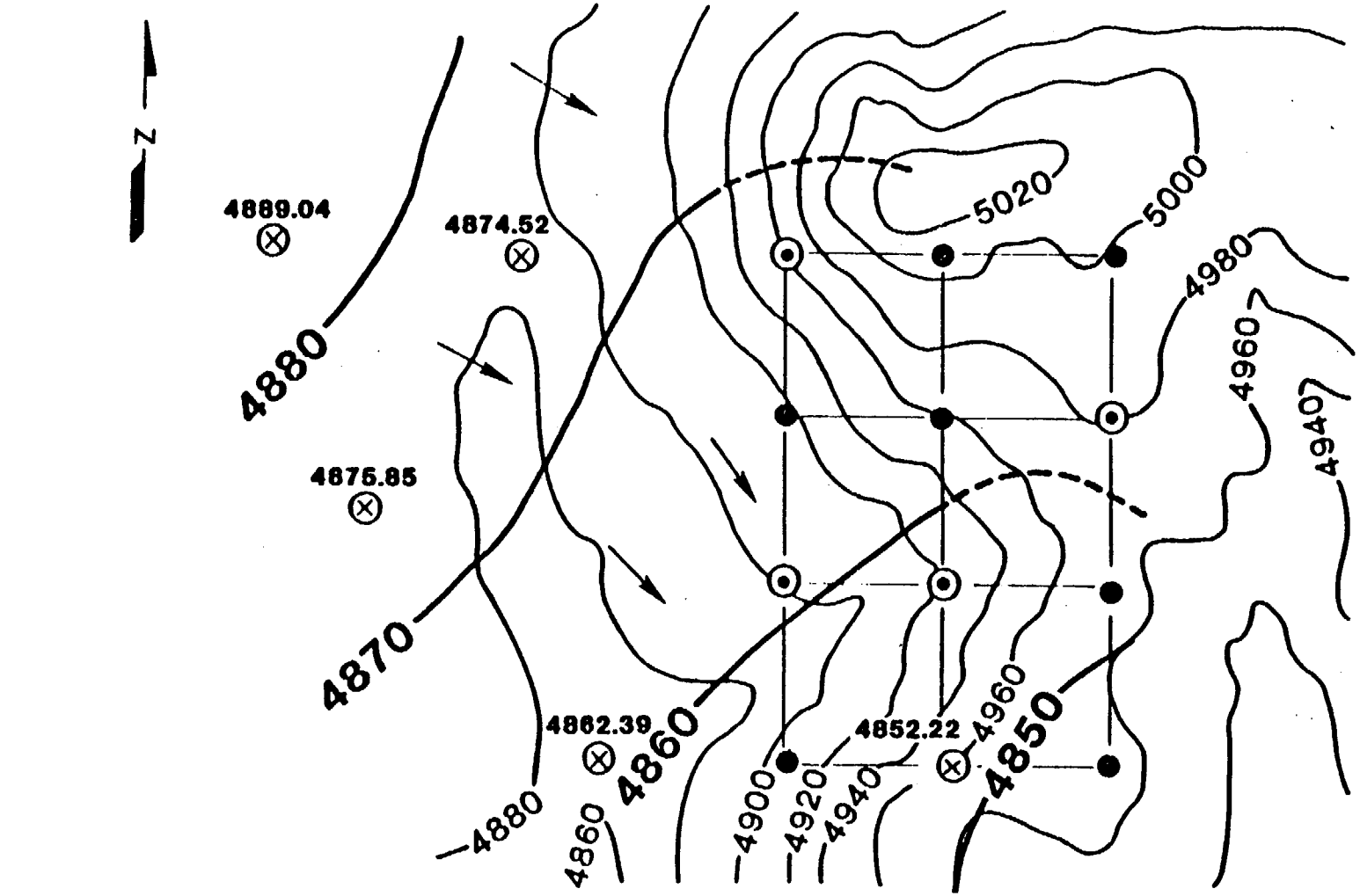


FIGURE 3.15 POTENTIOMETRIC SURFACE AT COLLINS RANCH SITE

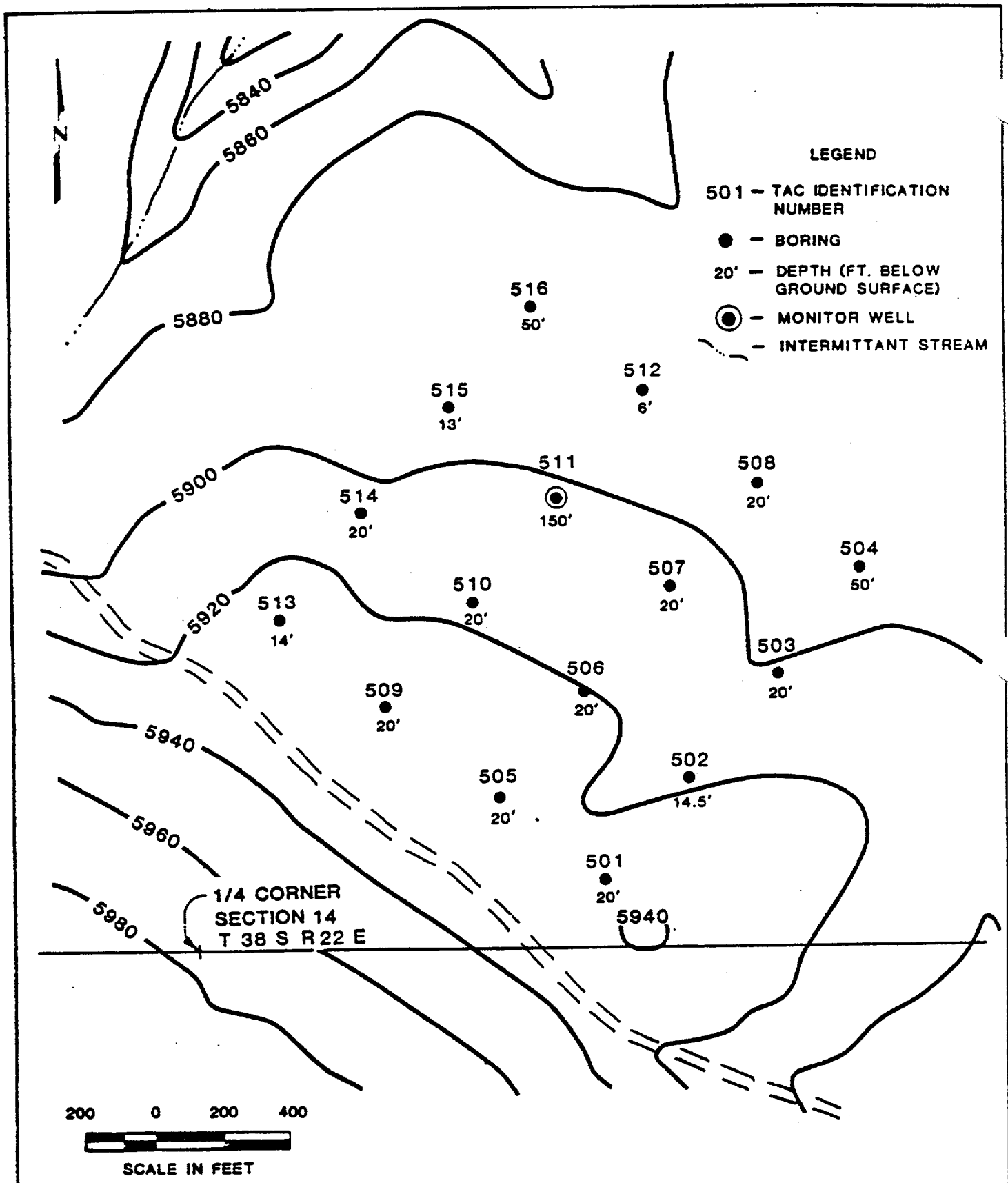


FIGURE 3.16
TAC FLYNN RANCH SITE BORINGS

fractures encountered in the bedrock are potential pervious zones for ground-water movement. Unsaturated conditions to a depth of 150 feet suggest that most local precipitation and snowmelt evaporates or drains to surface-water channels.

Borrow sites

Ground-water conditions for borrow materials at borrow site B would be the same as those described for the Collins Ranch alternate site and will not impact ground water. Ground-water conditions at borrow site G are as described for the Flynn Ranch site.

3.7 ECOSYSTEMS

Appendix F, Ecosystem Information, contains lists of the plant and animal species that have been observed or are characteristic of the Lakeview area and each of the alternate disposal sites.

3.7.1 Plants

Ecosystems regional description

The Lakeview site and the proposed alternate disposal sites are located in the ecoregion known as the Intermountain Sagebrush Province (Bailey, 1976; 1980). This semi-arid region is situated in the rain shadow of the Cascade Mountains to the west. The region is located in the ponderosa shrub forest natural vegetation type as mapped by Kuchler (1964; 1966).

Lakeview mill tailings site

The Lakeview site is characterized by five vegetation types and one unvegetated area. The tailings pile and evaporation pond no. 7 have an introduced grassland vegetation, while evaporation pond no. 1 has no vegetation. Evaporation ponds 2, 3, 4, 5, and 6 have been somewhat colonized by desert saltgrass (Distichlis spicata var. stricta). The embankments of all ponds are dominated by shrubs characteristic of the surrounding moist sodic bottom range site. Hammersley Creek is distinguished by a narrow riparian zone as it traverses the tailings site (Figure 3.17) (WRD, 1984b).

Collins Ranch site

The Collins Ranch site is characterized by four major range types. Most of the area, the gently sloping upland landforms as well as low-lying terrain between drainages, is characterized by the Shrubby Rolling Hills range site, a big sagebrush-antelope bitterbrush (Artemisia tridentata - Purshia tridentata) community. However, during the summer of 1984 most of the upland

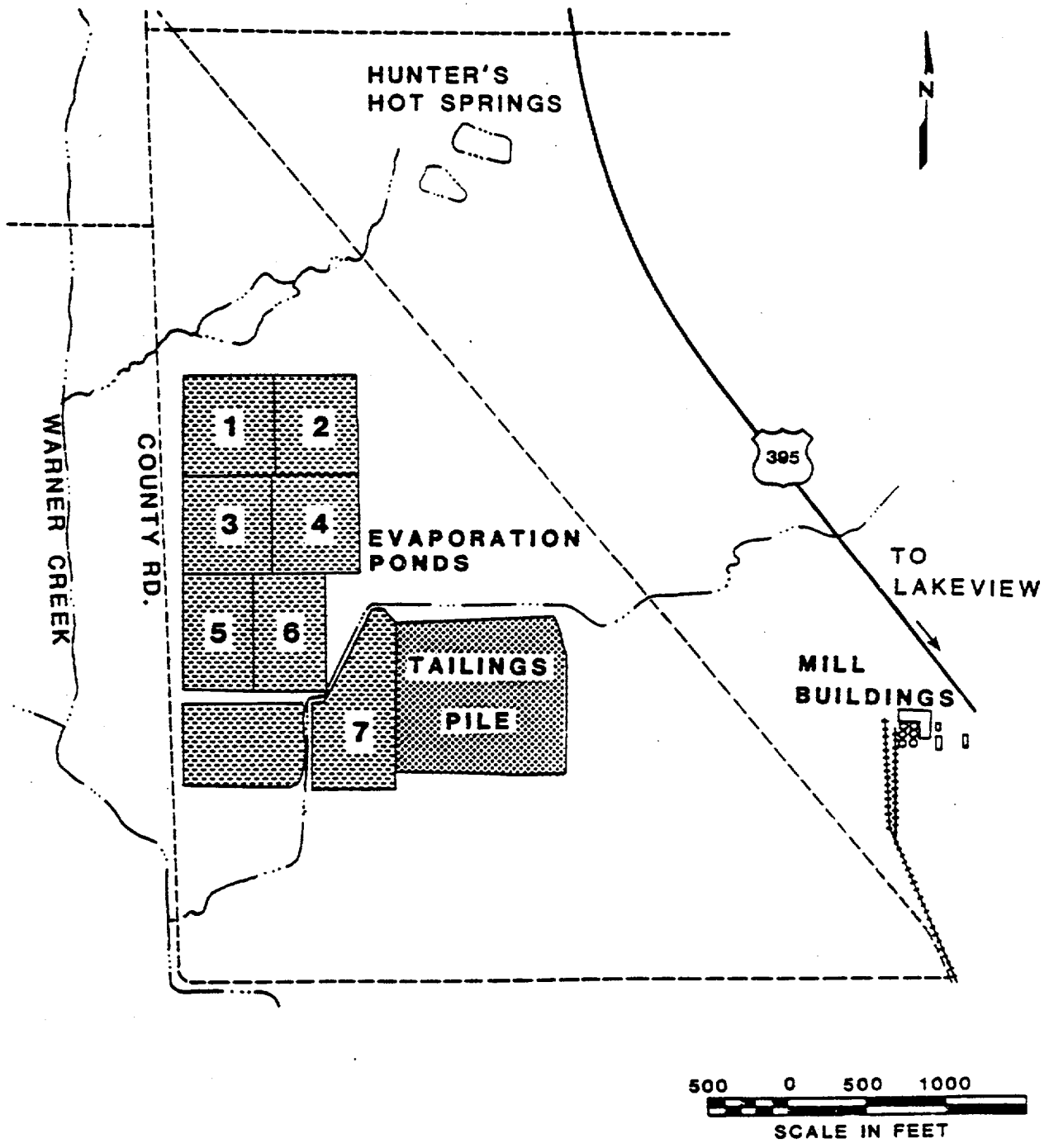


FIGURE 3.17
LOCATION MAP LAKEVIEW SITE

portions of this range site were burned during a range fire. The central portion of this site, a gently sloping basin underlain by a cemented hardpan, supports the Claypan Terrace range site, a low sagebrush (Artemisia arbuscula) community. South-facing exposures in the upland habitats support the South Exposure range site, a grassland with a low density of sagebrush. The floodplain along the small southeast flowing streams is characterized by the Well Drained Bottom range site, a grassland or meadow community (WRD, 1984b) (Figure 3.18).

Flynn Ranch site

The Flynn Ranch site is characterized by four major range sites. Gently sloping areas of deep to moderately deep soils are characterized by the Shrubby Rolling Hills range site. This antelope bitterbrush-big sagebrush (Purshia tridentata - Artemisia tridentata) unit is extensive in the Warner Mountains and predominates at the study area as well. The Stony Terrace range site, a low sagebrush (Artemisia arbuscula) community, occurs as small inclusions on shallow soils. The Mahogany Rockland site, a tree-dominated community, occupies shallow soils on basalt rock outcrops. The Juniper Rolling Hills range site, a woodland community, occurs on north-facing slopes and ridge tops in areas of deep soils (WRD, 1984c).

Borrow sites

The borrow area for Collins Ranch is a disturbed area on a steep, southwest-facing slope. Prior to disturbance the area was a conifer forest, and a dry mountain meadow range site that occurs in the bottomland along Augur Creek. This area is dominated by several species of grasses, an absence of shrubs, and a sparse cover and composition of forbs.

The borrow area for the Collins Ranch site is characterized by the Mountain Swale range site, a big sagebrush community, and small acreages of the Shrubby Rolling Hills, Stony Terrace, and Mahogany Rockland range sites (Figure 3.19).

3.7.2 Wildlife

Lakeview mill tailings site

Except for the rabbitbrush/greasewood embankments and the cover and water provided by Hammersley Creek, the mill tailings site has limited value for wildlife. Species observed or determined to be present based on tracks in the snow were the coyote (Canis latrans), red fox (Vulpes vulpes), mountain cottontail (Sylvilagus nuttallii), and jackrabbit (Lepus townsendii or L. californicus). Mule deer (Odocoileus hemionus) may occur irregularly as vagrants.

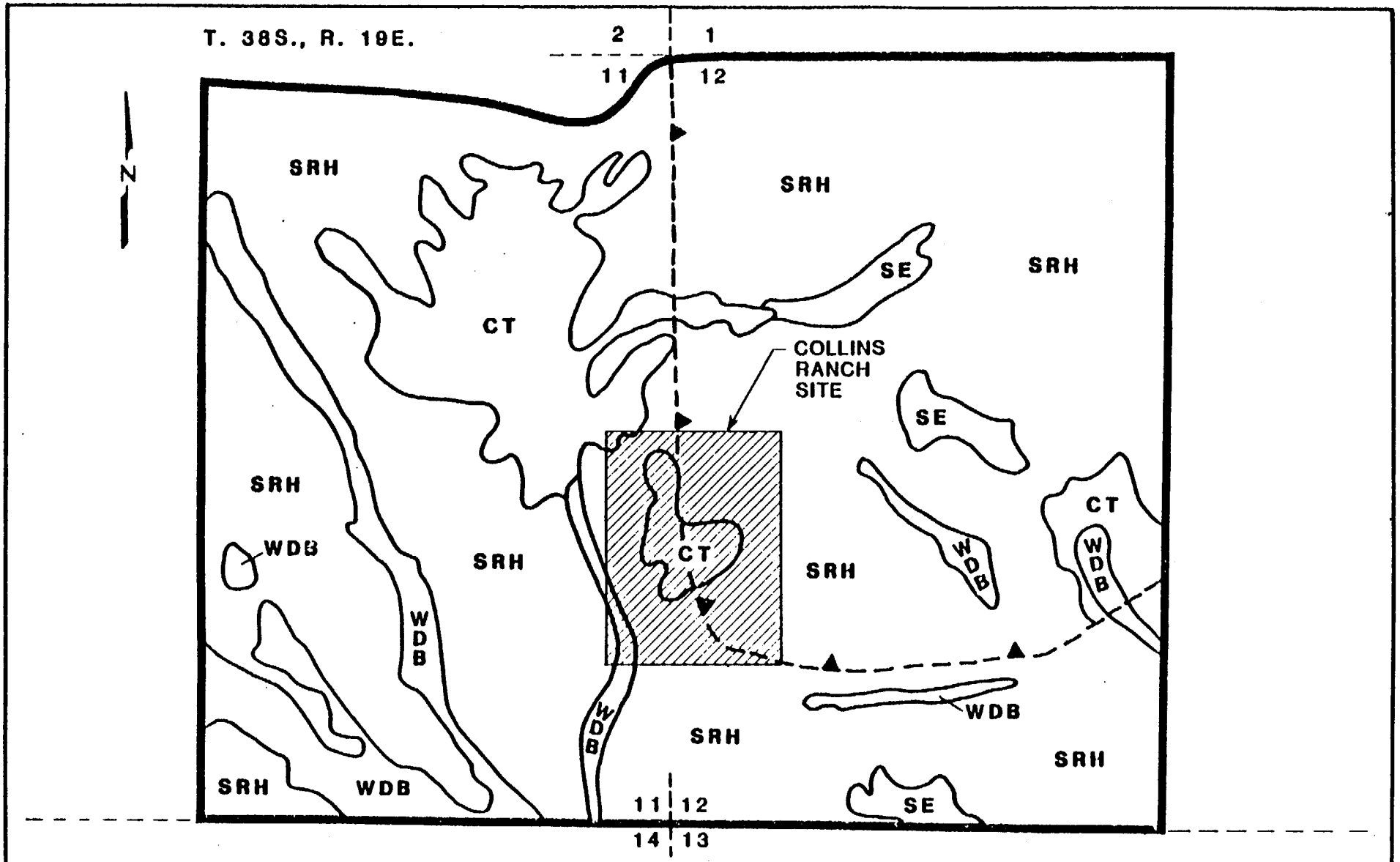


FIGURE 3.18
RANGE SITE TYPE MAP
FOR COLLINS RANCH

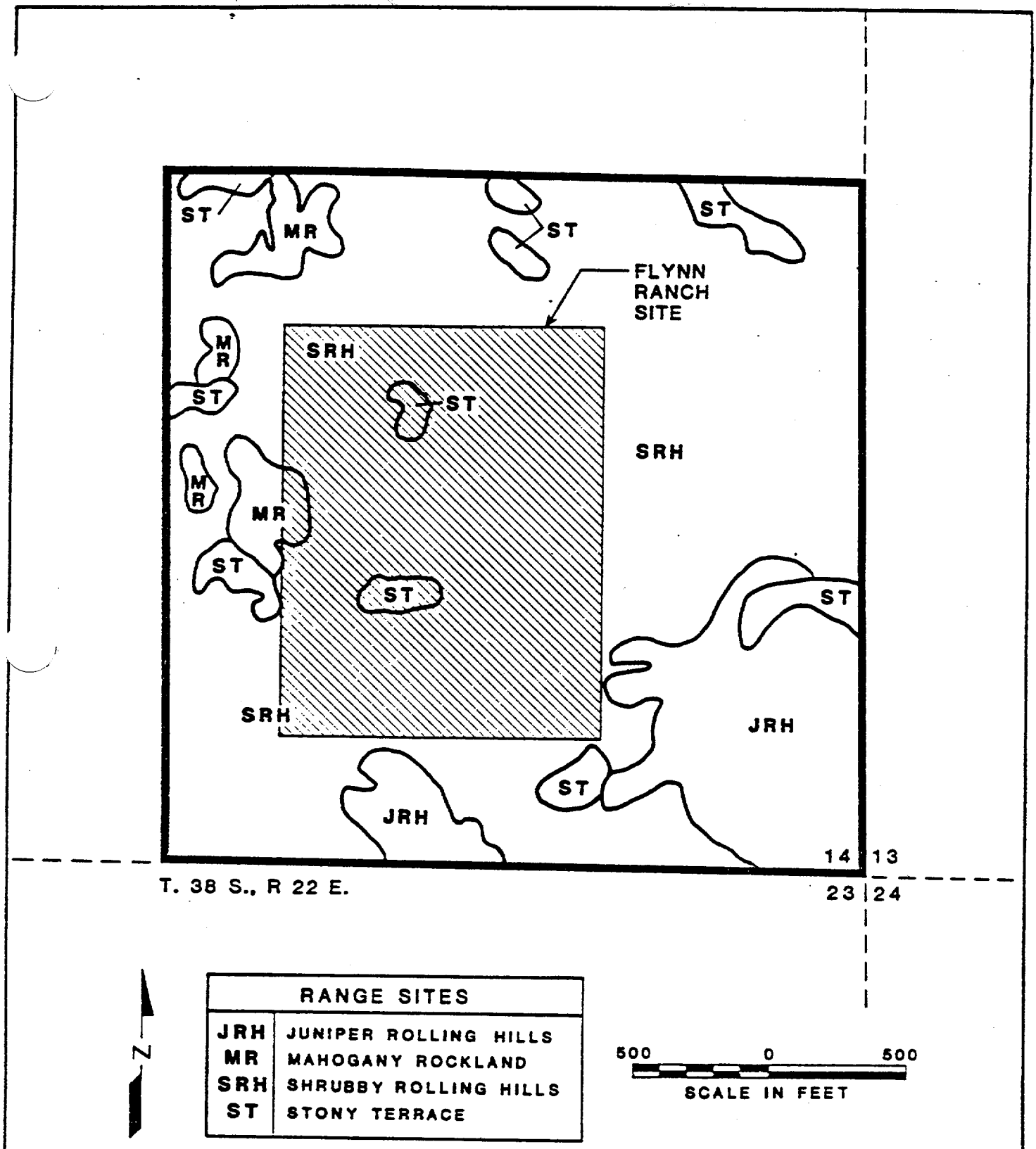


FIGURE 3.19
RANGE SITE TYPE MAP
FOR FLYNN RANCH

Bird species observed in the field reconnaissance were a ring-necked pheasant (Phasianus calchicus) along Hammersley Creek, a flock of Canada geese (Branta canadensis) feeding in a field north of the site, mallards (Anas platyrhynchos) in the open water of Hunters Hot Springs Creek, and a great blue heron (Ardea herodias) along Hammersley Creek south of the site.

Gamebirds potentially present (besides those listed above) include the gray partridge (Perdix perdix) on the weedy embankments, and a variety of small waterfowl such as cinnamon teal (Anas cynoptera), blue-winged teal (Anas discors), and green-winged teal (Anas crecca) along the drainages. Although some nesting by these ducks (as well as mallards and perhaps other species) is possible, most of the use by waterfowl probably occurs during migration.

Raptors hunting across the open terrain of the mill tailings site probably include red-tailed hawks (Buteo jamaicensis), northern harriers (Circus cyaneus), and short-eared owls (Asio flammeus) as year-round residents, with rough-legged hawks (Buteo lagopus) and ferruginous hawks (Buteo regalis) present in winter and a number of other species present as migrants or vagrants.

The herpetofauna of the mill tailings site probably is limited due to the small number of habitat types represented. A few amphibian species would be expected to breed along Hammersley Creek. A few reptiles could potentially use the cover and forage provided by the vegetation found on the embankments (WRD, 1984a).

Collins Ranch site

Wildlife that could be found at the Collins Ranch site include mountain cottontail (Sylvilagus nuttallii), and white-tailed jackrabbit (Lepus townsendii) in the dense sagebrush/rabbitbrush near Camp Creek. Other species would be the mule deer (Odocoileus hemionus) and coyote (Canis latrans). Mule deer probably occur year-round, with greatest use during transitional seasons. Snow cover may limit use in severe winters despite the abundance of palatable browse, while lack of tree cover (thermal and hiding) may limit summer use. Pronghorn (Antilocapra americana) reportedly move through in small numbers, and American elk (Cervus elaphus) also may occur as migrants or vagrants.

Bird species seen at the Collins Ranch site were the American robin (Turdus migratorius) and black-billed magpie (Pica pica) in the bottomland willows along Camp Creek, and two rough-legged hawks (Buteo lagopus) hunting along Augur Hill. In addition, drillings characteristic of yellow-bellied sapsuckers (Sphyrapicus varius) were found on the scattered aspens, chokecherries, and Klamath plums; nests of Say's phoebes

(Sayornis saya) and barn swallows (Hirundo rustica) were found in an abandoned homestead; and remains of a sage grouse (Centrocercus urophasianus) were discovered along Camp Creek.

Game birds besides the sage grouse that could potentially use the area include ring-necked pheasants (Phasianus calchicus) and gray partridge (Perdix perdix) in grassy areas along Camp Creek, although both prefer somewhat lusher herbaceous cover than is afforded by the narrow meadows, and migratory waterfowl at small stock ponds.

The herpetofauna of the Collins Ranch site is expected to be limited, due to the small variety of habitats available. Amphibians could breed in the minor drainages along Camp Creek and reptiles, such as the western fence lizard (Sceloporus occidentalis) and the sagebrush lizard (Sceloporus graciosus), would be found in big sagebrush/bitterbrush or big sagebrush/-rabbitbrush habitats (WRD, 1984b).

Flynn Ranch alternate

Wildlife observed at the Flynn Ranch site included the mule deer (Odocoileus hemionus) and mountain cottontail (Sylvilagus nuttallii). Tracks of both species were common, especially among the islands of mountain mahogany and junipers (Murie, 1979). Mule deer apparently utilize the site year-round, except during harsh winters when deep snow cover inhibits mobility and prevents use of the food resource. Normally, however, the abundance of palatable browse -- especially bitterbrush -- provides a nutritious winter food source. The thermal and hiding cover afforded by the juniper and mountain mahogany clumps and the availability of water and lush herbage along drainages also make the site suitable as summer range.

Other mammal species whose presence was verified by diagnostic sign were the coyote (Canis latrans), porcupine (Erethizon dorsatum), a woodrat (probably a bushy-tailed woodrat, Neotoma cinerea), and a weasel (probably a long-tailed weasel, Mustela frenata).

Bird species observed at the Flynn Ranch site included the Townsend's solitaire (Myadestes townsend), which feeds on juniper berries. Other songbirds present were the black-billed magpie (Pica pica), black-capped chickadee (Parus atricapillus), and American robin (Turdus migratorius), all in junipers and mountain mahogany.

Raptors observed included a rough-legged hawk (Buteo lagopus) and a golden eagle (Aquila chrysaetos) which was seen perched on a basalt cliff about three miles southwest of the site. Rough-legged hawks are common winter residents throughout the region, while golden eagles are year-round residents.

The herpetofauna of the Flynn Ranch is expected to be limited, owing both to the elevation of the area and the small variety of habits available (WRD, 1984c).

Borrow sites

Borrow site B probably supports many of the species found at the Collins Ranch site. However, the mesic meadow along Augur Creek and the mixed conifer forest on nearby slopes also attract additional species. These may include snowshoe hares (Lepus americanus), golden-mantled ground squirrels (Spermophilus lateralis), yellow pine chipmunks (Eutamias amoenus), and bobcats (Lynx rufus) in the conifer, besides chickarees (Tamiasciurus douglasi) which were observed there, and mountain voles (Microtus montanus), western jumping mice (Zapus princeps), and muskrats (Ondatra zibethica) in the wet meadows. Porcupine (Erethizon dorsatum) sign was seen in both the conifer and streamside cottonwood/aspen types.

The only small bird observed in the Augur Creek Meadows borrow area was a Steller's jay (Cyanocitta stelleri), but the riparian deciduous trees showed drillings and nest cavities typical of northern flickers, yellow-bellied sapsuckers, and hairy and downy woodpeckers (Picoides villosus and P. pubescens). One sapsucker nest had been filled with small twigs, as often is done by house wrens (Troglodytes aedon).

A limited herpetofauna would be expected at the borrow site due to the little variety of habitat. Additional species to those that could possibly inhabit the Collins Ranch site would be the rubber boa (Charina bottae) and common garter snake (Thamnophis sirtalis), which might be found in the more mesic environs of the Augur Creek meadows (WRD, 1984b).

The borrow area identified for use at the Flynn Ranch site supports similar wildlife use the alternate site. Diagnostic signs (Murie, 1979) observed in December 1984 were mountain cottontail and coyote tracks in the snow and woodrat and weasel droppings in an abandoned building (WRD, 1984c).

3.7.3 Threatened and endangered species

Plants

In the State of Oregon, there are two species of plants on the USFWS listing of endangered and threatened plants. One plant is proposed for protected status, and 113 plants are under review for protected status (USFWS 1980; 1982; 1983).

The Oregon Natural Heritage Data Base, maintained for the State by the Oregon Chapter of the Nature Conservancy, indicates that neither of the two species listed as endangered nor the one plant species proposed for protected status occurs in or near the Lakeview site or either of the two alternate sites (including the borrow areas). In addition, the USFWS has indicated that no threatened or endangered species occur on the alternate sites or borrow sites (Wolflin, 1985).

Wildlife

The only wildlife species listed by the USFWS (1982) potentially present at the existing tailings site are the American peregrine falcon (endangered) (Falco peregrinus anatum) and the bald eagle (threatened) (Haliaeetus leucocephalus), both of which could occur as vagrants or migrants because of the proximity to suitable habitat along nearby lakes and rimrocks. Use of the alternate sites or mill site by either species would be limited and irregular, if it occurred at all (WRD, 1984a,b,c). In addition, the USFWS has indicated that no threatened or endangered species occur on the alternate sites or borrow sites (Wolfin, 1985).

3.8 RADIATION

Appendix H, Estimates of Health Effects of Radiation, and Section 4.1 contain a discussion of radiation and radiological health effects calculations. Environmental radiation measurements and existing radiation levels at the Lakeview site and alternate disposal sites are discussed below.

3.8.1 Background radiation

Radioactive elements occur naturally throughout the air, water, soil, and rock of the earth. The concentration of these elements varies greatly throughout the United States. The purposes of collecting background radiation data are to provide a reference point to which levels of contamination on the processing site can be compared, and to assess remedial action construction impacts on the environment.

Background radioactivity levels typical of the Lakeview region and not influenced by the Lakeview tailings pile have been established (ORNL, 1980). The average background concentrations in soil were 0.8 pCi/g for radium-226 (Ra-226), 0.3 pCi/g for uranium-238 (U-238), and 0.7 pCi/g for thorium-232 (Th-232).

The average background gamma radiation exposure rate from both terrestrial and cosmic sources, measured at three feet above the ground, was 11 microR/hr, with a range of 8 to 19 microR/hr (ORNL, 1980). Cosmic rays (radiation from the sun and other sources external to the earth) contribute approximately 5.3 microR/hr (48 percent) to the 11 microR/hr total (EG&G, 1981).

Outdoor background radon-222 (radon) concentration measurements were made by the Oregon State Health Division (OSHD, 1984) during a three-month period in 1982 at three locations which resulted in background radon air concentrations ranging from 0.35 to 0.92 pCi/l. In another study, the average outdoor background radon concentration in the Lakeview area based on measurements at eight locations was 0.7 pCi/l (FBDU, 1981).

3.8.2 Radiation levels

Lakeview site

Previous remedial action activities were conducted in 1974 through 1977 at the Lakeview tailings site. These included clean-up and stabilization of the former mill area, partial excavation of material in the evaporation ponds, and application of cover material over the tailings pile.

Samples from 21 drill holes on the tailings pile were analyzed by gamma spectroscopy. Computer modeling was used to profile the pile contaminant distribution and the average radium-226 concentration. The resulting average radium-226 concentration of the tailings was 160 pCi/g; this includes the tailings, the existing two-foot-thick cover, and a two-foot layer of contaminated material underlying the tailings (BFEC, 1984; JEG, 1984). The total volume of contaminated material associated with the 30-acre pile (tailings, cover, and underlying materials) is approximately 424,000 cubic yards and the total inventory of the material is 77 Ci of radium-226.

During milling operations, records show that approximately 130,000 tons of ore containing an average U_3O_8 concentration of 0.15 percent were processed (ORNL, 1980).

The soil beneath the tailings pile exceeds the EPA standard of 15 pCi/g radium-226 to an average depth of approximately one foot. Elevated arsenic levels are also present beneath the tailings, approximately 600 ppm from zero-to-two feet beneath the tailings pile.

Using Schiager's (1974) estimate of 2.5 (microR/hr)/(pCi/g), the bare tailings gamma exposure rate would be 400 microR/hr based on the average tailings pile radium-226 concentration of 160 pCi/g. The existing cover on the tailings pile reduces the pile surface gamma exposure rate to an average of less than 25 microR/hr (EG&G, 1981).

The radon flux source term from the tailings pile was calculated using the RAECOM model (NRC, 1984) and resulted in an annual average radon flux of 59 pCi/m^2s for no-action conditions. Dispersion modeling described in Appendix H, Estimates of Health Effects of Radiation, Section H.3.1, estimated the radon air concentration at the center of the pile to be 1.4 pCi/l above background.

Results of field data from the evaporation ponds (69 acres) on the tailings site indicated elevated thorium-230 concentrations, averaging 65 pCi/g in the surface six-inch layer, 35 pCi/g in the six- to 12-inch layer, and 12 pCi/g in the 12- to 18-inch layer. Since radium-226 activity ingrowth would be above EPA standards in 1000 years, approximately 181,000 cubic yards of soil (to a depth of 18 inches) are planned for excavation from the evaporation ponds.

Field data (ORNL, 1980; BFEC, 1984) show that minimal spread of gamma-emitting contamination has occurred by wind or water erosion into areas beyond the tailings pile or evaporation ponds. Approximately 14 acres indicated elevated radium-226 concentrations immediately adjacent to the tailings pile and in isolated areas in the mill yard which were not cleaned during previous remedial action. Concentrations ranged from five to 170 pCi/g radium-226. Approximately 23,000 cubic yards of material are planned for excavation from these areas (to a maximum depth of one foot) having an average radium-226 concentration of approximately 21 pCi/g.

Collins Ranch and Flynn Ranch alternate sites

Limited data exist on background radiation levels at both alternate sites. Both sites are believed to have radiation levels consistent with regional levels as determined by ORNL (1980). These were 11 microR/hr for gamma exposure rate at three feet above the ground, 0.8 pCi/g radium-226 in soil, and 0.7 pCi/g thorium-232 in soil. Radon air concentration measurements were made at each site resulting in an average radon concentration of 0.12 pCi/l at one location on the Collins Ranch site and 0.17 pCi/l at one location on the Flynn Ranch site. The ground was snow-covered during approximately 50 percent of the three-month exposure period, which would tend to decrease ambient radon air concentration. Gamma exposure rate traverse measurements will be performed at each site.

3.9 LAND USE

The following is a brief description of the land use in the Lakeview area. This material summarizes more detailed data presented in Appendix G, Land Use and Socioeconomics.

In terms of regional land use, approximately 69 percent of the total acreage (95,299,789 acres) of Lake County is used for the grazing of livestock. Timber (23 percent), irrigated cropland (four percent), and lakes and reservoirs (two percent) also cover large portions of the county's total land area. All other uses each comprise less than one percent of the county's land area (Silvermoon, 1982).

Approximately 76 percent of Lake County's land area is publicly owned (69 percent Federal, four percent state, and three percent by local juris-

dictions). The remaining 24 percent is privately owned. The largest private holder of land is the timber industry, owning approximately five percent of the county's land (Silvermoon, 1982).

The privately owned tailings site is located on 258 acres of land, approximately one mile northwest of Lakeview, and is zoned for heavy industry. A lumber mill is located on the eastern portion of the site, while the tailings area in the western portion has been deemed unsuitable for development in its present state.

The Collins Ranch alternate disposal site is privately owned, zoned for agricultural use (used for grazing), covers approximately 20 acres and is located seven miles northwest of Lakeview.

The Flynn Ranch alternate disposal site is privately owned, covers approximately 25 acres of land, is zoned for agricultural use (used for grazing), and is located 26 road miles east-north-east of Lakeview.

Both the Collins Ranch site and the Flynn Ranch site have limited recreational use due to restricted access and commitment of lands for grazing purposes. Fremont National Forest, northwest of the Collins Ranch site, provides recreational facilities and timber products.

3.10 NOISE

A background noise survey was performed in Lakeview in the vicinity of the tailings pile (FBD, 1983). Noise levels at or near the tailings pile and at a number of other locations in Lakeview ranged from 43 to 66 decibels on the A-weighted scale (dBA). (The A-weighted scale most closely approximates that of the human ear.) Figure 3.20 provides a perspective on a variety of noise sources and the type of sources that generate the noise.

A noise level of 47 dBA was recorded at the center of the tailings pile in 1982. At the lumber mill 0.7 mile away, the former site of the uranium mill, a noise level of 66 dBA was recorded. At the nearest sensitive receptor (residence), located about 0.4 mile from the tailings pile, the recorded noise level was 64 dBA. At Hunter's Lodge (0.9 mile from the pile), and at Roberta Avenue near the highway to Klamath Falls (1.3 miles from the pile), noise levels were 43 dBA and 59 dBA, respectively.

No noise measurements were taken at either the Collins Ranch or the Flynn Ranch alternate disposal sites. Since the disposal sites are not in highly populated areas or along transportation routes, ambient noise levels will be lower than those recorded in Lakeview. Based on the National Academy of Science method of relating noise levels to population densities, noise levels at the alternate disposal sites (undeveloped rural areas), would be equivalent to an average day-night sound level of about 35 dBA (National Academy of Science, 1977). (L_{dn} is a noise rating system that assigns a 10 dB penalty to the nighttime period to account for the heightened perception to noise during that time.)

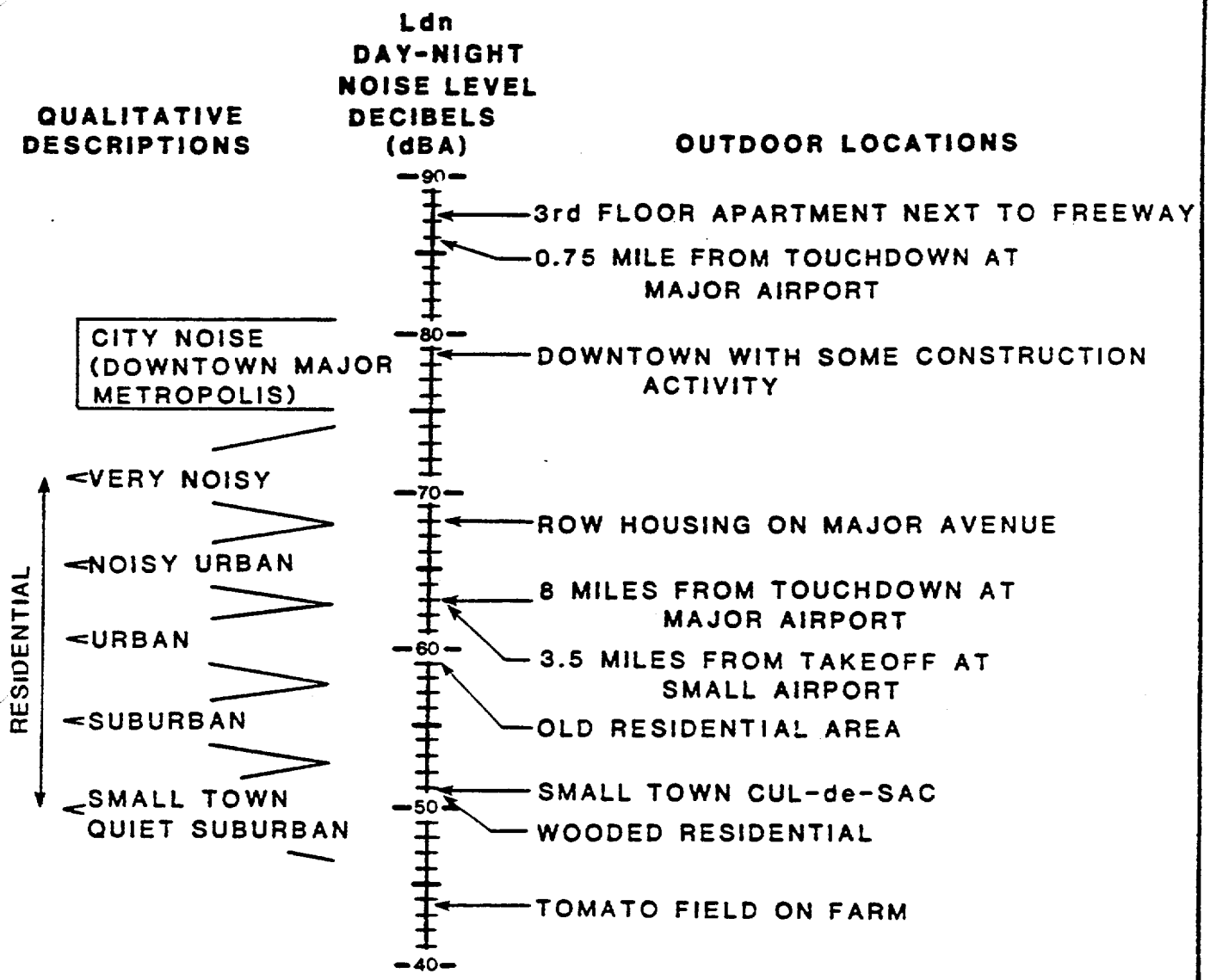


FIGURE 3.20
TYPICAL NOISE LEVELS (EPA, 1974)

No noise measurements were taken at the potential borrow areas. The borrow site for the Collins Ranch alternate is an existing gravel pit. Ambient noise level at this site would be expected to reflect the noise produced by internal combustion-engine-powered earthmoving equipment operating on the site, e.g., scrapers, front-end loaders, and trucks. At a distance of 100 feet from the source, these types of equipment produce noise levels in the 66-90 dBA range (EPA, 1972). Borrow site G, associated with the Flynn Ranch disposal alternative, may be a source of material for the radon cover and for restoration of the existing tailings site in Lakeview. The site is in a lightly developed rural area. Based on the National Academy of Science method of relating noise levels to population densities, ambient noise levels would be expected to be in the 35 to 40 dBA range.

3.11 SCENIC, HISTORIC, AND CULTURAL RESOURCES

3.11.1 Scenic resources

The scenic resources of the Lakeview site are characterized by a combination of industrial, suburban, and pastoral views of surrounding mountains. Noticeable features in the vicinity include lumber mills, ponds, irrigated pasture lands, residential areas, and ranches with clusters of cottonwood trees. The Hunters Hot Springs Geyser, north of the tailing pile, is a local scenic attraction.

Collins Ranch site

Scenic resources at the proposed Collins Ranch disposal site consist primarily of foreground and middleground views of hills and valley areas covered with grass, sagebrush, and mixed stands of juniper and ponderosa pine trees. The site is within the viewshed of one home and one road. Signs of a recent range fire are plainly visible when approaching the site.

Flynn Ranch site

The Flynn Ranch alternate tailings disposal site is characterized by foreground and middleground views of grass and sagebrush covered rangeland and forested foothills. Drake Peak is a prominent landmark that can be seen looking north from the disposal site. The disposal site is within the viewshed of County Road 3-13.

Borrow sites

The borrow site for the Collins Ranch alternative is characterized by foreground and middleground views of forested Augur Creek Canyon. The borrow site for the Flynn Ranch alternative has a visual character similar to the alternate disposal site.

3.11.2 Historical resources

History in the Lakeview area reflects many activities including ranching, timber production, farming, mineral development, and contact between Indians and Euro-American settlers. Prior to settlement in the late nineteenth century, the Goose Lake Basin and adjacent Warner Mountains were primarily occupied by bands of the Northern Paiute Indians. The aboriginal territory of the Gidutikad Band of Northern Paiute Indians consists of approximately 5000 square miles of land. It extends from the Fort Bidwell Indian Reservation, California, on the south, to Steens Mountain with the central portion being the Hart Mountain-Drake Peak area which includes the areas of the Collins and Flynn ranches (Bellon, 1984a). Life among the Gidutikad people involved collecting and processing a wide range of native plant foods with occasional wild game in a subsistence economy. Seasonal movement of small family groups generally ranged between productive food collection areas to traditional winter camping sites. Besides being the primary food supply, native plants were also used for medicinal purposes (Minor et al., 1979).

The first contact between local Indians and Euro-Americans came in 1827 when Hudson Bay Company fur trappers, led by Peter Skene Ogden, visited the Goose Lake Basin and surrounding areas. In the 1840's several expeditions under the direction of John C. Fremont travelled through south central Oregon.

In 1869, pioneers settled in the Goose Lake Valley following years of conflict between military units and local Indians. Eventually, government land policies and private land acquisitions led to the relocation of the local Paiute Indians to the Fort Bidwell Indian Reservation, approximately 47 miles south of Lakeview, in California. Livestock ranching became firmly established in the Lakeview area during the following years even though land speculation through government land grants worked to the disadvantage of many small homesteaders. Lake County was created by the state legislature in 1874, and in 1876, Lakeview became the county seat. By 1909 the Oregon Valley Land Company (OVL) had sold 14,000 parcels of Goose Lake Valley land primarily to small investors. Delays in obtaining irrigation water and other factors led to tax sales of many OVL parcels.

Mining has played only a minor role in the history and economy of Lake County. Although several mining districts were established in the Goose Lake area, the short-lived mining of uranium ore at the White King and Lucky Lass mines from 1958 to 1961 was the most prosperous. Uranium ore was processed at the uranium mill at Lakeview which was built and operated by the Lakeview Mining Company.

Some buildings in Lakeview are more than 50 years old and may be eligible for nomination to the National Register of Historic Places. The list of vicinity properties to be included in the remedial action will be checked to identify buildings that may be historic structures. As presently defined, neither alternative would affect known historic sites.

3.11.3 Cultural resources

All of the lands that would be affected by the remedial action under any of the alternatives are in the northern part of the Great Basin which has been occupied by man for as long as 13,000 years (Winthrop and Winthrop, 1985). Prior to 8,000 years ago Paleo-Indian big game hunters may have been present in the Goose Lake area. The subsequent Archaic tradition, while including big game hunting, also marked the expansion into more broad use of diverse native plant foods. Reliance on food gathering and hunting persisted until historic times when Indian groups were displaced from their traditional territories. Utilization of lacustrine (lake shore) locations by small extended family groups was a common theme throughout the Archaic period in the Great Basin. Bands of Paiute Indians that inhabited the south central Oregon area in the 1800's were a remnant of the Archaic tradition that had been passed on for hundreds of generations (Winthrop and Winthrop, 1985).

Pedestrian cultural resource surveys were conducted at the area surrounding the tailings pile, at each of alternate disposal sites, and at the proposed borrow sites (Winthrop and Winthrop, 1985). No historic or prehistoric sites were reported in the vicinity of the tailings pile.

Collins Ranch site

Adjacent to the Collins Ranch site, obsidian flakes and an obsidian projectile point fragment were reported as isolated finds. No other significant finds were identified on the Collins Ranch site.

Flynn Ranch site

One isolated find obsidian flake was found at the Flynn Ranch site.

Borrow sites

In the adjacent foothills near the Collins Ranch borrow site, five other prehistoric (and historic period) isolated finds and two historic use sites were located.

The two historic sites near the Collins Ranch borrow site are being evaluated by the Oregon State Historic Preservation Officer to determine if they are eligible for nomination to the National Register of Historic Places. Neither of the historical sites would be affected by the excavation of borrow materials (Winthrop and Winthrop, 1985).

The Flynn Ranch borrow site has not been surveyed for cultural resources; however, based on the results of the adjacent survey, no cultural resources are likely to occur. If the Flynn Ranch alternate is selected as the site for remedial action, a cultural resource survey would be conducted prior to excavation of borrow material.

Historical

The Fort Bidwell Indian Community Council has indicated that the area surrounding Drake Peak, including both alternate disposal sites, is a spiritual focal point for the Paiute Gidutikad people.

The Gidutikad people are concerned about sacred sites and cultural resources extending from the Fort Bidwell Indian Reservation to Steens Mountain country.

> "The aboriginal territory of the Gidutikad people covered portions of California, Nevada and Oregon with the center being from Hart Mountain to the Drakes Peak area. Besides being rich in wildlife and other subsistence resources, the aboriginal territory of our people has religious and cultural resources of contemporary significance to our tribe. The harvesting of plants and animals in this area is still an important part of our subsistence diet. Our religion was interwoven with the secular aspects of life. Hunting and harvesting required thorough spiritual preparation. The spiritual focus of our religion was on or near the mountains mentioned above. It was at these sites (Drake Peak, Hart Mountain, and Steens Mountain) that members of the aboriginal Northern Paiute Bands sought communion with the Ancient Power. And it is at these same sites, like the Drake Peak area, that now, centuries later, Gidutikad people continue to seek spiritual help. These mountains for the Gidutikad people are comparable to other shrines in other religions, such as Mecca to Islam or the Vatican to Catholic Christians (Bellon, 1984a)."

Although both alternate disposal sites are within areas sacred to the Gidutikad people, the Flynn Ranch is the more sensitive of the two being closer to Drake Peak (Bellon, 1984b; Lara, 1984; Washoe, 1984). The Northern Paiutes further stated their opposition to the Flynn Ranch alternative by speaking out against "desecration or abuse" of lands in the vicinity of Drake Peak (Bellon, 1984a).

3.12 SOCIOECONOMIC CHARACTERISTICS

The following is a brief description of the socioeconomic conditions of the Lakeview area. This material summarizes more detailed data presented in Appendix G, Land Use and Socioeconomics.

The 1983 populations of Lake County and Lakeview were estimated to be 7500 and 2750, respectively (Portland State University, 1983). These populations declined from 1980 census levels of 7532 (county) and 2770 (city).

In 1980, the city of Lakeview housing stock included a total of 1149 units, plus approximately 195 hotel/motel rooms. The total 1980 countywide housing stock was 3326. Vacancy rates for rental units in Lakeview were 9.1 percent, while countywide rental vacancy rates were 10.1 percent (Oregon Department of Human Resources, 1983).

The Lake County labor force included an average of 3740 people in 1983. Government and lumber and wood products are the largest sectors in terms of employment. The average county unemployment rate for 1983 was 10.8 percent. Lake County has consistently faced a higher average unemployment rate than the State of Oregon as a whole (Oregon Department of Economic Development, 1983).

Assessed valuation in 1983 for Lake County was $281,153,000. In 1981, the average property tax rate for the city of Lakeview was $21.60 per $1000 of assessed value. This rate, applied to the city's assessed valuation of $45,992,000, led to a tax levy of $993,308. The county received $4.9 million in fiscal year 1980-81 for schools and roads from timber revenues of the county's two national forests. Oregon has no sales tax (Oregon Department of Economic Development, 1983).

The Lakeview Police Department consists of five officers and the County Sheriff maintains five officers in Lakeview. The Oregon State Police also have a station in the city. City fire protection is provided by six firemen and a volunteer force of approximately 25 people (MESA, 1982). There are seven schools in the Lakeview School District. Total enrollment at these institutions was 1313 during the 1983-84 school year, while enrollment capacity at these institutions was over 1600. The nearest college to Lakeview is the Oregon Institute of Technology 90 miles to the west near Klamath Falls, Oregon (Lakeview Chamber of Commerce, 1984).

Lakeview has 3.5 million gallons of water storage capacity. The supply is available at a rate of 2800 gallons per minute. The capacity of the city's sewer system is at least double that which is necessary to service the estimated 3600 current users (MESA, 1982).

Major surface transportation routes in the Lakeview area include U.S. Highway 395 (north-south) and Oregon State Highway 140 (east-west) (Figure 3.21). Average daily traffic on U.S. 395 in Lakeview in 1983 was approximately 6900 trips per day at a point just south of the intersection with the western portion of State Highway 140. Traffic volumes on U.S. 395 drop sharply to the north: immediately north of the eastern portion of State Highway 140 Intersection 1983 volumes averaged 2900 trips per day; at the north Lakeview city limit, average daily volumes were 2250 (Putnam, 1984). Average daily flows on State Highway 140 at Lakeview were 3800 in 1980 (FBD, 1983). No significant congestion problems have been reported on the above roadways (MESA, 1982).

Bus service in Lakeview is provided by Pacific Trailways and by the Red Ball Stage. There are five public or private airports in Lake County.

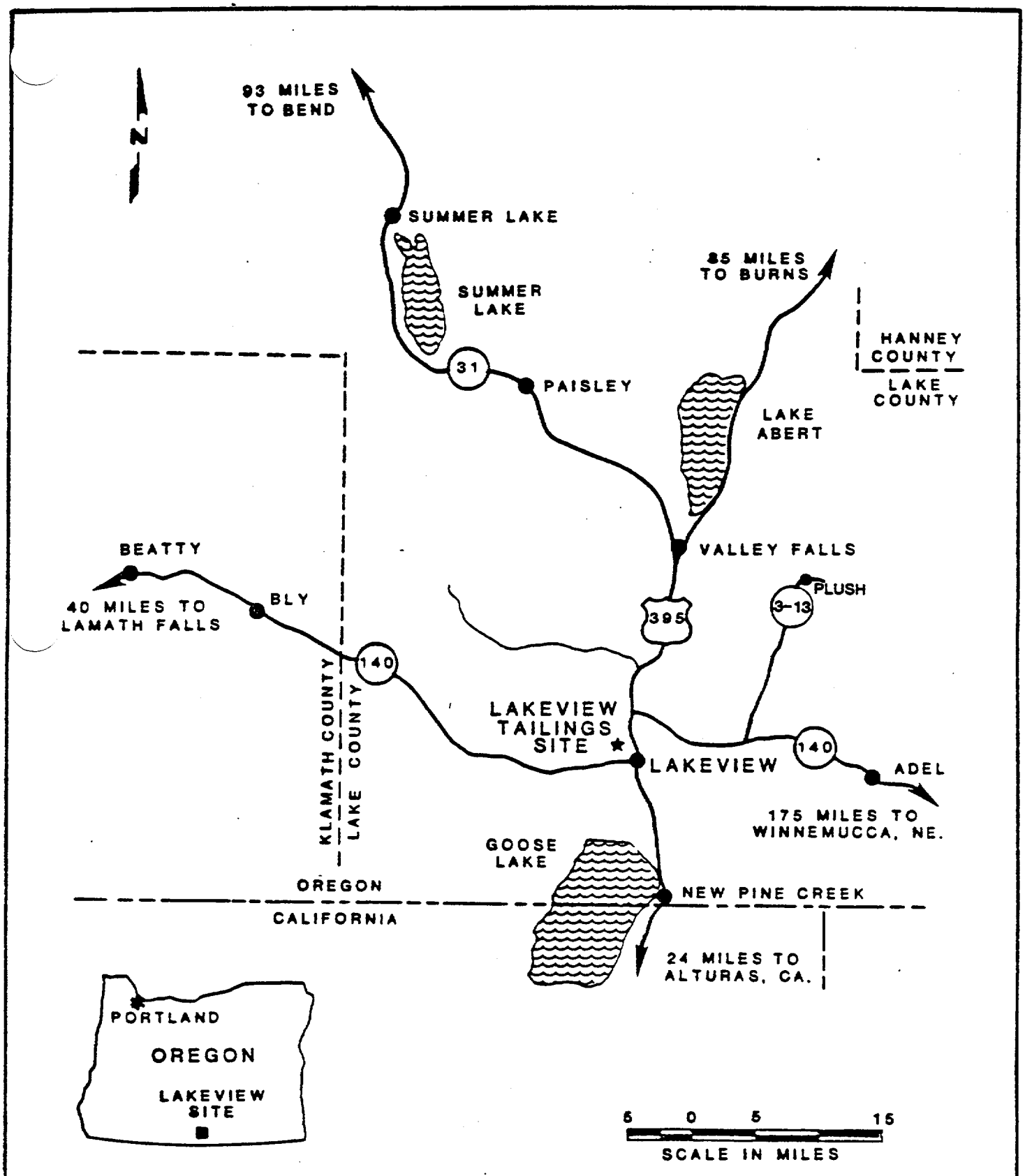


FIGURE 3.21
HIGHWAY MAP OF LAKEVIEW AREA

The Lakeview airport, which is four miles southwest of town, consists of two 100-foot-wide, one-mile-long illuminated runways. No commercial service is currently provided at the Lakeview airport.

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4.0 ENVIRONMENTAL IMPACTS

The environmental impacts of each of the alternatives are summarized in this chapter. A discussion of remedial action at the vicinity properties in Lakeview is not included in this document. The remedial action plan for vicinity properties is discussed in a separate paper (DOE, 1985a).

4.1 RADIATION

4.1.1 Exposure pathways

There are five principal radiological pathways by which individuals could be exposed during the remedial action (Figure 4.1). These are: 1) inhalation of radon daughters; 2) direct exposure to gamma radiation; 3) inhalation and ingestion of airborne radioactive particulates; 4) ingestion of ground and surface water contaminated with radioactive materials; and 5) ingestion of contaminated foods produced in areas contaminated by tailings. For the calculation of health effects, those pathways which would result in the largest radiological doses were considered in detail in Appendix H, Estimates of Health Effects of Radiation: inhalation of radon daughters and direct exposure to gamma radiation. Calculations were also performed which estimate radiation exposures and health effects to remedial action workers and the general population from the air particulate pathway and to the general population from the ground-water ingestion pathway.

Exposures and associated health effects to the general population via the gamma exposure and airborne radioactive particulate pathways during remedial action would be an order of magnitude smaller than the doses from radon daughter inhalation as calculated in Appendix H, Estimates of Health Effects of Radiation. Following better definition of the extent of ground-water contamination beneath and adjacent to the Lakeview pile, the significance of health impacts from consumption of this water will be estimated in more detail. Initial ground-water sample data indicate minimal radionuclide contamination and associated health effects. Exposures via ingestion of foods produced in the area that were contaminated by irrigation or windblown dust are anticipated to be much smaller (an order of magnitude or more) than the doses from radon daughter inhalation.

Radon is an inert (i.e., does not react chemically with other elements) gas produced from the radioactive decay of radium-226 in the uranium-238 decay series. As a gas, radon can diffuse through the tailings and into the atmosphere where it is transported by atmospheric winds over a large area. In the atmosphere, radon decays into its solid daughter products which attach to airborne dust particles and are inhaled by humans. These dust particles, with the radon daughter products attached, may adhere to the lining of the lungs and decay with the release of alpha radiation directly to the lungs.

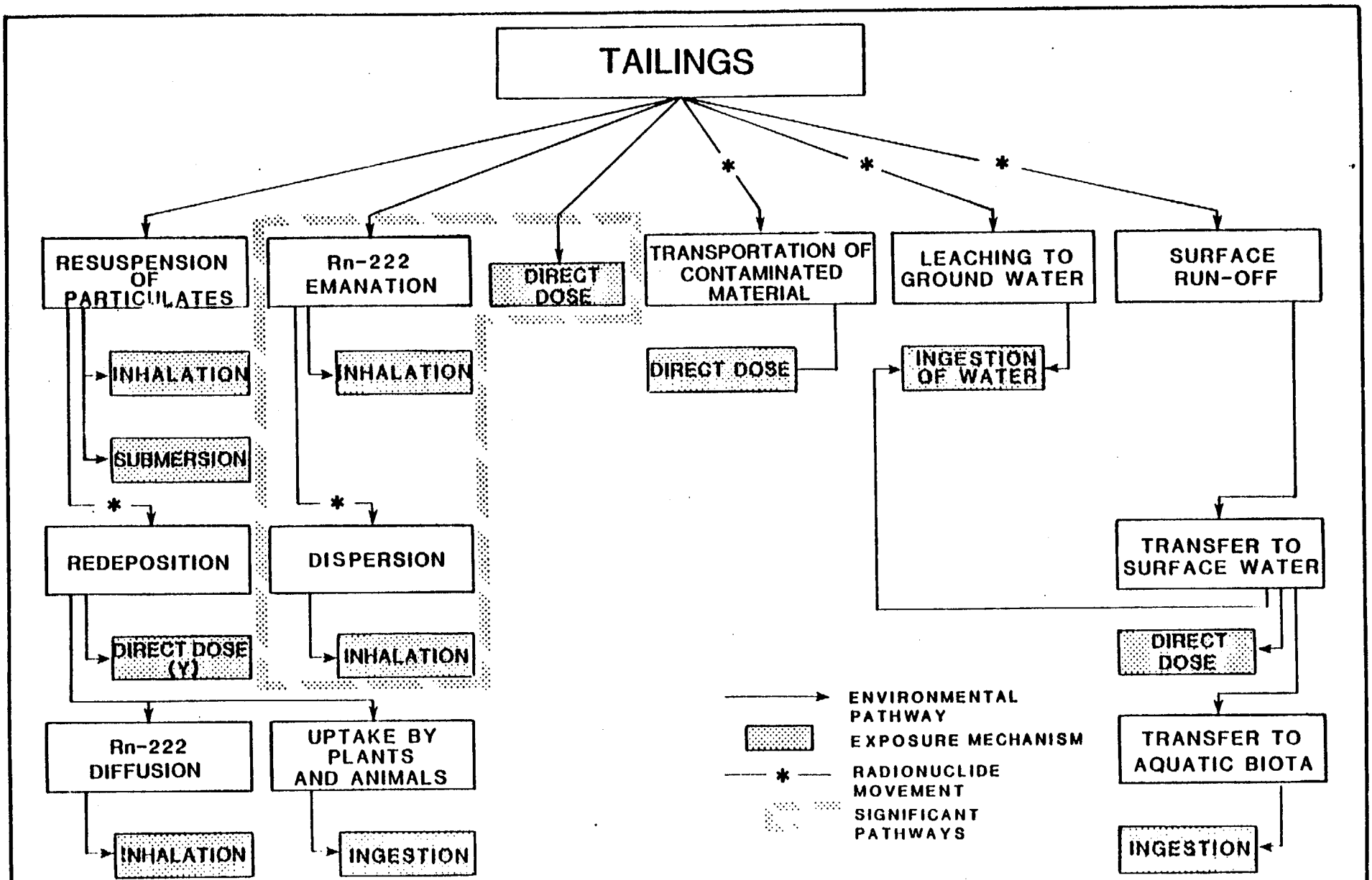

FIGURE 4.1

POTENTIAL RADIATION EXPOSURE PATHWAYS

TO THE GENERAL PUBLIC AND REMEDIAL ACTION WORKERS

Gamma radiation is also emitted by many members of the uranium-238 decay series. Gamma radiation behaves independently of atmospheric conditions and travels in a straight line until it impacts with matter. Gamma radiation emitted from the tailings delivers a dose to all parts of the body. Gamma radiation levels emitted from the tailings pile become negligible beyond 0.3 mile from the perimeter of the tailings due to the interaction of the gamma rays with matter in the air.

The general public and nearby workers are presently being exposed to radon daughters and direct gamma radiation from the existing tailings pile even though the pile has been partially stabilized. Radon is diffusing into the atmosphere where it is being dispersed by winds. Gamma radiation is being emitted from the tailings and slightly increases the gamma exposure rate to any person living or working within 0.3 mile of the tailings.

Following remedial action, there would be no exposure to direct gamma radiation since each alternative includes the construction of an earthen cover which gamma radiation could not penetrate. However, there would continue to be a small public exposure to radon and radon daughters following remedial action because the cover for each alternative would substantially reduce, but not eliminate, the release of radon. The tailings cover for each alternative would have a low permeability and thereby slow the rate of radon diffusion through the cover. Most of the radon would decay into solid daughter products before the radon could diffuse through the cover and enter the atmosphere. The rate of radon flux would be no greater than the allowable levels contained in the EPA standards (Appendix A, EPA Standards). This would result in a small lung dose to the nearby population as calculated in Section H.2.1, of Appendix H, Estimates of Health Effects of Radiation, with the health effects proportional to the size of the population.

Exposure to gamma radiation may cause genetic health effects in addition to somatic health effects (i.e., cancer). The genetic risk is approximately two-thirds of the somatic risk for gamma radiation and a genetic health effect in general may be considered less severe. Measures taken to reduce the somatic health effects would also reduce the genetic health effects. The health effects calculations in Appendix H, Estimates of Health Effects of Radiation, which are summarized here reflect only the somatic risk. The following sections discuss the excess somatic health impacts that would result for no action, during and after the implementation of each remedial action alternative, and the health impacts of construction-related accidents that might occur.

4.1.2 Health impacts

During remedial action

The estimates of excess somatic health effects (i.e., cancer) in this section are based on the procedures discussed in Section H.2 of Appendix H, Estimates of Health Effects of Radiation.

These procedures are based on realistic but conservative assumptions to estimate the level of excess health effects. Table 4.1 lists the estimated excess health effects that would occur for each alternative during remedial action.

During implementation of each of the alternatives except the no-action alternative, the exposure to the general population from the radiological pathways would increase as the tailings are disturbed on the site and as the tailings are transported to an alternate site. Remedial action workers would also be exposed to these pathways during remedial action.

The excess health effects to the general public and remedial action workers during remedial action are principally dependent on the amount of tailings and contaminated material to be moved, the distance the material is to be transported, and the number of people who live near the existing site. As presented in Appendix H, Estimates of Health Effects of Radiation, the increase in radon released from the tailings due to construction activities would be 1.7 times the radon released under no-action conditions. This results primarily from the removal of the present cover during remedial action. During construction, gamma exposure rate and airborne radionuclide particulate concentrations would be large compared to levels prior to remedial action. This is because gamma exposure rates would increase as the existing cover is removed and the tailings pile is excavated which results in direct exposure of more tailings primarily to remedial action workers. Airborne radionuclide particulate concentrations would increase from near-zero background levels to measurable levels caused by disturbance of the tailings.

The elevated gamma exposure rate primarily increases health effects to remedial action workers on the site but not to most of the general population. During remedial action for workers, the excess health effects from radon daughter inhalation would be approximately 60 percent of that from gamma exposure and the excess health effects from air particulate inhalation would be a maximum of 30 percent of that from gamma exposure. The excess health effects to remedial action workers account for approximately 70 percent of the total excess health effects during either remedial action alternative as presented in Table 4.1. The excess health effects to the maximally-exposed remedial action worker would be during remedial action at the Flynn Ranch alternate site and is estimated to be 0.48×10^{-4} excess health effects. This is equivalent to 0.0048 percent or one person out of 21,000 potentially suffering from excess health effects.

Inhalation of radon daughters is the dominant source term in the general population health effects calculation. The excess health effects to the general population account for approximately 30 percent of the total excess health effects during either remedial action alternative as presented in Table 4.1. The maximally-exposed individual living at 0.25 mile from the existing pile during remedial action for the Flynn ranch site would incur 0.055×10^{-4} estimated excess health effects, equivalent to 0.00055 percent or one person out of 180,000 people.

Table 4.1 Estimated excess health effects during remedial action[a]

Alternative[b]	General population radon daughter health effects	General population gamma health effects	General population radionuclide air particulate health effects	General population transportation gamma health effects	Remedial action worker radon daughter health effects	Remedial action worker gamma health effects	Remedial action worker radionuclide air particulate health effects	Total excess health effects
Collins Ranch site	0.00112	0.000010	0.000048	negligible	0.00087	0.00140	0.00044	0.0038
Flynn Ranch site	0.00133	0.000013	0.000048	negligible	0.00113	0.00185	0.00054	0.0049

[a]Appendix G contains a discussion of the methods and assumptions used to estimate these health effects.

[b]The no action alternative would result in 0.00081 excess health impacts per year.

As a comparison, an individual in the United States has a 16-percent chance of contracting cancer (NAS, 1980). An individual in Lake County has a risk of 3.4×10^{-4} per year of contracting lung cancer based upon cancer incidence data (Morton et. al., 1981). The excess health effects to an individual caused by the remedial action alternatives would therefore be a small fraction of the normal incidence rate.

Under no-action conditions for the general population, 0.00081 estimated excess health effects per year would occur, primarily from radon daughter inhalation, based on the current population distribution. This number of excess health effects is not directly correlated to the excess health effects listed in Table 4.1 because the excess health effects for the alternatives discussed are for the duration of the project: two years for Collins Ranch and 2.5 years for Flynn Ranch. The estimated excess health effects to a maximally-exposed individual living at 0.25 mile from the pile under no action conditions would be 0.031×10^{-4} excess health effects per year. This assumes a constant population distribution where no one eventually lives closer than 0.25 mile from the pile edge. Assuming a 70-year lifespan, the total risk to an individual would be 2.2×10^{-4} excess health effects or a risk of 0.022 percent. This is equivalent to one person out of 4,600 people potentially suffering from excess health effects.

The Collins Ranch alternative would result in 0.0039 total excess health effects during remedial action as presented in Table 4.1. Transportation health impacts to the general population would be negligible.

The Flynn Ranch alternative would result in slightly more estimated total excess health effects (0.0049) in comparison to tne Collins Ranch alternative. The increased health effects are due to a greater distance for movement of the material, which requires a longer time for remedial action and a greater number of remedial action workers. The total excess health effects resulting from the 2.5-year remedial action at the Flynn Ranch site would be equivalent to the excess health effects from six years under no-action conditions. Transportation health impacts to the general population would be negligible.

4.1.3 Hypothetical accidents

The Lakeview tailings contain radioactive elements in low concentrations that emit low levels of radiation. For any of the action alternatives, spillage of tailings resulting from a traffic accident involving a truck loaded with tailings would be cleaned up immediately and would therefore cause a short exposure time to persons living or working near the spill. Contractors working for DOE would be required to establish approved procedures for cleaning spills.

The only spill which could not be cleaned up would be one that occurs as a truck crosses a perennial stream or flowing ephemeral drainage. Relocation of tailings to either alternate site has the possibility of this occurring. However, the probability of such an accident is very low. In this case, much of the tailings could not be recovered but the concentration of radioactive elements, heavy metals, and ions from the small volume of spilled material would be rapidly diluted by the flowing waters and little or no health impacts would occur.

4.1.4 Health effects following remedial action

The procedures used to calculate the excess health effects following remedial action for each of the alternatives are discussed in Section H.3.4 of Appendix H, Estimates of Health Effects of Radiation. These procedures are based on realistic but conservative assumptions to estimate the level of excess health effects. Table 4.2 lists the estimated yearly excess health effects for each of the alternate sites following remedial action.

Following remedial action, the radon releases for each of the alternatives, except the no-action alternative, would be no greater than allowed by the EPA standards (Appendix A, EPA Standards). The design for each alternate site incorporates an earthen cover, which is placed to control erosion and water infiltration but also reduces the radon emanation to below the EPA standards.

The no-action alternative would result in the greatest yearly estimated excess health effects to the general population (0.00081 per year) which is at least 42 times greater than any other alternative following remedial action. These impacts would primarily occur because the tailings would not have a thick cover to inhibit radon emanation and the tailings pile would remain near the town of Lakeview. The excess health effects to the general population resulting from radon emanation would exceed those from gamma radiation by a factor of 62 for the no-action alternative.

The excess health effects calculations for the no-action alternative assume that the tailings would not be dispersed by natural erosion or man in the future; there is no way to accurately predict the level or rate of dispersion. However, as discussed in Section 4.5.1, dispersion would occur over time and the actual health effects from the no-action alternative might become greater than the 0.00081 per year as shown in Table 4.2.

The Collins Ranch alternative would result in 0.0000190 estimated excess health effects per year to the general population following remedial action. This site is relatively remote, but is close enough to the city of Lakeview to cause estimated excess health effects from the small increase in radon concentrations.

The Flynn Ranch alternative would result in 0.0000006 estimated excess health effects per year following remedial action. This site is the most remote alternate site. Under the existing

Table 4.2 Yearly estimated excess health effects following remedial action[a]

Alternative	General population radon daughter health effects per year	General population gamma health effects per year	Total health effects per year
No action	0.0008000	0.000013	0.0008100
Collins Ranch site	0.0000190	0	0.0000190
Flynn Ranch site	0.0000006	0	0.0000006

[a]Appendix H contains a discussion of the methods and assumptions used to estimate these health effects.

- population distribution there are very few people in the vicinity of the site, (the nearest year round resident resides 4.75 miles away) therefore the excess health effects are negligible. If a person lived at 0.25 mile from the Flynn Ranch site, the risk to that maximally-exposed individual would be 0.000038 excess health effects over a 70-year lifespan, equivalent to 0.0038 percent or one person out of 29,600 people. The risk to this individual would be a factor of 6.5 lower than the risk to an individual who lived at 0.25 mile from the existing site under no-action conditions.

Table 4.3 lists the estimated excess health effects for each alternate site that would occur 5, 10, 100, 200, and 1000 years following remedial action. This table adds the health effects that would occur during remedial action to the integrated yearly health effects following remedial action. It should be noted that the data in Table 4.3 reflect a stable population, assuming that the population in the vicinity of each site remains constant. The yearly excess health effects for any site would vary with changing population distribution around that site.

4.2 AIR QUALITY

The air quality impact analysis was conducted by defining all clearing, loading, hauling, unloading, covering, and reclamation activities associated with each relocation alternative. Preliminary calculations demonstrated that engine (i.e., combustion) emissions associated with clearing, loading, unloading, covering, and reclamation would be minimal (see Appendix C, Weather and Air Quality, Table C.1.8). Likewise engine emissions from hauling were estimated to be insignificant.

Preliminary calculations indicated that particulates generated during remedial action may be in the highest concentrations, therefore, modeling emphasis was placed on fugitive dust. Clearing and grubbing activities are of short duration compared to hauling and have less chance of coinciding with days of high background concentrations. Hauling at and near the loading/unloading sites has the highest potential for continuous air quality impacts. For this reason roads in the proximity of the Lakeview site, Collins and Flynn Ranch disposal sites, and borrow sites were modeled.

Fugitive dust emissions from loading and unloading were estimated to be approximately 0.003 pounds per cubic yard (cy) when uncontrolled. Fugitive dust from hauling was estimated to be approximately 2.8 pounds per cubic yard-mile. Clearing and grubbing activities generate approximately 60 pounds per hour of fugitive dust at each site. Each of these emissions can be reduced by 50 percent by water application. All analysis in this section assume the use of water for dust control.

Modeling of project-related 24-hour total suspended particulates (TSP) increments was based on the use of the Industrial Source Complex Dispersion Model for short-term applications (ISCST). This model is described in further detail in Appendix C, Weather and Air Quality. The ISCST model is particularly appropriate for an application of this type

Table 4.3 Total estimated excess health effects[a] 5, 10, 100, 200, and 1000 years following remedial action

Alternative	Number of years following remedial action				
	5 years	10 years	100 years	200 years	1000 years
No action[b]	0.0041	0.0082	0.082	0.16	0.81
Collins Ranch site	0.0039	0.0040	0.0057	0.0076	0.023
Flynn Ranch site	0.0049	0.0049	0.0050	0.0050	0.0055

[a] These estimates assume that the population in the vicinity of each site remains constant and includes the health effects during remedial action.

[b] The calculations for no action assume the tailings are not dispersed by natural forces or by man because there is no way to accurately predict the level or rate of dispersion. However, if the dispersion could be predicted and were factored in to the above estimates, the health effects for the no-action alternative would greatly increase.

since it considers dry deposition and can also accommodate large area emission sources such as trucks traveling on haul roads. The emissions used as inputs to the model are presented in Appendix C, Weather and Air Quality, and correspond to the activities which produce the maximum emission rate.

Table 4.4 presents the highest 24-hour TSP concentrations near each site. The receptor points for which impacts are described in Table 4.4 are located at approximately 2000 feet from the roadway. Receptor points closer to the roadway would be unduly influenced by "saltation," (i.e., the physical displacement of moderately large particles) and would not clearly depict the suspension of fine particles that can be transported by light winds. A receptor was also identified in the model located approximately one kilometer southeast of the tailings site in the city of Lakeview to measure the possible impact on the local population.

Table 4.4 also shows the maximum TSP concentration expected if any of the sites had an ambient background concentration equal to the highest 24-hour levels recorded at Klamath Falls (216 microg/m^3) or Cedarville (112 microg/m^3). The Federal secondary standard of 150 microg/m^3 would be exceeded at each activity site (existing tailings site, disposal site, borrow site, and in the city of Lakeview) for both action alternatives. The Federal primary standard of 260 microg/m^3 would be exceeded for both action alternatives if Klamath Falls data are used to characterize current background conditions at Lakeview, because of the high ambient background concentrations at Klamath Falls. However, as stated in Section 3.4, ambient conditions at Cedarville, California are considered more likely to resemble conditions at Lakeview than ambient conditions at Klamath Falls. Using the Cedarville baseline data, under the Collins Ranch alternate, the Federal primary standard would be exceeded at the Lakeview tailings site and at the Collins Ranch disposal site. The primary standard would be approached (but not exceeded) at the borrow site proposed for use under the Collins Ranch alternate; levels in the city of Lakeview would be well below the Federal primary standard.

Using the Cedarville background data, under the Flynn Ranch disposal alternate, 24-hour TSP concentrations would not exceed or approach the Federal primary standard.

In summary, incremental 24-hour TSP concentrations would be somewhat less at the Lakeview site if the tailings are relocated to the Flynn Ranch alternate disposal site rather than to the Collins Ranch site. This is due primarily to the fact that the distance between removal and disposal sites is greater for the Flynn Ranch alternative and fewer trips per day are possible given the same equipment and work schedule. (A smaller number of trips per day would result in lower daily emissions and thus lower 24-hour TSP concentrations).

The total tonnage of dust emitted would be substantially less for the Flynn Ranch alternate than for the Collins Ranch alternate because of the increased use of paved roads under the Flynn Ranch alternate. Disposal at either site would cause the Federal secondary 24-hour TSP standard to be exceeded at points 2000 feet from the roadway. The Federal primary 24-hour TSP standards could be exceeded under the Collins Ranch alternate if actual background levels exceeded 56 microg/m^3; under the Flynn Ranch

Table 4.4 Projected air quality (microg/m^3)

Site	Predicted 24-hour	Project maximum added to Klamath highest 24-hour (avg)	Project maximum added to Cedarville highest 24-hour (avg)
Collins Ranch site			
Lakeview tailings site	152	368	264
Disposal site	204	420	316
Borrow site	136	352	248
City of Lakeview (1 km southwest of tailings site)	94[a]	310	206
Flynn Ranch site			
Lakeview tailings site	85	301	197
Disposal site	115	331	227
Borrow site	77	293	189
City of Lakeview (1 km southeast of tailings site)	56[a]	272	168

[a]Four days per year or less.

alternate, the Federal primary standard would not be exceeded unless actual background levels exceeded 145 microg/m^3.

Neither alternative would cause air quality problems in the city of Lakeview because of the predominant southerly winds. The annual TSP standards of 75 and 60 microg/m^3 (primary and secondary, respectively) would not be exceeded anywhere under either action alternative.

It should be noted that the modeling used in this analysis is conservative, and assumes that there is a simultaneous occurrence of high impact from hauling emissions (due to low wind speed and limited mixing) and high ambient background concentrations of particulates (which are probably wind generated and occur only during periods of high winds and strong mixing). The lack of extensive on-site meteorological and air quality data preclude a refinement of the predicted impacts.

4.3 SOILS

Both of the relocation alternatives would result in the temporary disturbance and permanent loss of soils. Disposal at the Collins Ranch site would require use of materials excavated from the disposal site itself and from the borrow site two miles away. For disposal at the Flynn Ranch alternate site, borrow materials would be obtained from a quarry on or adjacent to the disposal site. Additional materials would be obtained from the Flynn Ranch borrow site (to the north) as required. Borrow sites for both action alternatives have already been disturbed previously as sources of fill material, and no new disturbance would be required for either of the relocation alternatives.

Either relocation alternative would require the temporary disturbance of 30 acres of soils at the existing processing site for use as a construction staging area. An additional 115 acres of soils would be permanently lost due to excavation of contaminated soils to varying depths.

Disposal of the tailings at the Collins Ranch site would result in the temporary disturbance of 26 acres of soils at the disposal site for a construction staging area. Thirty-nine acres of soils would be permanently lost by construction of a site access road (25 acres) and by the emplacement of the stabilized pile and surrounding drainage ditch and maintenance road (14 acres).

The no-action alternative would result in the continuing contamination (with radium-226) of soils adjacent to the tailings site due to dispersion of the tailings by wind and water erosion. The rate of this continuing contamination cannot be accurately quantified, but eight acres of soils have been contaminated to the present time.

Disposal of the tailings at the Flynn Ranch site would result in the temporary disturbance of 61 acres of soils for a construction staging area. Additionally, 35 acres of soils would be permanently lost as a result of roadway construction to access the site (16 acres) and by emplacement of the stabilized pile and surrounding drainage ditch and maintenance road (19 acres).

For either relocation alternative, the areas disturbed during the cleanup of contaminated soils at the tailings site and adjacent to the final stabilized embankment would be reclaimed, recontoured with a suitable plant growth medium, and revegetated. Similar reclamation measures, including contouring and revegetation, would be performed at the borrow sites in accordance with the borrow permits issued for the sites.

4.4 MINERAL RESOURCES

All of the alternatives, except no action, would result in the consumption of borrow materials (clay, sand, rock, and gravel). Disposal at the Collins Ranch site would require approximately 487,000 cubic yards of material. Disposal at the Flynn Ranch site would require approximately 495,000 cubic yards of material. The no-action alternative would not require the use of borrow materials.

The consumption of borrow materials from local sources would have a negligible impact on the availability and cost of these resources in the region as all of these materials are commercially available in large quantities throughout the Lakeview area. Relocating the tailings to either alternate site would preclude access to sand or rock deposits underlying either disposal site. Access to sand and rock deposits beneath the existing tailings pile would be restricted by selection of the no-action alternative. Regardless of the alternative selected, no impact on availability of sand and gravel resources in the region is expected.

Neither of the relocation alternatives would have any impacts on other mineral resources in the area. Known deposits of mercury in the Goose Lake Basin would not be affected by the remedial action. Geothermal resources of potential commercial value exist along the east side of the Goose Lake Basin. Relocation of the tailings would improve access to these resources. Geothermal resources of commercial value do not exist at either alternate site. There are no mining claims on file for either of the alternate disposal sites.

4.5 WATER

4.5.1 Surface water

Section 4.5.1 describes the potential surface-water impacts from each remedial action alternative and summarizes water use during each remedial action alternative. Additional details are provided in Appendix D, Hydrology.

Disposal at the Collins Ranch site

During remedial action, the cover and restoration excavation and relocation of the contaminated materials would result in surface disturbance. Runoff from these disturbed areas could likewise be contaminated. Also, contaminated waste water would be generated by activities such as the washing of equipment. The

remedial action design includes the construction of drainage controls and a retention pond(s) during disposal site preparation to prevent the discharge of contaminated water from the site. The contaminated water would be retained for evaporation or use in the compaction of the tailings and contaminated materials.

After remedial action, surface runoff created by intense rainfall could cause erosion of the stabilized tailings pile which could result in the transport of contaminants into local surface waters. Several control features were incorporated into the remedial action design to prevent erosion of the stabilized pile and subsequent contamination of adjacent surface waters. The sideslopes of the pile would be limited to five horizontal to one vertical (20 percent), and the top of the pile would be gently crowned (three percent). These shallow slopes would promote drainage from the pile with non-erosive flow velocities. Permanent drainage ditches would direct surface flows around and away from the embankment.

The rock erosion protection barrier placed on the top and sideslopes (two feet thick) of the pile is designed to withstand the erosive forces of severe rainfall events such as a Probable Maximum Precipitation (PMP). The drainage ditches would also be lined with erosion protection material designed to withstand the PMP occurring on the drainage area above the site. This PMP would generate sheet flow rates ranging from 0.30 to 0.60 cubic feet per second per foot (cfs/ft) of slope width on the pile. Details on the rock erosion protection are contained in Appendix B, Site Conceptual Design.

During processing site preparation, appropriate measures would be taken to prevent discharge of contaminated water from the site. As with the disposal site preparation, these measures would include construction of drainage controls and a retention pond(s). A waste-water treatment facility would also be installed and operated.

Also included in processing site preparation is the relocation of Hammersley Creek, which flows north of the present tailings pile (see Section 3.6.1), to a lined channel south of the designated site boundary. After remedial action, the site would be restored to present elevations and graded in order to promote drainage south to Hammersley Creek and west to East Branch Thomas and Warner Creeks. Hammersley Creek would remain in the lined channel south of the site (DOE, 1985b).

No action

The no-action alternative would result in the continued exposure of the tailings pile to erosion from surface runoff. The present cover on the pile was not designed to provide protection against sheet and gully erosion created by severe rainfall events. Eventual erosion of the present cover would result in the transport of contaminants from the tailings pile into local surface waters.

While the potential effects of flooding and stream meander have not been completely assessed, it is likely that the pile would be affected by either event due to the location of the tailings with respect to Hammersley Creek, Warner Creek, or the East Branch of Thomas Creek.

Disposal at the Flynn Ranch site

Both during and after remedial action, the Flynn Ranch alternate would incorporate the same erosion protection measures as the Collins Ranch alternate to prevent the release of contaminants from the sites and to assure the long-term stability of the stabilized tailings pile. These measures would include: construction of drainage controls and evaporation ponds at both the tailings and disposal sites; placement of a rock erosion protection barrier over the stabilized pile; and grading of the area around the stabilized pile to divert surface runoff around and away from the pile.

Flooding and river meander are not stability considerations for the Flynn Ranch alternate because of the disposal site's distance from (approximately 1.1 miles) and elevation above (approximately 220 feet) the closest perennial stream.

The effects of remedial action on surface water at the processing site would be the same for the Flynn Ranch alternative as for the Collins Ranch alternative.

Borrow sites

During remedial action, appropriate drainage controls would be used at both borrow sites in order to minimize or prevent erosion and any corresponding surface-water impacts. After remedial action, the site would be reclaimed according to the applicable requirements to control erosion.

Water use

Table 4.5 lists the anticipated water consumption for each remedial action alternative. Water would be used by remedial action workers for personal consumption and cleanup, watering haul roads, the compaction of the tailings and cover, and for washing equipment. Water is available from a variety of sources including municipal water, installation of shallow water wells, and surrounding lakes. The sources of the water would be determined by the Remedial Action Contractor.

Table 4.5 Water consumption during remedial action

Remedial action alternative	Gallons consumed
Collins Ranch	19,847,000
Flynn Ranch	13,264,000

4.5.2 Ground water

Disposal at the Collins Ranch site

During the relocation of the tailings to the Collins Ranch site, there would be no impacts to the ground water. The excavated and contoured disposal area on the western slope of Augur Hill would not encounter any saturated formations. Under the proposed design, the base of the tailings rests 20 feet above the current ground-water levels beneath the site. In the event of extreme water level rises following spring snow melt in the Fremont Mountains, the site design would incorporate a chimney drain to direct ground-water flow lines away from the stabilized material.

Impacts to ground water at the Lakeview tailings site may result from excavation of the contaminated materials due to the shallow position of ground water at the site. Any increase in the release of contaminants would be only for a short duration until all materials were removed. Some dewatering of the shallowest saturated zones may be necessary and the design feature of a water treatment facility should prevent the release of intercepted contaminated ground water.

After remedial action, impacts to ground water at the Collins Ranch disposal site would be minimal. The one foot clay cover design should further reduce the naturally low site infiltration rate or potential leaching mechanism. Potential for leaching by ground-water inundation at the base of the pile is low, as discussed in Appendix D, Hydrology, Section D.2.7.1. Predicted rates of radionuclide and heavy metal migration to the ground water are discussed in Appendix D, Hydrology, Section D.2.6.3, and are on the order of 10^3 to 10^6 years.

Seasonal fluctuation in ground-water levels will continue to be monitored through at least June, 1985. Should seasonal fluctuation in the ground-water level show an upward migration of ground water beyond levels anticipated, a capillary break layer, consisting of a two-foot layer of graded sand and gravel, would be constructed.

Removal of the source of contamination from the Lakeview processing site should eliminate contaminant generation from leaching. The existent contamination would continue to migrate downgradient with concomitant dilution and attenuation effects. Active aquifer restoration measures could also be employed to reduce contaminant levels in the aquifer.

Disposal at the Flynn Ranch site

During the relocation of tailings to the Flynn Ranch site there would be no impacts to the ground water. The partially below-grade disposal area would be excavated to a depth of approximately seven feet and depth to ground water is beyond 150 feet. Impacts at the Lakeview tailings site would be similar to those

under the disposal option at Collins Ranch both during and after the remedial action.

After remedial action, the impacts to the ground water at the Flynn Ranch site would be minimal to non-existent for a time period of hundreds of years due to the slow rate of partially saturated flow and the depth beyond 150 feet where ground water may be encountered.

Aquifer restoration

Relocation of the tailings and contaminated material to either disposal site would remove the source of any future contamination of the shallow aquifer at the Lakeview site. The natural movement and discharge of the ground water in the aquifer would eventually reduce the concentrations of the contaminants to background levels. Due to the naturally slow movement of ground water and sometimes slow geochemical reaction rates to the attainment of chemical equilibrium, aquifer restoration could be implemented to accelerate the natural flushing process and the removal of soluble contaminant species. A decision on whether to perform aquifer restoration will be made following additional data collection and analysis.

Ground-water data collection and analysis continues in the vicinity of the former Lakeview processing site in an effort to answer questions on the source of ground-water contamination. Stable isotope analysis testing will be performed on the samples to identify the sources of ground-water contamination, i.e., geothermal or leaching through the pile. Ground-water contamination resulting from geothermal activity will not be corrected as a part of this remedial action. Ground-water contamination attributed to leaching of the existing tailings pile, in the event it has occurred, would be examined to determine if restoration is necessary.

Aquifer restoration is generally very costly in comparison to ground-water protection techniques such as physical containment. The selection of an optimum restoration method must consider the criteria of technical feasibility, effectiveness, and cost; these criteria are governed by the volume of the contaminated ground water and the ability to remove and treat that volume of water. The evaluation of aquifer restoration must also consider the present and future use of the contaminated ground water and the possible development of other water sources to replace the contaminated ground water.

This last criterion becomes important in the evaluation of aquifer restoration at the Lakeview site. There is no present use of the shallow aquifer within the extent of measured contamination. However, there is water use by domestic and irrigation wells that tap multiple aquifers generally to depths of 200 feet surrounding the site area. Additional ground-water data collection and analyses are being conducted to determine whether the

deeper aquifer investigated in the field program (75 feet) is being contaminated by vertical movement of shallow contaminated ground water or if the natural geothermal water in the area is responsible for notably higher levels of sulfate and TDS reported in the deeper zone downgradient of the site. Upon completion of this data collection and analyses, the need for aquifer restoration can be determined and an optimum restoration method can be selected if necessary. A major consideration in addition to the additional analyses is the naturally elevated levels of arsenic, fluoride, and boron noted in geothermal ground water. This natural phenomenon may preclude the development of this local ground water for major domestic and irrigation use.

4.6 IMPACTS ON PLANTS AND ANIMALS

The temporary loss of vegetation, habitat for wildlife, and grazing acreage for livestock are potentially the greatest impact to plants and animals due to remedial action. Surface disturbance caused by the excavation of contaminated soils, the construction of haul roads, staging areas, borrow sites, and a new disposal facility require the temporary disturbance of from 245 to 282 acres.

Vegetation losses can be based on range site production figures to determine the land's productivity or animal carrying capacity.

Wildlife effects can be divided into four basic types of impacts: short-term disturbance; short-term loss of habitat; short-term direct mortality, and long-term loss of habitat.

The short-term disturbance impacts would result from intensive levels of activity by workers and heavy equipment and resultant noise levels. Short-term habitat loss (both actual and effective) would last only during the relocation process. After the tailings relocation has been completed, disturbed areas would be reclaimed. Over the long run, there would be limited habitat loss due to permanent access roads and restricted use limitation. Short-term direct mortality may impact both small and large species.

Impacts to nearby aquatic systems are anticipated to be limited. During remedial action, impacts to nearby streams from increased sedimentation would be minimized through use of sediment control devices such as evaporation ponds, mulch or hay bales, fabric fences, and the like. No long-term impacts would occur.

Collins Ranch site

Relocation to the Collins Ranch site would directly impact approximately 245 acres. This includes surficial disturbance to the existing tailings site, road construction and up-grading, and preparation of the actual disposal site. Of the total area disturbed, the only permanent loss of habitat would be the access roads to the disposal site. Construction staging areas and the borrow site would be reclaimed and revegetated.

Vegetative production figures for the Collins Ranch site depend on the specific survey site affected. Range sites in a good condition class vary from a low productivity of 30 to 100 lbs per acre for the Stony Terrace range site to a high of 500 to 3000 lbs per acre for the Well Drained Bottom range site. Carrying capacity or stocking rates for cattle correspondingly vary from 8 to 25 acres per AUM for Stony Terrace to 0.25 to 1.5 acres per AUM for the more productive Well Drained Bottom range site. This impact would be of short duration since the site would be revegetated.

The wildlife impacts vary. The short-term disturbance impacts would most likely affect furtive species such as big game, raptors, and upland game, which are highly mobile and thus would tend to avoid the disturbed locales and surrounding buffer zones of up to 0.5 mile. Small birds, some reptiles, and small mammals would also be displaced during the relocation process, but with smaller buffer zones.

The short-term habitat loss would be limited predominantly to the construction phase of this project.

The sensitivity of big game, raptors, and gamebirds to increased levels of human activity would result in an effective short-term habitat loss greater than the actual area to be affected.

Short-term direct mortality could affect small mammals, reptiles, and songbirds', eggs or nestlings located within the area of activity. Mortality of larger species is also possible as a result of increased traffic volumes along the haul routes and the potential for animal-vehicle collisions.

Long-term loss of habitat would be limited primarily to the access road approaching the disposal site. The revegetation plan would reopen the area for grazing, but the forage capacity of the site would be limited by the plant succession allowed.

The proposed remedial action planned for the Collins Ranch site and the actual tailings pile design are planned to maximize the integrity of the disposal site. The proposed rock cover (beneath the rock-soil matrix) is designed to limit burrowing animal invasion. The impact of this design may limit the suitability of the area for burrowing animals and subsequently the number of predators in the area.

No impacts to threatened or endangered species would occur.

No action

Implementation of this alternative would have no impacts on the plants and animals or their habitat.

Flynn Ranch site

Relocation within the Flynn Ranch site would directly impact approximately 282 acres. This includes surficial disturbance to the existing tailings site, road construction and upgrading, and the preparation of the

actual Flynn Ranch site. Of the total area disturbed, the only permanent loss of land would be the access road to the disposal site. Construction staging areas and the borrow sites would be reclaimed and revegetated.

Vegetative production figures for the Flynn Ranch site depend on the specific sites affected. Production figures for the range sites in a good condition class vary from a low of 30 to 100 lbs per acres for the Stony Terrace range site to a high of 250 to 700 lbs per acre for the Rolling Hills range site. Carrying capacity or stocking rates for cattle correspondingly vary from eight to 25 acres per AUM for Stony Terrace to one to three acres per AUM for the more productive Rolling Hills range site.

Revegetation of both areas following completion of the project would mitigate this loss of productivity.

The wildlife impacts are similar to those for the Collins Ranch site. The short-term would be slightly higher due to the increase acreage of this alternative. The same is true for short term habitat loss. The short-term direct mortality would also be higher. This as a result of the disturbance of a larger acreage and also the increased hauling distance to the Flynn Ranch site.

The vegetative cover and plant succession allowed at the Flynn Ranch site would be similar to that of the Collins Ranch site. Vegetative growth would be limited to ensure the integrity of the tailings pile.

No impacts to threatened or endangered species would occur.

4.7 LAND USE

The following section describes the impacts of the various remedial action alternatives on land use in the Lakeview area. More detailed information is provided in Appendix G, Land Use and Socioeconomics.

To meet Lake County land use requirements, a change in the current A-2 zoning of either the Collins Ranch or Flynn Ranch sites would be required. This is because of the County's A-2 designation is an Exclusive Farm Use Zone and mill tailings disposal is a land use not provided for in Exclusive Farm Use Zones. Selection of an alternate disposal site would require obtaining a rezoning of the site to be obtained from the Lake County Planning Commission. This would require a formal application and a Public Hearing before the Commission.

Collins Ranch site

Relocation to the Collins Ranch site would permanently restrict the use of 20 acres to agricultural (grazing) purposes. Once the disposal site has been revegetated, it would be opened for restricted use. The current tailings site would be released for any use consistent with Lake County zoning restrictions. A long-term surveillance and maintenance plan would be implemented to control future land use.

No action

The no-action alternative would have no effect on current land uses; however, the current 30-acre tailings site would not be available for further development. In addition, the possibility exists for the future degradation of the existing site and a subsequent misuse in the restricted area.

Flynn Ranch site

Relocation of the tailings pile to the Flynn Ranch site would permanently restrict the use of 27 acres of land for agricultural use. Once the site was revegetated, the area would be opened for grazing. The current tailings site would be released for any uses consistent with Lake County zoning restrictions. A long-term surveillance and maintenance plan would be implemented to control future land use.

Borrow sites

Both areas selected for borrow sites have been used as sources for borrow materials before. The area of the borrow site would be increased, but the site would be reclaimed following completion of the project. Both areas would be available for future use as sources of borrow materials.

4.8 IMPACTS ON NOISE LEVELS

Noise impacts were estimated for the proposed remedial action alternatives. For both action alternatives, the major noise-producing sources would be the heavy-duty construction equipment used at the sites and the trucks used to haul tailings and borrow materials. Typical sound levels generated by the type of equipment used in the action alternatives are presented in Table 4.6.

A noise prediction model (Kessler et al., 1978) was used to estimate the maximum A-weighted sound level emitted from each of the sites during the remedial action. The model is based on the numbers and types of equipment operating on the site, usage factors for operation in the noisiest modes, and the distance from the activity to the nearest noise-sensitive receptors. The model tends to overpredict noise levels since it assumes a clustering of equipment. In reality, the equipment would be located over a number of acres. The model is based on actual field measurements of construction equipment and is derived from the equation:

$$Leq = 10 \log \sum_{i}^{n} (UF_i)(n_i)(10^{L_{P_i}}/10)$$

where

Leq = average noise level of all equipment

UF_i = usage factor of equipment type i

Table 4.6 Sound levels for equipment used for remedial action at Lakeview and alternative borrow sites

Equipment	Maximum sound level at 50 feet (dB)
D-8 bulldozer	88
Front-end loader	85
Scraper	87
Water truck	89
Haul truck	86
Compactor	87
Grader	83

Ref. Kessler et al., 1978.

n_i = number of units of equipment type i

LP = maximum sound level of equipment type i

The maximum equivalent sound (Leq) predicted by the model at the Lakeview site resulting from remedial activities is approximately 94 dBA (decibels as measured on the A-weighted scale) at a location 50 feet from the center of activity. The Lakeview site is considered to be worst case in terms of noise impact, regardless of the alternative, because ambient noise levels are highest there. The nearest residences to the Lakeview site are approximately 2100 feet distant. Project noise emissions would be attenuated by 23 dBA over this distance, resulting in a 66 dBA noise level at the nearest housing area. These sound levels are greater than the EPA recommended level for outdoor activity and annoyance of 55 dB(L_{dn}) but less than the 70 dB(L_{eq}) level established for the protection of hearing (EPA, 1974). (For purposes of comparison in this particular application, Leq and Ldn are essentially identical).

Collins Ranch site

Maximum equivalent sound levels projected to result from the proposed remedial action at the Collins Ranch are 94 decibels (dB). Other than the remedial action workers, who would be required to wear hearing-protection devices, no noise receptors (i.e., residence) would be located near enough to be affected by the elevated noise levels.

There would also be noise produced by the haul trucks traveling between the various sites. Noise produced by the trucks can be expected to be approximately 85 dB at a location 50 feet removed from the roadway. Such levels would be annoying to those along the transportation routes, but the elevated noise level occurrences would be extremely brief in duration at any single location as the trucks pass by.

No Action

The no-action alternative would have no impacts on noise levels.

Flynn Ranch site

Maximum equivalent sound levels projected to result from the proposed remedial action at the Flynn Ranch are identical to the Collins Ranch site. Similar noise abatement devices would be required for remedial action workers at this site.

Noise impacts from truck traffic transferring the tailings would reach the same level of intensity but should be less frequent due to fewer total number of vehicle trips per day.

Borrow sites

The maximum equivalent sound level projected to result from borrow site activity would occur at the Flynn Ranch Borrow site and is estimated to be 93 dB.

It is not expected that any noise sensitive receptors (i.e., residences) would be located near enough to either site to be affected by this activity. Remedial action workers will be required to use hearing-protection devices.

4.9 IMPACTS TO SCENIC, HISTORIC, AND CULTURAL RESOURCES

Impacts to scenic resources

Disposal of the tailings at either alternative site would cause the views across the selected disposal site to be changed due to the straight lines of the final tailings cover configuration.

Collins Ranch site

Visual impact at the Collins Ranch site would be minimal due to its location. Nestled in a bowl area on the back side of Augur Hill, the site is not visible from the highway. The site might be visible from higher elevation points in the Fremont National Forest to the west, but visual impact should be minimal.

No action

The no-action alternative would have no impact on scenic resources.

Flynn Ranch site

Land user visual sensitivity is slightly higher with the Flynn Ranch site due to the location of the site within the viewshed of County road 3-13. This would potentially be noticeable to southbound traffic and could be mitigated with the vegetation media selected.

Borrow sites

Activity at either borrow site would be visible from area roads due to the proximity of the sites to transportation corridors. Excavation at the borrow sites would alter the elements of color, contrast, and texture until surface reclamation was complete.

Impacts on historic and cultural resources

No sites currently listed on the National Register of Historical Places would be impacted by any of the alternatives. Impacts to historic

sites in the town of Lakeview as a consequence of vicinity property decontamination may occur, but are unlikely. A complete assessment of these potential impacts cannot be completed until a decision is made to include specific vicinity properties in cleanup activities. Once the specific vicinity properties requiring remedial action are identified, the Oregon State Historical Preservation Officer (SHPO) will be contacted to determine if any of the properties are eligible for registration in the National Register of Historic Places.

Collins Ranch site

A Class III archaeological survey has been completed for the Collins Ranch site. No significant archeological sites were identified (Winthrop and Winthrop, 1985).

The Northern Paiute Indians from the Ft. Bidwell Indian Reservation have expressed concern about relocating the uranium tailings to this site, and its potential impact in conflicting with contemporary use by Native American Indians. The final Collins Ranch site is estimated to impact only approximately 20 acres and therefore the impact is considered minimal.

No action

The no-action alternative will have no impact on historical or cultural resource.

Flynn Ranch site

A Class III archaeological survey has been completed at the Flynn Ranch site and no significant archeological resources were identified (Winthrop and Winthrop, 1985).

Northern Paiute Indians from the Fort Bidwell Indian Reservation have expressed concern that this alternate site would adversely affect traditional and contemporaneous Indian use of the Drake Peak area (Bellon, 1984a). The tribe indicates that the action may interfere with the utilization of animals, plants and insects which are essential to the spiritual and traditional Indian values. Bellon further states that "desecration of sacred sites and cultural resources near these mountains (Drake Peak and Hart Mountain) would be equivalent to the destruction of sacred places important to believers of the major world religions" (Bellon, 1984b).

Remedial action at Flynn Ranch would directly affect approximately 282 acres, including reclaiming the current tailings site in Lakeview. This is much less than one percent of the approximate 5,000 square miles of aboriginal territory of the Gidutikad Band of the Northern Paiute Indians. Most of this disturbance would be on a temporary basis although revegetation would be accomplished with grasses rather than existing vegetation.

Borrow sites

Two historical sites near the Collins Ranch borrow sites, a dugout and trash dump, were identified during the archaeological survey of the Collins Ranch area. Although not directly affected by this alternative, indirect impacts to the historic sites may be caused by improved access roads and subsequent vandalism of these features.

No significant finds were identified at the proposed Collins Ranch borrow site.

No archaeological survey of the proposed Flynn Ranch borrow was completed due to the area not being identified at the time of the survey. Should remedial action occur at the Flynn Ranch site, a Class III Archaeological survey would be completed. Archaeological sites identified at this burrow site that are deemed to be significant by the State Historic Preservation Officer (SHPO) would be avoided if feasible. Significant sites that could not be avoided would be studied further, excavated (if necessary), and salvaged to maximize the recovery of archaeological data. Mitigation by avoidance, fencing, excavation, or salvage would be determined in consultation with the SHPO and the surface land owner.

4.10 IMPACTS ON POPULATION AND WORK FORCE

The following section describes the impacts of the two remedial action alternatives on the Lakeview area's population and workforce. More detailed information is provided in Appendix G, Land Use and Socioeconomics.

Collins Ranch

Tailings disposal at Collins Ranch would involve an average workforce of 70 workers over a 24-month period; the peak workforce would involve 81 workers. An estimated 56 of the 70 workers needed on average would reside within commuting distance of Lakeview. Direct project employment-related inmigration is estimated at 14 individuals. A total of 31 indirect jobs would be created; it is assumed that the indirect jobs would be taken by Lake County residents.

The creation of 101 new jobs for a 24-month period and would result in a total temporary population increase of 29. This would represent a 0.4 percent increase in the Lakeview County population and 0.4 percent increase in Klamath County - Lake County employment over 1982 levels.

No action

The no-action alternative would have no impacts on the local population or employment base.

Flynn Ranch site

Tailings disposal at Flynn Ranch would involve an average workforce of 73 workers over a 30-month period; the peak workforce would involve 79 workers. An estimated 59 workers of the average workforce would be cur-

rent residents of Lake County or residents of areas outside Lake County but within commuting distance of Lakeview (i.e., Klamath Falls). Direct project employment-related inmigration is estimated at 14 individuals. A total of 32 indirect jobs would be created; it is assumed that the indirect jobs would be taken by Lake County residents.

The creation of 105 new jobs for a 30-month period and would result in a total population increase of 29. This would represent a 0.4 percent increase in the County population and a 0.4 percent increase in Klamath County - Lake County employment over 1982 levels.

4.11 IMPACTS ON HOUSING, SOCIAL STRUCTURE, AND COMMUNITY SERVICES

The following section describes the impacts of the remedial action alternatives on the Lakeview area's housing, social structure, and community services. Appendix G, Land Use and Socioeconomics, contains more detailed information.

The impact for both action alternatives is quite similar with respect to housing, social structure, and community services.

Housing

The Collins Ranch and Flynn Ranch disposal alternatives would each bring 14 workers into Lake County. Given a 1980 housing stock in Lake County of 3,326 units with a vacancy rate of 10.1 percent, plus an additional 195 hotel/motel units in Lakeview, negligible impacts would be expected on the local housing situation under either alternative. Any impacts would likely be seasonal.

No action

The no-action alternative would have no impacts on local housing.

Social structure

Because the estimated population inmigration is small (29 under either alternative), neither of these two disposal alternatives would adversely affect local social structures.

No action

The no-action alternative would have no impact on the local social structure.

Social services

The project-related inmigration population would be expected to include seven school age children for either relocation alternative. Given a total 1983-1984 enrollment in the schools of the Lakeview School District of over 1300, while capacity is over 1600, little impact on the public schools would be expected.

Project sewer demand would be 2900 gallons per day for either relocation alternative, using a per capita sewage generation factor of 100 gallons per day. Because the estimated 3600 users of the Lakeview sewer system use less than half of the system's current capacity, no problems would be expected in supplying the needs of the additional 29 inmigrants. Because of the low level of population increase associated with either relocation alternative, no adverse impacts would be expected on local public safety, health care, or recreation facilities/systems.

No action

The no-action alternative would have no impacts on community services.

4.12 ECONOMIC STRUCTURE

Implementation of either of the relocation alternatives would impact the local economy through wages and salaries paid to direct and indirect employees, through the project's local spending for materials, equipment, and supplies, and through indirect expenditures as project dollars spent.

Collins Ranch site

Tailings relocation to the Collins Ranch site would produce $3,470,000 in local wages and salaries, $5,860,000 in local expenditures for materials, and $1,300,000 in local expenditures for equipment. Using a multiplier of 1.23 (every dollar in wages and salary would generate an additional $0.23 in secondary spending), an additional $798,100 in local spending would result. Thus, total impact of the Collins Ranch alternative on the local economy is estimated at $11,428,000.

No action

The no-action alternative would have no impact on the local economic structure.

Flynn Ranch site

The total direct input of the Flynn Ranch alternative to the local economy is estimated at $4,300,000 in both direct and indirect wages and salaries, $6,660,000 in local expenditures for materials, and $1,470,000 in local expenditures for equipment. Using a multiplier for local wage and salary expenditures of 1.23, an additional $989,000 in local expenditures would be generated (Mountain West Research, Inc., 1979). Thus, the total impact on the local economy of the Flynn Ranch alternative is estimated at $13,419,000.

4.13 IMPACTS ON TRANSPORTATION NETWORKS

The primary roadways that would be affected by the two action alternatives are U.S. Highway 395, State Highway 140, a private logging road owned by the Fremont Sawmill (Collins Ranch alternative), and County Road 3-13 (Flynn Ranch alternative).

Collins Ranch

The primary roadway affected by the Collins Ranch disposal alternative would be a privately-owned (Fremont Sawmill) logging road that leads from the current tailings site to the vicinity of the disposal site (and to a potential borrow area two miles northwest of the disposal site). During the peak logging season, traffic on this private road approaches 50 to 60 one-way truck trips and 20 auto trips each day (Shelton, 1984).

Maximum project traffic flows would occur over the 17-month tailings relocation phase. A total of 446 one-way trips per day would be expected: 144 truck trips for tailings relocation, 152 worker commute trips, and 150 trips for miscellaneous purposes. No congestion problems would be expected to occur on this lightly travelled two-lane roadway. However, coordination would be required between the remedial action contractor and the logging operator to minimize potential conflicts and accident risks between the two sets of activities (logging and remedial action).

No action

The no-action alternative would have no impact on transportation networks.

Flynn Ranch

Relocation of the tailings to the Flynn Ranch alternate disposal site would affect a segment of U.S. Highway 395 extending north from the northern portions of the city of Lakeview. As stated in Section 3.12, average daily 1983 traffic volumes on U.S. 395 at the north Lakeview city limits were 2250 trips per day. Traffic volumes further to the south in Lakeview were higher: just south of the intersection with State Highway 140, 1983 daily volumes averaged 6900 trips per day.

The segment of State Highway 140 that extends east from U.S. 395 also would be affected, as this is the route to the disposal site. Average 1983 daily volumes on State Highway 140 just east of U.S. 395 were 420 trips per day (Putnam, 1984). A segment of County Road 3-13 extending north from State Highway 140 also would be affected; 1983 volumes on this roadway segment were 100 trips per day.

Incremental project traffic on the above roadways would stem from site preparation, worker commuting, tailings relocation and the transport of clean fill material. Impacts would be short term (i.e., the duration of the remedial action); no long-term impacts would occur. All project

vehicular traffic would occur during normal weekday working hours. There would be no project activities during the winter months when weather conditions may be adverse.

Maximum traffic impacts would occur over the 24-month period when tailings relocation was underway. During this period an average of 97 one-way truck trips per day would occur, as well as 150 worker commute trips (75 workers times two trips per day, assuming one occupant per vehicle), and 150 trips per day for miscellaneous purposes. This total of 397 incremental project trips per day would represent an increase of 17.5 percent over 1983 average daily traffic volume on U.S. Highway 395 at the north Lakeview city limit. The 397 project-related trips would represent nearly a doubling of 1983 average daily volumes on State Highway 140 east of U.S. Highway 395, and an increase of nearly 400 percent over 1983 volumes on the lightly travelled (100 trips per day) County Road 3-13. Because there is ample current capacity on the above roadways, it is not expected that project traffic would create congested conditions.

4.14 ENERGY AND WATER CONSUMPTION

Table 4.7 lists direct project fuel, electricity, and water consumption for the two remedial action alternatives.

The equipment used to complete the remedial action (trucks, dozer, loader, grader, scraper, and the like) would consume fuel as shown in Table 4.7. Electricity would be used at the field office, change/shower, laundry, and dewatering/waste-water treatment facilities. Water consumption would mainly consist of non-potable water for uses such as compaction and dust control.

Table 4.7 Energy and water consumption summary

Alternative	Fuel use (gallons)	Electricity use (KWH)	Water use (gallons)
Collins Ranch	963,000	489,000	19,847,000
Flynn Ranch	1,279,300	620,000	13,264,000

Using a per capita water consumption rate of 100 gallons per day, project-related inmigrants would consume roughly 2900 gallons per day under either remedial action alternative. Total inmigrant water consumption would approximate 2,120,000 gallons under the 24-month Collins Ranch alternative, and 2,650,000 gallons under the 30-month Flynn Ranch alternative. The Lakeview City Engineer has stated that the City's active solicitation of conventions and the ability of the utilities to meet temporary increases in demand during the Annual Roundup and Fair (the population of the City increases 10 to 14 percent) are evidence supporting the conclusion that Lakeview can accommodate additional demands on utilities (MESA, 1982). Water and fuel supplies for both direct project uses and for inmigrant workers are sufficiently available locally under either remedial action alternative.

No action

The no-action alternative would have no impact on local energy and water consumption.

4.15 IMPACTS FROM ACCIDENTS NOT INVOLVING RADIATION

The various remedial action alternatives would involve extensive use of heavy construction machinery (e.g., dozers, scrapers, front-end loaders) and many heavy truck trips as tailings, other contaminated material, and clean cover material were transported between the tailings disposal site and borrow sites. Project workers would also be commuting between their homes and the work site. Because a substantial proportion of the project work force is expected to be available locally, an average commuting distance of 10 miles (one-way) is assumed for project workers for the Collins Ranch alternative, with an average one-way commute of 15 miles for the Flynn Ranch alternative.

The construction equipment used and transportation activities associated with each alternative pose the risk of accidents and resulting injuries and fatalities. Based on nationwide data, the operation of all types of machinery (e.g., tractors, forklifts, cranes, bulldozers, and trucks) would result in about 0.15 non-fatal accidents leading to loss of work time per man-year (DOT, 1977).

Based on a 1982 report (Ramano et al., 1982), truck travel (nationwide in both urban and rural areas) resulted in one fatality per 20,833,000 miles travelled and 0.82 injuries per million miles travelled (equivalent to one injury per 1,270,000 miles travelled). Based on 1983 data obtained from personnel of the Oregon Department of Transportation (Visticha, 1984), fatal accidents in the State of Oregon occurred at the rate of one fatal accident for each 41,266,000 miles travelled (484 fatal accidents in 19,972,650,000 miles); injury accidents occurred at the rate of one injury accident for each 866,000 miles travelled (23,067 non-fatal injury accidents in 19,972,650,000 miles travelled). The analyses presented below express expected transportation fatalities and injuries in terms of both of the above accident rate factors.

Non-radiological accident impacts associated with the various remedial action alternatives are estimated below based on the vehicle miles travelled and man-years of labor associated with each alternative. It should be noted that they include truck use, and thus appear to be partly redundant with the purely transportation accident data.

Collins Ranch

Tailings disposal at the Collins Ranch site would involve approximately 910,000 total vehicle miles of off-site travel. Based on 1983 Oregon fatal accident rate data, 0.22 fatal accidents would occur. Based on 1983 Oregon injury accident rate data, 1.05 injury accidents would be expected. Based on nationwide truck-only accident rates, 0.44 fatal accidents and 0.74 injury accidents would occur.

This alternative would involve a total of 138.5 man-years of labor. Assuming an equipment use accident factor of 0.15 injury accidents per man-year, 20.8 injury accidents leading to loss of work time would be expected. In summary, as shown in Table 4.8, the Collins Ranch alternative would be expected to result in 0.07 to 0.14 fatalities and 21.2 to 21.9 injuries.

No action

The no-action alternative would have no impact in terms of traffic or construction-related accidents.

Flynn Ranch

Tailings disposal at Flynn Ranch would involve approximately 2,835,000 vehicle miles travelled. Fatal accidents would be expected to range from 0.22 (local data) to 0.44 (nationwide truck-only data); between 2.33 and 3.28 injury accidents would be expected. The 181.3 man-years of labor associated with tailings relocation to Flynn Ranch would produce 20.7 equipment-use-related accidents. Thus, in summary, as shown in Table 4.8, the Flynn Ranch alternative would result in 0.22 to 0.44 fatalities and 29.5 to 30.5 injuries.

4.16 MITIGATIVE MEASURES

As stated earlier, the engineering designs for all alternatives, except stabilization in place, are based on existing published data. If an alternative other than the proposed action is selected, additional site-specific data would be obtained before the final engineering designs are prepared.

4.16.1 Mitigative measures during remedial action

The following mitigative measures were incorporated into the design and approach for each of the relocation alternatives in order to reduce the environmental impacts.

- Application of water dust suppressant to dirt and gravel haul roads to inhibit dust emissions.
- Construction of an earthen tailings cover to inhibit radon emanation (consistent with EPA standards) and surface-water infiltration.
- Use of local labor whenever possible to reduce the sociological impacts to the local communities and maximize economic benefits.
- Covering of haul trucks to prevent dispersion of tailings during relocation.

Table 4.8 Non-radiological accident impacts

Alternative	Total off-site vehicle miles travelled	Total man-years of labor	Traffic accident fatalities	Traffic accident injuries	Equipment use accident injuries	Total fatalities	Total injuries
Collins Ranch	910,000	138.5	0.07 - 0.14	0.44 - 1.05	20.8	0.07 - 0.14	21.2 - 21.9
Flynn Ranch	2,835,000	181.3	0.22 - 0.44	2.33 - 3.28	27.2	0.22 - 0.24	29.5 - 30.5

Injury accidents are defined as those leading to loss of work time.

- Construction of surface runoff diversion channels to direct runoff away from the stabilized tailings and prevent long-term erosion.

- Construction of a rock cover on the stabilized tailings to assure that the stabilized pile could withstand the erosive effects of a Probable Maximum Precipitation (PMP).

- Design of the stabilized tailings to withstand a Maximum Credible Earthquake (MCE).

- Selection of borrow sites which are as close to the disposal sites as possible to reduce costs and eliminate the impacts of long haul distances.

- Reclamation, including filling, grading, and revegetating of borrow sites (as required).

- Removal of all contaminated soils (consistent with EPA standards) adjacent to the existing tailings pile and consolidation of the contaminated soils with the tailings.

- Stockpiling of various soils encountered at the borrow sites for future use during reclamation.

- Immediate cleanup of any off-site spills.

- Implementation of a complex cover design for the tailings piles designed to prevent inadvertent human intrusion after remedial action.

- Conducting operations only during normal work hours to prevent noise disturbance to local residents.

- Construction of retention pond(s) to prevent dispersal of tailings by runoff during remedial action.

- Maintaining close communications with the local population through an established public task force.

- Cleanup of equipment used before release for use on other projects to prevent the spread of contaminated materials.

- Construction of temporary berms at each site to prevent surface water from leaving the site during remedial action.

- Placement of a rock-soil matrix on the tailings embankment, revegetation of the site, and release for use as grazing land.

- Backfilling, grading, topsoiling, and revegetating the areas disturbed at the Lakeview site as required during removal of tailings, contaminated soils, and borrow material.

- o Grading, topsoiling, and revegetating areas disturbed at the disposal site for a temporary staging area.

- o Release of the Lakeview mill site for use following remedial action consistent with Lake County zoning laws.

- o Salvage of any unavoidably affected archaeological resources determined to be eligible for the NRHP.

Collins Ranch site

A tailings embankment with a capillary break and filter layer, would be constructed at the Collins Ranch site if necessary to prevent contamination of ground water.

No action

No mitigative measures are addressed for the no-action alternative.

4.16.2 Worker protection during remedial action

Training sessions appropriate to the degree of radiation hazards present at the site would be conducted for all employees prior to the start of work. These sessions would include discussion of the industrial and radiological safety procedures, emergency procedures, and the effects of prenatal radiation exposure. Records would be maintained which document successful completion of training by employees.

Controlled areas would be designated and conspicuously marked. Access to these areas would be restricted, and all personnel and equipment would be monitored for contamination. Access control records would be maintained. Those records would include a log of personnel and equipment entering and leaving the restricted area and a log of dosimeters issued.

Protective clothing would be distributed to employees at the access control point when conditions warrant. Change and cleanup facilities would be provided.

Thermoluminescent dosimeters (TLDs) or film badges would be supplied to permanent employees working in controlled areas. Dosimeters would be changed quarterly or more frequently if necessary. Urinalysis would be used to monitor employees' internal exposures where potential ingestion of radioactive material is indicated by air sampling data. Additional dosimetry might be required if positive results were noted. A system of employee health records would be maintained which documents individual radiation exposures and the results of personnel dosimetry and bioassays.

Air particulate samples would be collected in work areas and at site boundaries. Samples would be analyzed for gross alpha levels, and would be stored for later isotopic analyses, if necessary. Additional samples would be collected in work areas where ventilation was limited, and analyzed for radon daughter concentrations.

A respiratory protection program would be developed by the Remedial Action Contractor (RAC), with procedures developed for training employees and checking for adequate fit of respirators. Respirators would be used in work areas where air particulate concentrations exceeded a projected monthly concentration of 25 percent of the regulatory limit for a given radionuclide. Industrial hazards would be controlled in accordance with OSHA regulations.

Additional details of the health and safety plan are available in the draft Remedial Action Plan (DOE, 1985b).

4.16.3 Maintenance and surveillance

Title I of the UMTRCA defines the authority and roles of the Department of Energy (DOE), the Nuclear Regulatory Commission ("Commission"), and the intent of licensing regarding inactive tailings sites in the various states. In part, Section 104(f)(2) of the UMTRCA reads:

> "...upon completion of the remedial action program...(the site) shall be maintained pursuant to a license issued by the Commission in such manner as will protect the public health, safety, and the environment. The Commission may, pursuant to such license or rule or order, require...monitoring, maintenance, and emergency measures necessary to protect public health and safety and other actions as the Commission deems necessary to comply with the standards (EPA) of Section 275..."

Accordingly, the remedial action must demonstrate compliance with the EPA standards (40 CFR Part 192) and thus, the prime objective of licensing is to ensure continued compliance with the EPA standards via a post-remedial action surveillance and maintenance program.

DOE would conduct the maintenance and monitoring program pursuant to the requirements of the Commission's license until termination of the authority of UMTRCA (i.e., March 7, 1990). At that time, the DOE or another agency to be designated by the President would maintain the site as required by the Commission.

A detailed custodial surveillance and maintenance program would be defined jointly by the DOE and the NRC during the NRC license application and approval process. The following are the basic elements of this program as proposed by DOE at this time.

Site inspections

Site inspections constitute a visual and definitive verification that the disposal site continues to function as designed and assures continued compliance with the design standards. Inspections would consist of two phases: Phase I, which is a systematic walk-over, is designed to qualitatively evaluate the condition of the disposal site; Phase II constitutes investigations to quantitatively assess changes in the disposal site that could lead to functional failure of the design in the absence of custodial maintenance. The Phase I inspection would be conducted on a specific schedule, such as annually, by a team of qualified professionals. The inspection team would review as-built drawings, engineering details, aerial photographs, and supporting documentation. A site walk-over would then be performed to evaluate any changes at the site with regard to factors such as erosion, flood effects, slope cover stability, settlement, displacement, plant or animal intrusion, and access control.

Based upon the evaluation and recommendations of the inspection team, Phase II studies might be conducted to quantitatively determine the magnitude and rate of effect of changes in the above factors. From these studies, the need for a corrective action (i.e., custodial maintenance) would be ascertained.

Aerial photography

Aerial photography might be used to supplement site inspections. The objectives might be to identify changes in site conditions (e.g., patterns of developing erosion that might affect the function of the design), provide visual documentation of year-to-year variation in site conditions, and to identify activities (e.g., road conditions, storm drainage construction) adjacent to the site that might affect its function.

Aerial photography might be conducted on the same schedule as site inspection. Photographs would be taken at both low (i.e., high resolution) and higher (i.e., for adjacent activities) altitudes, and at oblique and vertical angles. The types of film, ground control, camera specifications, amount of aerial overlap, interpretative keys, and other requirements, would be established prior to completion of remedial action.

Ground-water monitoring

New monitoring wells would be drilled after completion of the remedial action. Locations for these wells would be selected in order to monitor the performance of the tailings embankment. Some existing monitoring wells, used for site characterization studies, might be used as a secondary monitoring network. Details of the ground-water monitoring would be developed during the NRC licensing process.

Reporting

Summary surveillance and monitoring reports that evaluate the results of these activities, recommend needed custodial maintenance (i.e., corrective actions), and future surveillance and monitoring would be prepared. Reports and supporting documentation would be placed on file with DOE, NRC, the State of Oregon, and Lake County.

Custodial maintenance

The need for custodial maintenance (i.e., corrective action) can only be determined following site inspection and monitoring, and by NRC and DOE evaluation of the reports of these activities. However, it is anticipated that custodial maintenance would consist primarily of the following:

- Limited soil/rock replacement because of unanticipated erosion, human or animal intrusion, or cover disturbance. These activities would be expected to be required infrequently.
- Control of deep-rooted plants by infrequent application of herbicides or physical removal as required.
- Mechanical repairs to monuments, warning signs, or other items when necessary.

Contingency plans

Procedures would be developed to initiate inspection and to institute custodial maintenance of the disposal site in case of severe meteorological events (e.g., extreme rainfall), or seismic events or unusual human intrusion.

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GLOSSARY

absorbed dose, radiological	Radiation energy absorbed per unit mass, usually given in units of rads.
alluvium	Sediment deposited by a flowing river.
alpha particle	A positively charged particle emitted from certain radionuclides. It is composed of two protons and two neutrons, and is identical to the helium nucleus.
animal unit month (AUM)	The amount of feed or forage required by one mature cow and calf for one month.
anisotropy	A variation in the general water flow direction within an aquifer. Water in an anisotropic aquifer may not flow parallel to the hydraulic gradient.
aquifer	A subsurface formation containing sufficiently saturated permeable material to yield usable quantities of water.
atom	A unit of matter; the smallest unit of an element consisting of a dense, central, positively charged nucleus surrounded by a system of electrons, equal in number to the number of nuclear protons and characteristically remaining undivided in chemical reactions except for a limited removal, transfer, or exchange of certain electrons.
A-weighted scale	Sound pressure level scale which most closely matches the response of the human ear. This scale is most commonly used to measure environmental noise and is often supplemented by the time and duration of the noise to determine the total quantity of sound affecting people.
background radiation	Radiation arising from radioactive material other than that under consideration. Background radiation due to cosmic rays and natural radioactivity is always present, and there is always background radiation due to the presence of radioactive substances in building materials, and the like.
beta particle	Charged particle emitted from the nucleus of an atom during radioactive decay, with mass and charge equal to those of an electron.
bioassay	A method for quantitatively determining the concentration of radionuclides in a body by measuring the quantities of those radionuclides that are eliminated from the body, usually in the urine or the feces.
Class I to III archaeological surveys	Relates to an archaeological investigation of probable occurrence of cultural resources within a given locale. A Class I survey is a literature search for predetermined archaeological features of historic significance; a Class II

	survey is a combination of a literature review and a partial but cursory excavation of an area to determine the presence of cultural resources; a Class III survey is an in-depth inspection of an area to determine the presence of archaeological materials where the likelihood of their occurrence is high, based on the history of the area.
colluvium	Weathered geologic material transported by gravity.
confined aquifer	An aquifer bounded above and below by relatively impermeable rock layers.
confining layer	A stratum immediately above or below an aquifer with a hydraulic conductivity less than that of the aquifer.
curie (Ci)	The unit of radioactivity of any nuclide, defined as precisely equal to 3.7×10^{10} disintegrations per second.
daughter product(s)	A nuclide resulting from radioactive disintegration of a radionuclide, formed either directly or as a result of successive transformations in a radioactive series; it may be either radioactive or stable.
decay, radioactive	Disintegration of the nucleus of an unstable nuclide by spontaneous emission of charged particles, photons, or both.
decontamination	The reduction of radioactive contamination from an area to a predetermined level set by a standards-setting body such as the EPA, by removing the contaminated material.
disintegrations per minute or second	The number of radioactive decay events occurring per minute or second.
disposal	The planned safe permanent placement of radioactive waste.
dose	A general term denoting the quantity of radiation or energy absorbed, usually by a person; for special purposes, it must be qualified; if unqualified, it refers to absorbed dose.
dose, absorbed	The amount of energy imparted to matter by ionizing radiation per unit mass of irradiated material at the point of interest; given in units of rads.
dose commitment	The cumulative dose equivalent that results and will result from exposure to radioactive materials over a discrete time period; given in units of rems.
dose equivalent	The quantity that expresses all kinds of radiation on a common scale for calculating the effective absorbed dose; defined as the product of the absorbed dose in rads and modifying factors, especially the qualifying factor; given in terms of rems. Often abbreviated "dose."

endemic	Belonging to or native to a locality or region.
eolian erosion	Land erosion caused by wind.
escarpment	A steep face terminating high lands abruptly, a cliff.
excess health effects	Adverse physiological response from radiation exposure (in this report, one health effect is defined as one cancer death from exposure to radioactivity).
exposure	The presence of gamma radiation that may deposit energy in an individual; given in units of roentgens.
external dose	The absorbed dose that is due to a radioactive source external to the individual as opposed to radiation emitted by inhaled or ingested sources.
facies	A rock or group of rocks that differ from comparable rocks in age, composition or fossil content.
floodplain	Lowland or relatively flat areas that are subject to flooding. A 100-year floodplain has a 1 percent or greater probability of flooding in any given year.
flux, radon	The emission of radon gas from the earth or other material, usually measured in units of picocuries per square meter per second.
forbs	Herbs other than grasses.
gamma	A high energy and deep penetrating form of radiation.
gamma dose	Radiation dose caused by gamma radiation.
gamma logging (or logs)	A technique for determining gamma radiation levels at various depths in a bore hole.
gamma ray	High energy electromagnetic radiation emitted from some radiation radionuclides. The energy levels are specified for different radionuclides.
gamma spectral analysis (gamma spectroscopy)	An analytical technique for identifying radionuclides based on their different gamma energy levels.
graminoids	Grasses
grazing allotment	An entitlement given by a government agency or Indian tribe to a person or persons to use a specified parcel of land for the grazing of livestock.
ground water	Water below the land surface, generally in a zone of saturation.

half life	The time required for 50 percent of the quantity of a radionuclide to decay into its daughters.
hog wire	A type of barbed wire having four pointed barbs and weighing 400 pounds per mile.
hydraulic conductivity	Ratio of flow velocity to driving force (for viscous flow under saturated conditions of a specified liquid in a porous medium).
hydraulic gradient	Pressure gradient; rate of change of pressure head per unit of distance of flow at a given point.
inert gas	One of the chemically unreactive gases: helium, neon, argon, krypton, xenon, and radon.
in-situ	In the natural or original position.
internal dose	The absorbed dose or dose commitment resulting from inhaled or ingested radioactivity.
isopleths	An isogram on a graph showing the occurrence or frequency of a phenomenon as a function of two variances.
isotopes	Nuclides having the same number of protons in their nuclei, but differing in the number of neutrons; the chemical properties of isotopes of a particular element are almost identical.
lacustrine	A geological term referring to belonging to or produced by lakes.
licensing	In this report, the process by which the NRC will, after the remedial actions are completed, approve the final disposition and controls over a disposal site. It will include a finding that the site does not and will not constitute a danger to the public health and safety.
loess	Accumulations of windborne dust.
maintenance, custodial (passive)	The repair of fencing, the repair or replacement of monitoring equipment, revegetation, minor additions to soil cover, and general disposal site upkeep such as mowing grass.
man-rem	Unit of population exposure obtained by summing individual dose-equivalent values for all people in the population. Thus, the number of man-rems attributed to 1 person exposed to 100 rems is equal to that attributed to 100 people each exposed to 1 rem.
mass wasting	The slow downslope movement of rock debris (due to gravity).
mesic	Habitat with a moderate amount of water or an organism which lives in such a habitat.

micro	A prefix meaning one millionth (x 1/1,000,000 or 10^{-6}).
milli	A prefix meaning one thousandth (x 1/1000 or 10^{-3}).
Modified Mercalli (scale)	A standard scale for the evaluation of the local intensity of earthquakes based on observed phenomena such as the resulting level of damage. Not to be confused with magnitude, such as measured by the Richter scale, which is a measure of the comparative strength of earthquakes at their sources.
monitor	To observe and make measurements to provide data for evaluating the performance and characteristics of the disposal site.
National Register of Historic Places	Established by the Historic Preservation Act of 1966. The Register is a listing of archaeological, historical, and architectural sites nominated for their local, state, or national significance by state and Federal agencies and approved by the Register staff.
native ground water	Naturally occurring ground water which has not had its chemical character altered as a result of human activities.
nuclide	A general term applicable to all atomic forms of the elements; nuclides comprise all the isotopic forms of all the elements. Nuclides are distinguished by their atomic number, atomic mass, and energy state.
orographic	Weather patterns influenced by mountains.
palatable browse	Twigs, shoots, leaves, and the like, that animals are able to consume.
passive institutional controls	Those controls which preclude human contact with the waste or require a continuing social order. Examples include Federal ownership of a disposal site, monuments on the site, records with agencies, and physical barriers (e.g., riprap covers, vegetation, waste burial).
perched ground water	Ground water separated from an underlying body of ground water by unsaturated rock.
permeability	The ease with which liquids or gases penetrate or pass through a layer of soil. Technically, it is the volume of fluid that will flow through a unit area under a unit hydraulic gradient, measured in centimeters per second or equivalent units.
permissible dose	That dose of ionizing radiation that is considered acceptable by standards-setting bodies such as the EPA.
person-rem	Same as man-rem.
pico	A prefix meaning one trillionth (1 x 1/1,000,000,000,000 or 10^{-12}).

picocurie	A unit of radioactivity defined as 0.037 disintegrations per second.
piezometric surface	The potentiometric surface of an aquifer. This represents the pressure exerted on a confined aquifer, or the water table in an unconfined aquifer.
pit run rock	Rock materials (sometimes with a rock diameter specification) that are not screened for size segregation prior to use in the construction industry.
primary succession type	A plant that colonizes an area not previously covered by vegetation.
proton	An electrically positive elementary particle found in the nucleus of an atom. Also, the nucleus of a hydrogen atom.
rad	A unit of measure for the absorbed dose of radiation. It is equivalent to 100 ergs per gram of material.
radioactive decay chain	A succession of nuclides, each of which transforms by radioactive disintegration into the next until a stable nuclide results.
radioactivity (radioactive decay)	The property of some nuclides of spontaneously emitting particles or gamma radiation or of spontaneous fission.
radioisotope	A radioactive isotope of an element with which it shares almost identical chemical properties.
radionuclide	A radioactive nuclide.
radium-226	A radioactive daughter product of uranium-238. Radium is present in all uranium-bearing ores; it has a half life of 1620 years.
radon-222	The gaseous radioactive daughter product of radium-226; it has a half life of 3.8 days.
radon-daughter product	One of several short-lived radioactive daughter products of radon-222. All are solids.
range type	A distinctive kind of rangeland that has a certain potential for producing rangeland plants. Each type has its own combination of environmental conditions and characteristic plant communities.
recharge	Resupply, replenish.
rem	A unit of dose equivalent equal to the absorbed dose in rads times quality factor times any other necessary modifying factor. It represents the quantity of radiation that is equivalent in biological damage to 1 rad of x-rays.
riparian	Habitat located along a flowing waters edge (riverbank, streambank, and the like).

roentgen	A unit of measure of ionizing radiation in air; 1 roentgen in air is approximately equal to 1 rad and 1 rem in tissue.
soil infiltration rate	The rate at which water enters the soil surface and moves vertically.
soil percolation rate	The rate at which water moves through soil in all directions.
stabilization	The reduction of radioactive contamination in an area to a predetermined level by a standards-setting board such as the EPA, by encapsulating or covering the contaminated material.
surveillance	The observation of the disposal site for purposes of visual detection of need for custodial care, evidence of intrusion, and compliance with other license and regulatory requirements.
tailings, uranium-mill	The wastes remaining after most of the uranium has been extracted from uranium ore.
thorium-230	A radioactive-daughter product of uranium-238; it has a half life of 80,000 years and is the parent of radium-226.
transmissivity, hydraulic	A measure of the ability of an aquifer to transmit water equal to the product of the permeability and the thickness of the aquifer, expressed in gallons per day per foot of drawdown.
UMTRA Project	Uranium Mill Tailings Remedial Action Project of the Department of Energy.
unconfined aquifer	An aquifer without an upper confining layer. Also known as phreatic or water-table aquifers.
uranium-238	A naturally-occurring radioisotope with a half life of 4.5 billion years; it is the parent of uranium-234, thorium-230, radium-226, radon-222, and others.
vicinity property	A property in the vicinity of the Lakeview site that is determined by the DOE, in consultation with the NRC, to be contaminated with residual radioactive material derived from the Lakeview site, and which is determined by the DOE to require remedial action.
water table	The surface of a body of unconfined ground water at which pressure is equal to that of the atmosphere.
working level (WL)	A measure of radon-daughter-product concentrations. Technically, it is any combination of short-lived radon decay products in 1 liter of air that will result in the ultimate emission of alpha particles with a total energy of 130,000 MeV.

working-level month (WLM)	The exposure resulting from inhalation of air with a month (WLM) concentration of 1 WL for 170 working hours. Continuous exposure of a member of the general public to 1 WL for one year results in approximately 53 WLM.

ABBREVIATIONS AND ACRONYMS

acres/aum	Acres per animal unit month
ADT	Average Daily Traffic
AEC	Atomic Energy Commission
ANL	Argonne National Laboratories, Argonne, Illinois
AQCR	Air Quality Control Region
ARCO	Atlantic Richfield Company
AUM	Animal Unit Month
avg	Average
BEIR	Advisory Committee on the Biological Effects of Ionizing Radiation of the National Academy of Sciences (also their report)
BLM	Bureau of Land Management, U.S. Department of the Interior
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
Ci	Curies
cm	Centimeter
cfs	Cubic feet per second
cfs/ft	Cubic feet per second per foot
CO	Carbon monoxide
COE	Corps of Engineers
cy	Cubic yard
dBA	Decibels on the A scale; a logarithmically based unit of sound intensity weighted to account for human auditory responses
DEQ	Oregon Division of Environmental Quality
DOE	U.S. Department of Energy
EA	Environmental Assessment
EIS	Environmental Impact Statement
EGR	External gamma radiation

EPA	U.S. Environmental Protection Agency
°F	Degrees Farenheit
ft/yr	Feet per year
FWS	U.S. Fish and Wildlife Service
FBDU	Ford, Bacon, & Davis, Utah, Inc.
FONSI	Finding of No Significant Impact
FR	Federal Register
g	Grams; a unit of weight = 0.035 ounce
gal	Gallon
gpd	Gallons per day
gpm	Gallons per minute
HC	Hydrocarbon
ISCST	Industrial Source Complex Dispersion Model for Short-Term Application
KGRA	Known Geothermal Resource Area.
kw	Kilowatt
kwh	Kilowatt hours
l	Liter; a unit of volume = 1.057 quarts
L_{dn}	Day-night sound level, measured in decibels
L_{eq}	Equivalent sound level, measured in decibels
lbs/acre	Pounds per acre
m	Meter; a unit of length = 3.28 feet; also milli, a prefix meaning one-thousandth (10^{-3})
MCE	Maximum Credible Earthquake
mg	Milligrams; a thousandth of a gram
m/s	Meters per second
mg/l	Milligram per liter
MGD/microg	Microgram; a millionth of a gram
mph	Miles per hour

microg/m^3	Microgram per cubic meter
mR/hr	Milliroentgens per hour
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act of 1969 (PL91-190)
NOAA	National Oceanic and Atmospheric Administration
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
NRC	U.S. Nuclear Regulatory Commission
NRHP	National Register of Historic Places
O_3	Ozone
ORNL	Oak Ridge National Laboratory, Oak Ridge, Tennessee
OVL	Oregon Valley Land Company
p	Pico, a prefix meaning one trillionth (10^{-12})
pCi/g	Picocuries per gram
pCi/l	Picocuries per liter
pCi/m^2sec	Picocuries per square meter per second
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
ppm	Parts per million
RAC	Remedial Action Contractor
Rn-222	Radon-222
Ra-226	Radium-226
RDC	Radon-daughter concentration
SCS	Soil Conservation Service, U.S. Department of Agriculture
SHB	Sergent, Hauskins, and Beckwith
SHPO	State Historic Preservation Officer
SIP	Stabilization in place
SO_2	Sulfur dioxide

SO_x	Any oxide of sulfur
TDS	Total dissolved solids
Th-232	Thorium-232
TSP	Total suspended particulates
U_{238}	Uranium-238
UMTRA Project	Uranium Mill Tailings Remedial Action Project
UMTRCA	Uranium Mill Tailings Radiation Control Act of 1978 (PL95-604)
U_3O_8	Uranium oxide
USBR	Bureau of Reclamation, U.S. Department of the Interior
USGS	U.S. Geological Survey
VRM	Visual Resource Management Program of the U.S. Bureau of Land Management
WL	Working level (a measure of radon-daughter-product concentration)
WLM	Working-level month (exposure to 1 WL for 170 hours)
WWTP	Waste-water treatment plant

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APPENDIX D

HYDROLOGY

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D.1 SURFACE WATER

D.1.1 INTRODUCTION

The following sections address surface-water conditions at the Lakeview processing site, proposed alternate disposal sites, and borrow sites for each action alternative. A general description of the watershed and surface-water occurrences is included for each site, along with analyses of flooding potential and surface-water quality.

D.1.1.1. Lakeview processing site

The Lakeview site is in the drainage basin of Thomas Creek, a perennial tributary of Goose Lake which is a closed basin lake with an overflow elevation of 4,716 feet. This elevation is approximately 35 feet below the base of the tailings pile and is approximately eight miles south of the existing site.

An unnamed intermittent stream issuing from Hammersley Canyon, northeast of the site, flows across the site adjacent to the north side of the pile. This creek is referred to as Hammersley Creek in this report. Thomas Creek flows approximately one mile west of the site and the East Branch of Thomas Creek flows 1,000 to 2,500 feet west of the site. An ephemeral stream, Warner Creek, flows approximately 1,000 feet west of the site where it joins the East Branch of Thomas Creek. The confluence of the East Branch of Thomas Creek with Hammersley Creek is approximately 1,800 feet southwest of the site. Surface-water flows are also encountered approximately 0.5 mile north of the tailings in the Hunters Hot Springs area. All drainage flows northeast to southwest across the site. Surface drainage is shown in Figure D.1.1.

The drainage area for Hammersley Creek is about 3.34 square miles with a slope of 355 feet per mile. An area of approximately 30 square miles drains into Thomas Creek above the Lakeview site. The majority of this drainage basin is located in the wooded area northwest of Lakeview. The drainage basin for Goose Lake is approximately 1,140 square miles including the lake area.

D.1.1.2 Collins Ranch alternate disposal site

The Collins Ranch alternate disposal site is located along the southwestern slopes of Augur Hill adjacent to a drainage divide. There is a drainage area of approximately 15 acres above the proposed embankment area which drains towards Camp Creek, located approximately 3000 feet southwest of the site at an elevation 50 feet below the site. Camp Creek has a drainage area of approximately 13 square miles above the location where it flows past the alternate disposal site.

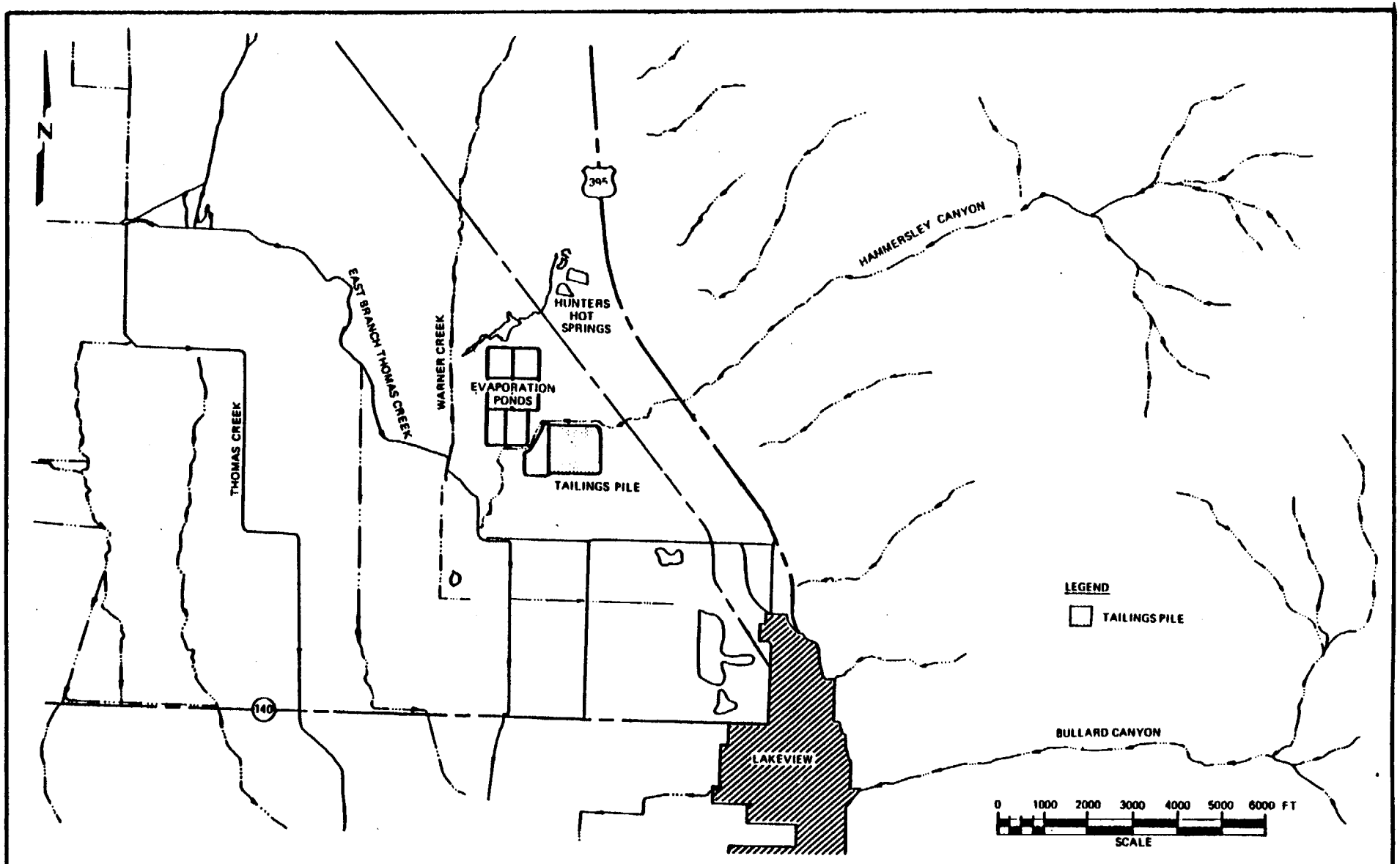


FIGURE D.1.1

LAKEVIEW PROCESSING SITE-DRAINAGE CHARACTERISTICS

Camp Creek is a tributary of Augur Creek which is located 10 to 20 feet lower than Camp Creek in elevation at approximately 6000 feet from the Collins Ranch site. The confluence of these two creeks is 1.5 miles south of the site and 110 feet below the site in elevation. Surface-water characteristics are shown in Figure D.1.2.

D.1.1.3 Flynn Ranch alternate disposal site

The Flynn Ranch site is also located on a drainage divide. Flows across the site drain to the northeast toward Flynn Reservoir (Figure D.1.3). A dry, poorly incised channel drains the small area northwest of the site. Flows in this channel are rarely, if ever, encountered. The closest perennial stream is Mapes Creek, which flows into Flynn Reservoir approximately one mile from the site. Mapes Creek has a drainage area of less than seven square miles above Flynn Reservoir. An ephemeral stream which flows north of the site joins Mapes Creek 1500 feet upstream of Flynn Reservoir at an elevation approximately 220 feet below the site. Peddlers Creek, a small ephemeral stream, flows to the southeast, approximately 1.2 miles southwest of the proposed alternate disposal site.

D.1.1.4 Borrow sites

The Collins Ranch borrow site is located approximately two miles northwest of the alternate disposal site and is within the Augur Creek drainage basin. The borrow area is approximately 1000 feet east of Augur Creek on the opposite side of the Fremont Sawmill logging road. The borrow area elevation ranges from 30 to 100 feet above the streambed elevation.

The Flynn Ranch borrow site is located approximately 1200 feet upstream of Flynn Reservoir, just below the previously mentioned point where Mapes Creek is joined by the ephemeral stream. The borrow area is separated from Flynn Reservoir by U.S. Highway 140 and from Mapes Creek by a dirt access road.

D.1.2 FLOOD ANALYSIS

D.1.2.1 Lakeview processing site

There are no USGS stream gaging stations in the Lakeview area. At a former station on Thomas Creek, about 5.5 miles northwest of the site near the point where the stream issues from the mountains, average flows of 9,480 acre-feet per year were recorded for the seven-year period of record before 1931.

Several investigations were conducted for the Department of Energy at the Lakeview site in order to characterize the

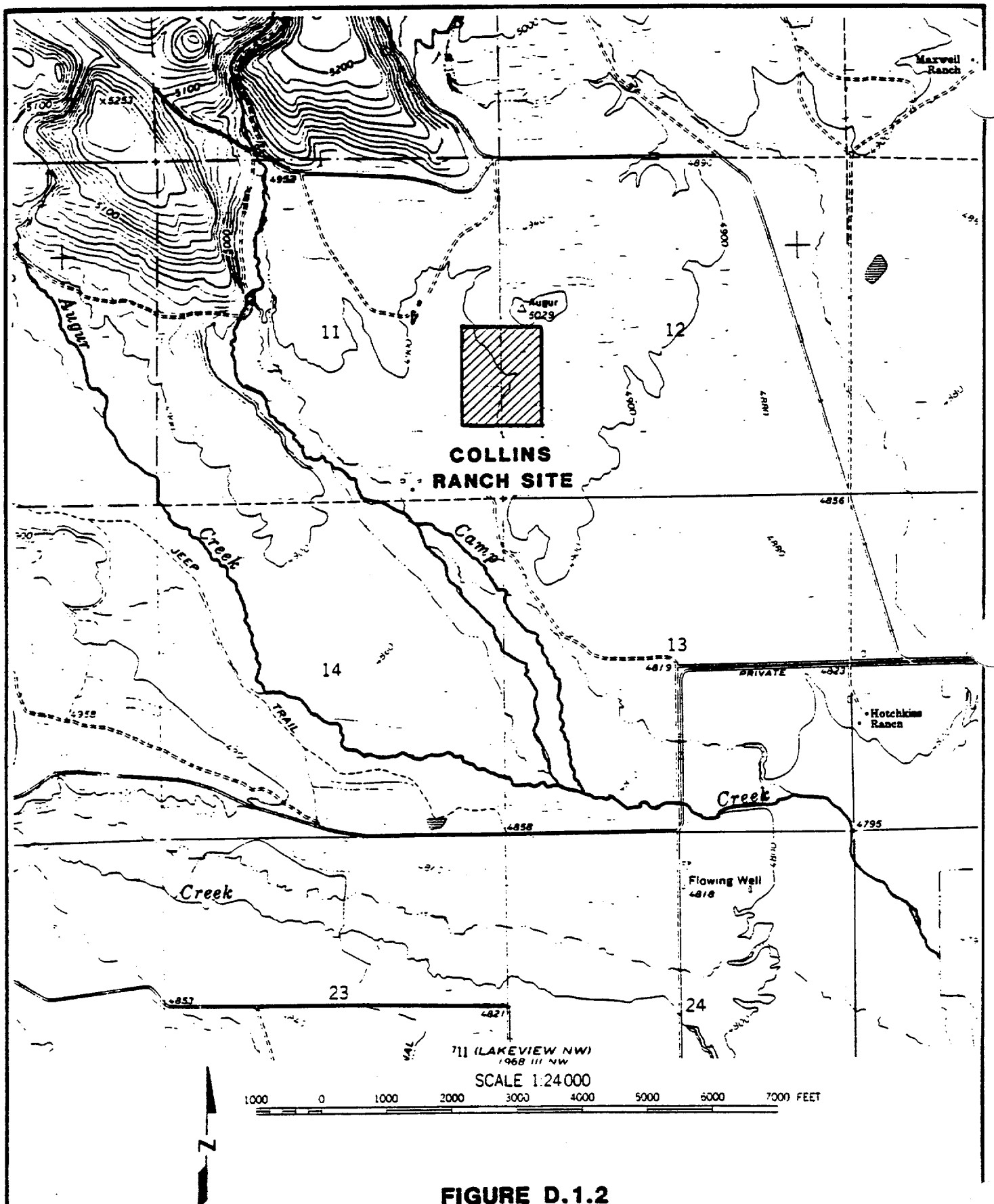


FIGURE D.1.2

COLLINS RANCH SITE-DRAINAGE CHARACTERISTICS

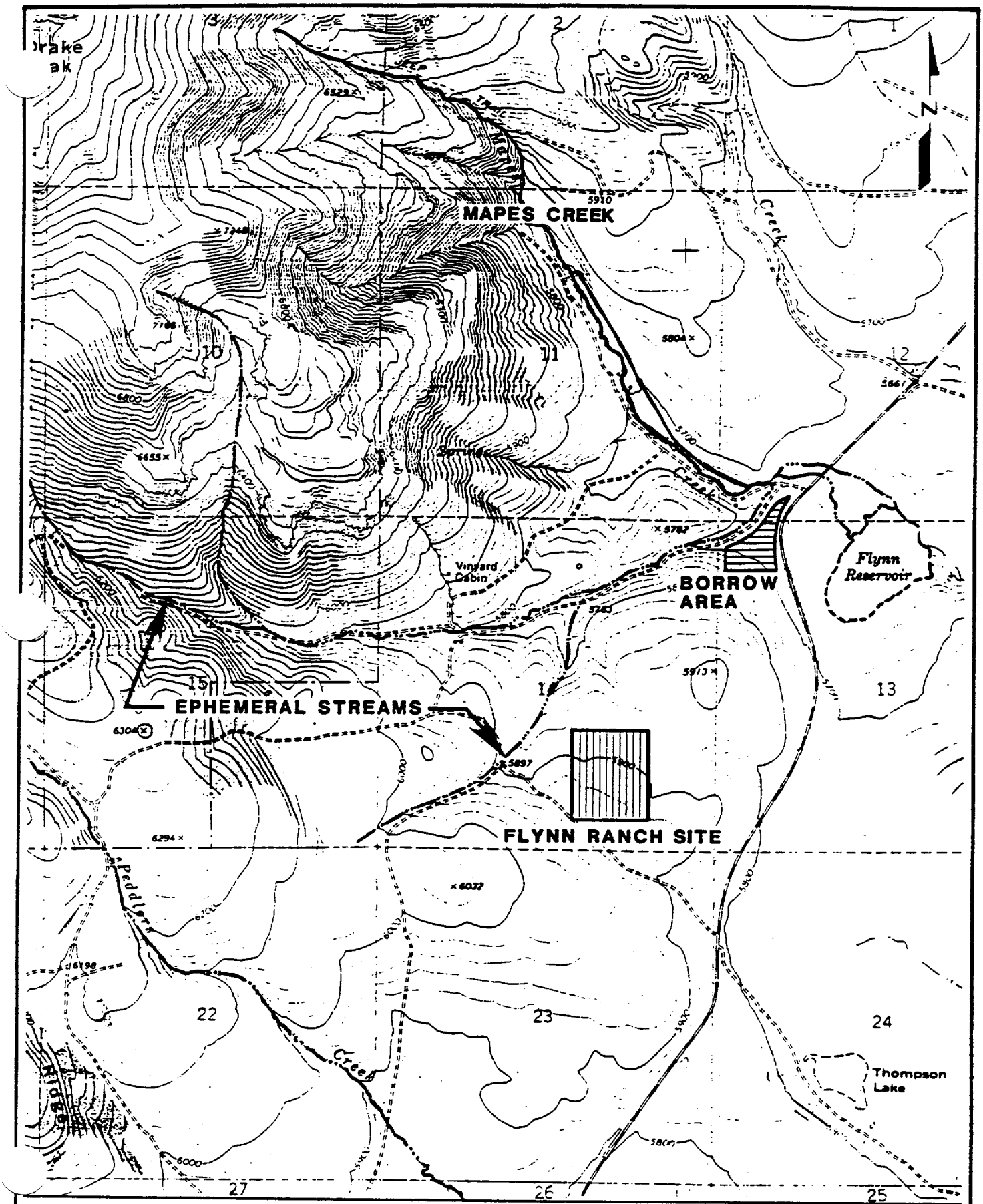


FIGURE D.1.3 **FLYNN RANCH SITE-DRAINAGE CHARACTERISTICS**

existing hydrologic system. The results of the flood potential study for Hammersley Creek, which flows across the site adjacent to the north side of the tailings pile, indicated that a flood with a return period of 200 years would have a peak flow at the site of 520 cfs. The 1000-year peak flow would have a peak expected magnitude of 780 cfs. During either of these flood events, the base of the pile would become inundated with flow velocities ranging from 5.6 to 8.4 feet per second adjacent to the pile.

No data are available for historical floods of the East Branch of Thomas or Warner Creek. The effects of a 100-year flood for Thomas and Warner Creeks has been analyzed by the Federal Insurance Administration of the U.S. Department of Housing and Urban Development. The flood hazard boundary map for the Lakeview area (Figure D.1.4) shows that the entire tailings pile and evaporation ponds areas would be located in the 100-year floodplain (FEMA, 1978). This analysis did not incorporate flooding of Hammersley Creek.

D.1.2.2 Collins Ranch alternate disposal site

Flooding is not considered to be a hazard at the Collins Ranch site. A very small drainage area, less than 15 square miles, is above the site. The closest perennial stream, Camp Creek, flows at an elevation 50 feet below the site at its closest point, which is approximately 3000 feet from the site.

There has been very little flood analysis done on Camp Creek in the Collins Ranch area. A study of 100-year floodplains was conducted in 1978 for the Federal Emergency Management Agency (FEMA, 1978). In this study, the 100-year floodplain for Camp Creek was just beyond the present stream channel and at least 2950 feet from the proposed embankment area.

Upstream from the site, about one mile, the creek is restricted in a narrow valley which could create high flood levels. As it approaches the site, however, the valley opens into a broad basin which would lower flood levels and reduce velocities making it improbable that the site could be flooded by Camp Creek.

D.1.2.3 Flynn Ranch site

No flood flows are expected at this site because of its distance from and elevation above the closest stream channel of Mapes Creek. Mapes Creek flows approximately 5500 feet from the site at an elevation over 200 feet lower than the site at its closest point. An area of approximately 0.14 square mile above and including the site drains towards the Flynn Ranch site.

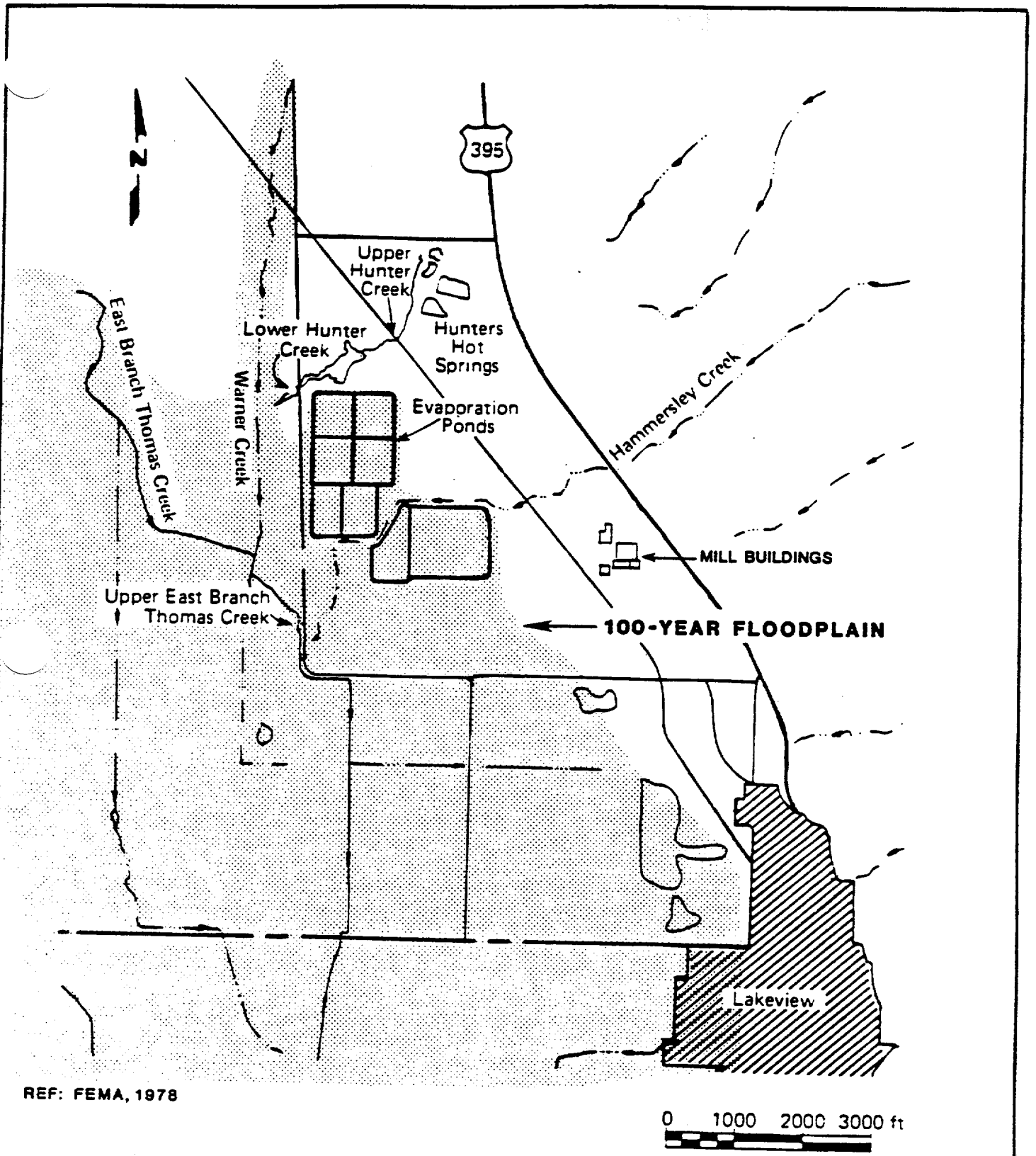


FIGURE D.1.4
100-YEAR FLOODPLAIN THOMAS AND WARNER CREEKS
LAKEVIEW PROCESS SITE

D.1.2.4 Borrow sites

The Collins Ranch borrow site may be affected by flooding of Augur Creek, even though it is at an elevation of 30 to 100 feet above the streambed. No data on historical floods are available for this site. The Fremont Sawmill logging road would serve to protect the borrow area from much of the flow if flooding were to occur.

The Flynn Ranch borrow site, likewise, may be affected by flooding of Mapes Creek. However, due to the very small watershed above the site, flows resulting from high intensity rainstorms would not be expected to cause damage.

D.1.3 SURFACE-WATER QUALITY

D.1.3.1 Lakeview processing site

Analytical results of surface-water samples indicate that surface water in the Lakeview area is of two chemical types. Water flowing in the East Branch of Thomas Creek is dominated by sodium and bicarbonate ions, with a total-dissolved-solids (TDS) concentration of 220 to 260 milligrams per liter (mg/l). Water flowing out of the Hunters Hot Springs area (termed Hunters Creek herein) is dominated by sodium and sulfate ions, with large amounts of chloride also present. The total TDS concentration of Hunters Creek was found to be 800 to 850 mg/l. Hunters Creek also has elevated arsenic concentrations relative to the East Branch of Thomas Creek. No water was present in Hammersley Creek during the sampling effort (FBD, 1983).

Differences in the chemistry of the two streams are due to the presence of Hunters Hot Springs immediately upstream from the Hunters Creek samples. The discharge from the geyser at Hunters Hot Springs is rich in sodium, sulfate, chloride, with a TDS concentration similar to that found in Hunters Creek. Arsenic concentrations are also high in the geothermal source relative to levels in the East Branch of Thomas Creek. Dilution by the greater quantity of water flowing in the East Branch of Thomas Creek upstream from the confluence with Hunters Creek accounts for the difference in concentrations.

Even though surface water in the area is not used for domestic purposes, a comparison of the chemical condition of the water with drinking-water standards promulgated by the U.S. Environmental Protection Agency (40 CFR Part 141) is helpful in defining water quality. Except for the arsenic concentrations in Hunters Creek, no concentrations of trace metals or radioactive constituents were found in the surface waters that exceeded the National Interim Primary Drinking Water Regulations or National Secondary Drinking Water Regulations for public water supplies. As noted previously, the high arsenic concentration in Hunters Creek occurs naturally as

discharge from the geothermal water at Hunters Hot Springs. No significant differences in constituent concentrations occurred in either stream between the upstream and downstream samples.

D.1.3.2 Alternate disposal sites

There are no surface-water quality data available for any of the ephemeral or perennial streams in the Collins Ranch or Flynn Ranch alternate disposal site areas. Since flooding is not a hazard at either of these sites, it is not considered necessary to analyze surface-water samples from any of the streams in the site vicinities.

Water quality in the vicinity of the sites must meet the standards outlined in the Oregon Department of Environmental Quality (ODEQ) Administrative Rules, Chapter 340, Division 41, Goose and Summer Lakes Basin. Applicable standards are summarized in the following paragraph.

Dissolved oxygen (DO) concentrations shall not be less than 75 percent of saturation at the seasonal low, or less than 95 percent of saturation in spawning areas during spawning, incubation, hatching, and fry stages of salmonid fishes. No measurable increases in temperature shall be allowed outside of the assigned mixing zone as measured relative to a control point immediately upstream from a discharge when stream temperatures are 68°F or greater; or more than 0.5°F increase due to a single-source discharge when receiving water temperatures are 67.5°F or less; or more than 2°F increase due to all sources combined when stream temperatures are 66°F or less except for specifically limited duration activities which may be authorized by ODEQ. pH values shall not fall outside the range of 7.0 to 9.0. Radioisotope concentrations shall not exceed maximum permissible concentrations (MPCs) in drinking water, edible fishes, wildlife, irrigated crops, livestock and dairy products, or pose an external radiation hazard.

Dissolved chemical substances shall not exceed the standards listed in Table D.1.1.

Table D.1.1 Surface-water-quality standards

Constituents	Standard (mg/l)
Arsenic (As)	0.01
Barium (Ba)	1.0
Boron (Bo)	0.5
Cadmium (Cd)	0.003
Chromium (Cr)	0.02
Copper (Cu)	0.005
Cyanide (Cn)	0.005
Fluoride (F)	1.0
Iron (Fe)	0.10
Lead (Pb)	0.05
Manganese (Mn)	0.05
Phenols (totals)	0.001
Zinc (Zn)	0.01

Ref. Oregon Department of Environmental Quality (ODEQ).

D.2 GROUND WATER

D.2.1 INTRODUCTION

This section presents ground-water data and analyses of ground-water hydraulics and chemistry for the processing site, Collins Ranch alternate disposal site, and Flynn Ranch alternate disposal site. Descriptions of the fieldwork conducted, methods of data analysis with calculations, and discussion of remedial action options in light of the analytical results are included. Development of the site conceptual models are contingent upon ongoing data collection and analyses. Ground-water data have been collected at the two alternate disposal sites during and following alternate site evaluation field drilling programs. The field data collected and the analytical methods used to complete the ground-water impact analyses also are discussed here.

D.2.2 DATA COLLECTION

Data have been collected at the Lakeview processing site and at the alternate disposal sites for the purpose of evaluating the present and future characteristics of the ground-water regimes. From these evaluations, the changes in water levels and the present and future rates, characteristics, and concentrations of contaminant migration will be projected.

D.2.2.1 Data collectors

Various contractors have conducted field studies to determine the geologic and hydraulic properties of the shallow alluvial materials, to determine the water quality, and to assess the nature and extent of solute transport from the Lakeview processing site. Field investigations of the alternate disposal sites were conducted by the Technical Assistance Contractor (TAC). The field studies at the Lakeview processing site were conducted by:

- Geochemical and Environmental Chemistry Research, Inc. (GECR).
- Ford, Bacon, and Davis, Utah, Inc. (FBDU).
- Technical Assistance Contractor (TAC) under contract to the U.S. Department of Energy (DOE).

The studies by GECR included chemical analyses of:

- Surface-water and ground-water samples.
- Soil, tailings, and cover samples.
- Water elutriates of soil, tailings, and cover samples.

- o Acid elutriates of soil, tailings, and cover samples.

The FBDU studies included:

- o Geotechnical boreholes.
- o Installation of six monitor wells.
- o Downhole logging.
- o An aquifer test in the alluvium directly beneath the pile.
- o Slug-discharge tests in completed monitoring wells.
- o Water-quality sampling and analyses.

Field studies by the TAC included:

- o Geophysical survey at the processing site.
- o Disturbed soil samples.
- o Aquifer tests within two zones in the alluvium at the processing site.
- o Slug tests.
- o Packer tests at the Flynn Ranch alternate disposal site.
- o Water-quality sampling and analyses.
- o Determination of local ground-water uses.
- o Tensiometers and suction water samples in the tailings and evaporation ponds.

No ground-water investigations were conducted at proposed remote borrow sites. Field operations at the borrow sites were limited to visual inspection, and in some cases, test pits that were logged by the TAC.

D.2.2.2 Data collection procedures

Lakeview tailings site

The following section describes the procedures used by GECR for sampling water and solids and determining the chemical conditions.

Geochemical data were collected from the processing site and from an area of seven square miles surrounding the city of Lakeview. The GECR sampling locations are shown on Figures D.2.1 and D.2.2.

The procedures used for sampling water and solids prevented cross-contamination between samples. In-situ parameters such as pH and Eh, were determined potentiometrically in the field, or within eight hours after sample collection. Surface- and ground-water samples were collected in new polyethylene bottles after rinsing the bottles with the water being sampled. The cations, chloride, and sulfate in the water were stabilized by filtering through a 0.45-micron filter and acidifying with nitric acid to a pH less than 2.0, in accordance with EPA-6004-79-020 (USEPA, 1979) standard methods. A one-liter sample collected for total gross alpha analysis was not filtered or acidified.

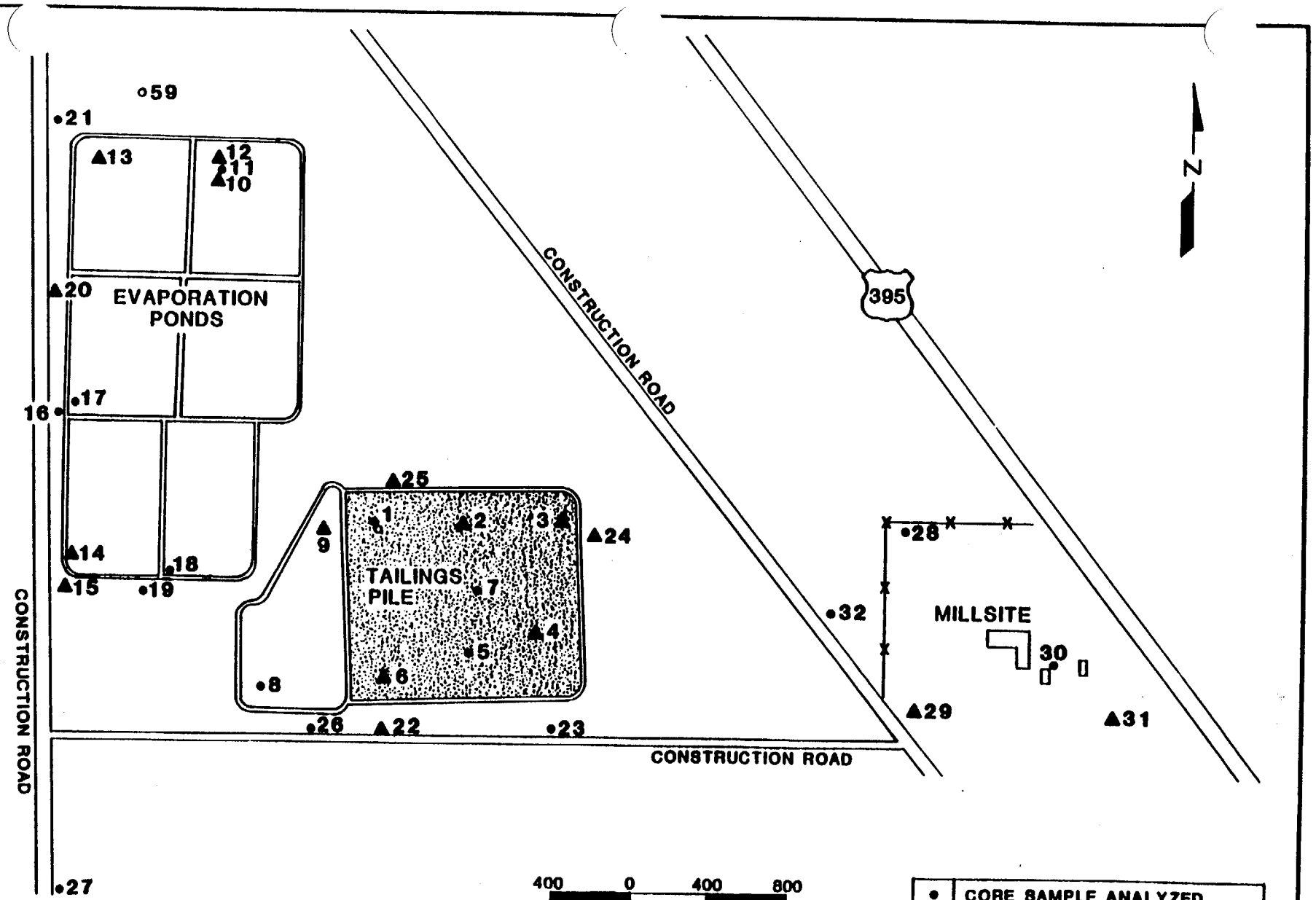


FIGURE D.2.1

GECR SAMPLING SITES WITHIN THE LAKEVIEW PROCESSING SITE AREA

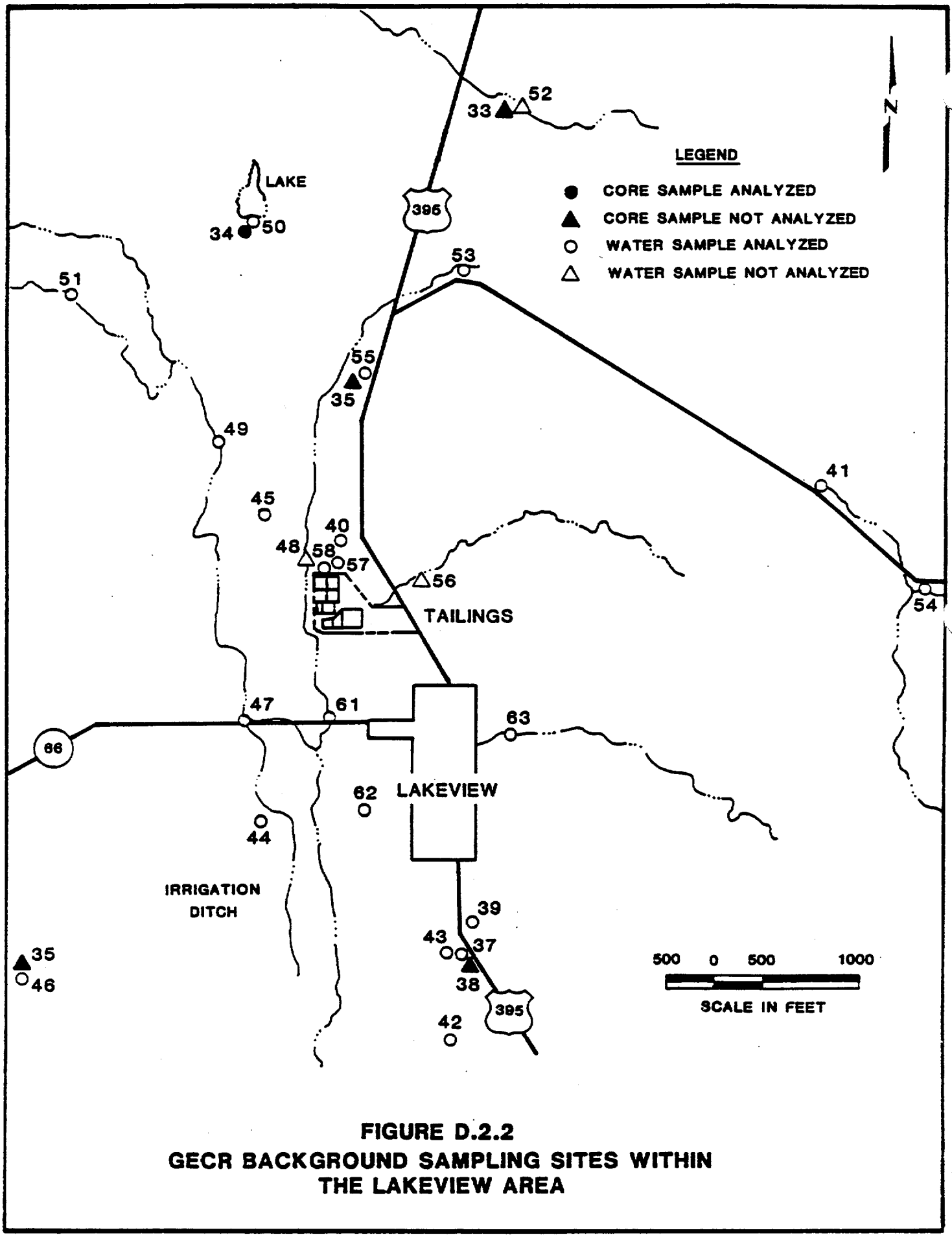


FIGURE D.2.2
GECR BACKGROUND SAMPLING SITES WITHIN THE LAKEVIEW AREA

The core samples were obtained with an 18-inch split spoon sampler (ASTM D1586) (ASTM, 1984) on a one- to 1.5-inch outside diameter drill rod, driven by either a sledge hammer or by a truck-mounted drill rig. The top 10 to 20 cm of each split spoon sample were discarded to prevent cross-contamination. Depths of sample intervals were recorded. A 1:4 solid/water slurry was prepared from each solid sample for pH and Eh measurements to be taken in the field. Solid samples were dried under ambient conditions and ground to at least 100 mesh (0.150mm) by mortar and pestle. Samples were split for solid and extract analyses.

Water extracts were performed by a procedure developed to obtain maximum removal of soluble materials in the shortest time. Twenty-five grams of solid were added to 100 ml of distilled water and agitated to keep solids in suspension. Solids were washed twice for 15 minutes each, the solution centrifuged, and supernatant decanted off. The extract was filtered, acidified, and diluted volumetrically to 500 ml.

Acid extracts were performed on the water extracted solids using hydrochloric acid at a pH less than 2.0. One-tenth gram of solid was added to 100 ml of 0.75N hydrochloric acid and then agitated for one hour. The solution was centrifuged, extract decanted and filtered, and diluted to 500 ml.

Water samples and water extracts were chemically analyzed by the laboratory of the Center for Environmental Sciences at the University of Colorado, Denver. Atomic absorption, inductively coupled plasma, and UV-VIS spectrophotometry were used for the cations: Ag, Al, As, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Pb, Se, Si, Sr, and V. The anions Cl and SO_4 were determined by ion chromatography. Uncertainties in the measurements were less than 10 percent for concentrations greater than one order of magnitude above the detection limit for each element, but the uncertainty increased as the detection limit was approached.

The dried solids were analyzed for Na, Mg, K, Ca, Al, Ba, Cl, Mn, Sr, Ti, V, U, and Dy at Los Alamos National Laboratory, New Mexico, by neutron activation analysis. Uncertainties in the measurements were usually less than 10 percent at concentration values greater than one order of magnitude above the detection limit.

Uranium in waters and extracts of solids was analyzed by GECR with a Scintrex UA-3 uranium analyzer. The measurement is based on the fluorescence of a uranyl complex formed by addition of the reagent Fluran, which converts the various uranyl species into a single species with a high degree of luminescence. The selectivity of the system provides a detection limit of five ppb uranium.

The following section describes the procedures used by FBDU for core drilling, monitor well installation, downhole logging in completed wells, aquifer testing, slug testing, and water-quality sampling.

Ten holes were drilled on the tailings pile and adjacent area to characterize subsurface conditions and local ground water at the Lakeview processing site (Figure D.2.3). Holes LV082-1 through LV082-4 were drilled five inches in diameter to depths of 10 to 15 feet, logged, sealed with cement, and abandoned. Lithologic logs may be obtained from TAC files, Albuquerque, New Mexico.

Boreholes LV082-5 through LV082-10 were drilled to serve as monitor wells. These holes were drilled eight inches in diameter with an air-rotary rig using either air or Lakeview city water as a drilling medium. An eight-inch steel casing was used to maintain hole integrity during drilling. Monitor wells were completed in a fashion similar to Figure D.2.4. Four-inch diameter ABS casing, slotted with a power saw, was installed in each well. The annular space was backfilled with a four- to eight-mesh gravel pack, a two-foot bentonite seal, coarse gravel, and a surface grout. A removable ABS cap and lockable steel surface casing were installed at each well. Table D.2.1 lists TAC-designated site ID's and corresponding FBDU identification numbers. Table D.2.2 lists FBDU and TAC well construction information.

After the installation of casing and the completion of the hole, each monitor well was logged with a suite of downhole geophysical and radiometric tools by Bendix Field Engineering Corporation (BFEC). Radiometric geophysical logs of each borehole are on file at the TAC Albuquerque Operations Office.

To determine hydraulic characteristics of the alluvial aquifer beneath the pile, a pump test was initiated in LV082-5. The test was terminated after only 8.5 hours, due to difficulty of maintaining a constant pumping rate of five gallons per minute. No drawdown was measured in any of the observation wells (LKV082-6 through LKV082-10).

Values of hydraulic conductivity were determined with slug-discharge tests in each of the monitor wells. Depth to water was measured before the test with an electric water-level indicator and during the test with a steel tape fastened to the indicator for rapid measurements. Immediately after removing the bailer, recovery of water level was measured at intervals until 90 percent recovery or stabilization occurred.

A suite of soil, tailings, and surface-water and groundwater samples were collected by FBDU. Locations of solid samples are shown in Figure D.2.5, and location of water samples are shown in Figure D.2.6. Water samples were collected in plastic bottles, filtered through a 0.45-micron filter, and

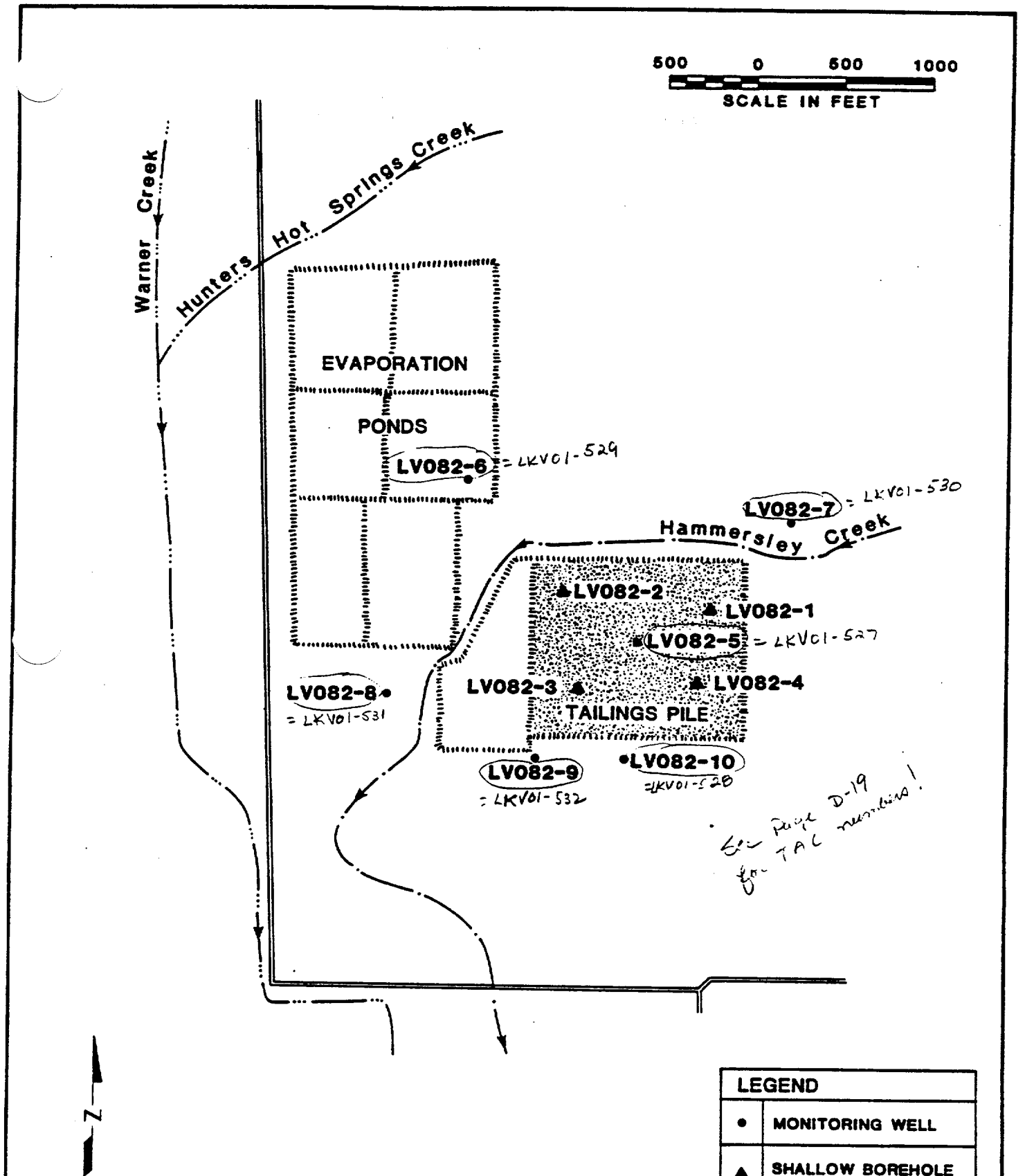


FIGURE D.2.3

LOCATION OF HOLES DRILLED BY FBDU AT THE LAKEVIEW SITE

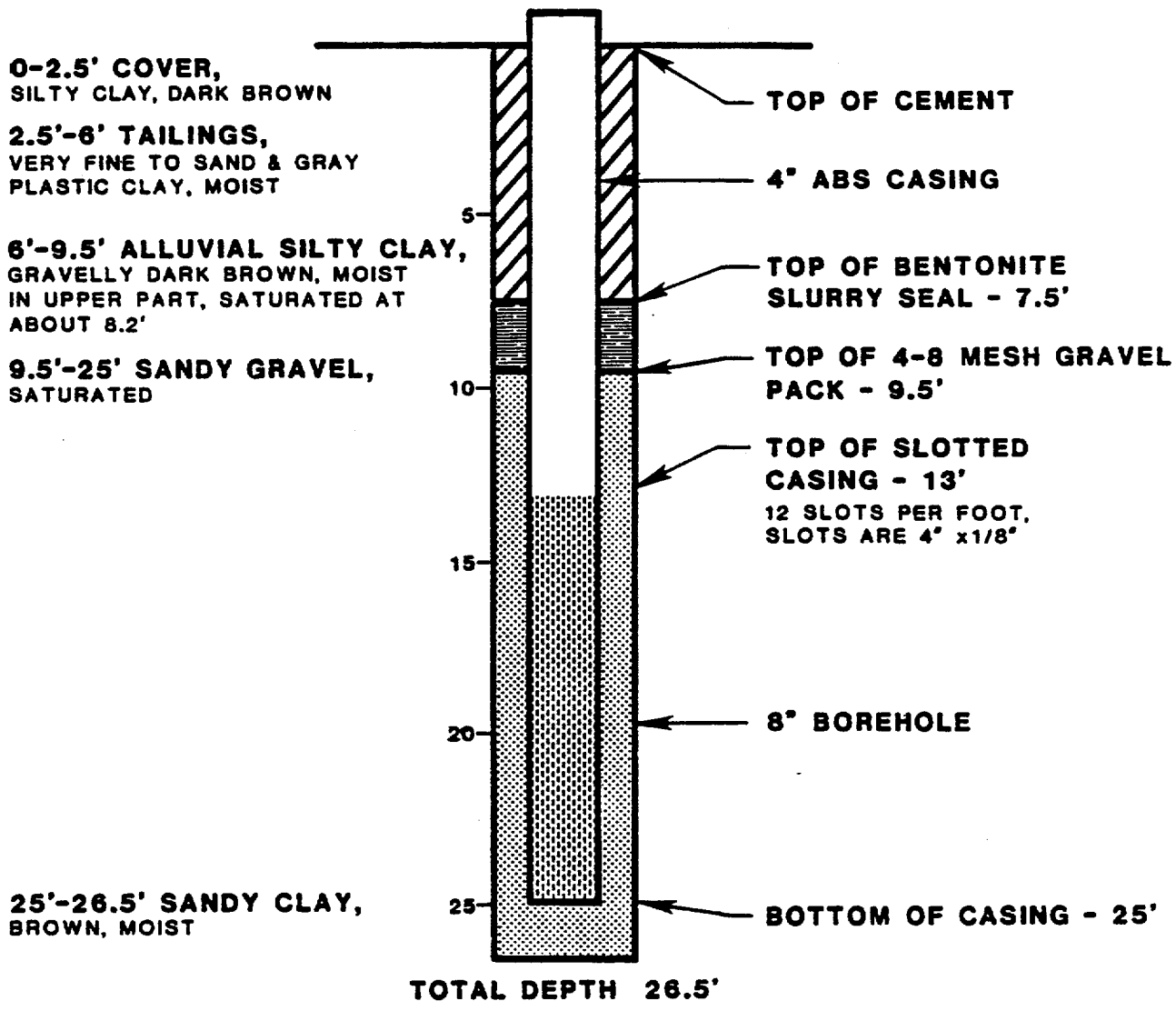


FIGURE D.2.4 FBDU TYPICAL WELL-COMPLETION DIAGRAM

Table D.2.1 TAC identification numbers for FBDU monitor wells

FBDU monitor wells (Figure D.2.3)	TAC-designated[a] site ID code
LKV082-5	LKV01-527
LKV082-6	LKV01-529
LKV082-7	LKV01-530
LKV082-8	LKV01-531
LKV082-9	LKV01-532
LKV082-10	LKV01-528

[a]All data entered into the UMTRA Project Data Base Management System (DBMS) will appear with TAC identification ID's.

Table D.2.2 Lakeview processing site monitor well information

Site code	Location ID	Well installer	Well diameter (in.)	Total depth (ft)	Surface elevation (ft. MSL)	Top of casing (ft. MSL)	Screened interval	
							Begin depth (ft from top of casing)	Length (ft)
LKV01	501	TAC	2.000	27.00	4769.32	4771.05	20.00	5.00
LKV01	502	TAC	2.000	87.00	4769.27	4771.36	79.70	5.00
LKV01	503	TAC	2.000	27.00	4745.89	4747.73	20.00	5.00
LKV01	504	TAC	2.000	79.92	4745.94	4747.63	72.92	5.00
LKV01	505	TAC	2.000	30.00	4742.74	4744.64	23.00	5.00
LKV01	506	TAC	2.000	84.00	4742.91	4744.72	77.00	5.00
LKV01	507	TAC	2.000	25.00	4741.00	4742.77	18.00	5.00
LKV01	508	TAC	2.000	79.00	4740.92	4743.25	72.00	5.00
LKV01	509	TAC	2.000	36.00	4740.06	4742.14	29.00	5.00
LKV01	510	TAC	2.000	77.00	4739.87	4742.30	70.00	5.00
LKV01	511	TAC	2.000	34.00	4746.63	4748.39	27.00	5.00
LKV01	512	TAC	2.000	89.00	4746.35	4748.34	82.00	5.00
LKV01	513	TAC	2.000	24.00	4749.48	4751.47	17.00	5.00
LKV01	514	TAC	2.000	77.00	4749.55	4751.63	70.00	5.00
LKV01	515	TAC	2.000	27.00	4750.97	4753.02	20.00	5.00
LKV01	516	TAC	2.000	79.00	4750.95	4752.94	72.00	5.00
LKV01	517	TAC	2.000	77.00	4753.57	4755.41	70.00	5.00
LKV01	518	TAC	2.000	31.00	4737.55	4739.79	24.00	5.00
LKV01	519	TAC	6.000	42.00	4746.57	4748.78	30.00	10.00
LKV01	520	TAC	6.000	87.00	4746.66	4746.93	70.00	15.00
LKV01	521	TAC	2.000	23.00	4746.52	4748.16	16.00	5.00
LKV01	522	TAC	2.000	59.00	4746.49	4748.45	52.00	5.00
LKV01	523	TAC	2.000	27.00	4758.07	4759.62	20.00	5.00
LKV01	524	TAC	2.000	77.00	4758.12	4759.90	70.00	5.00
LKV01	525	TAC	2.000	31.00	4738.09	4739.96	24.00	5.00
LKV01	526	TAC	2.000	70.00	4737.82	4739.57	63.00	5.00
LKV01	527	FBDU	4.000	25.00	4754.80	4756.36	25.00	12.00
LKV01	528	FBDU	4.000	23.00	4747.50	4749.10	23.00	6.00
LKV01	592	FBDU	4.000	23.00	4749.50	4751.36	23.00	14.00
LKV01	530	FBDU	4.000	16.00	4765.50	4767.84	16.00	9.00
LKV01	531	FBDU	4.000	38.00	4743.20	4744.92	38.00	13.00
LKV01	532	FBDU	4.000	25.00	4742.90	4743.75	22.00	13.00

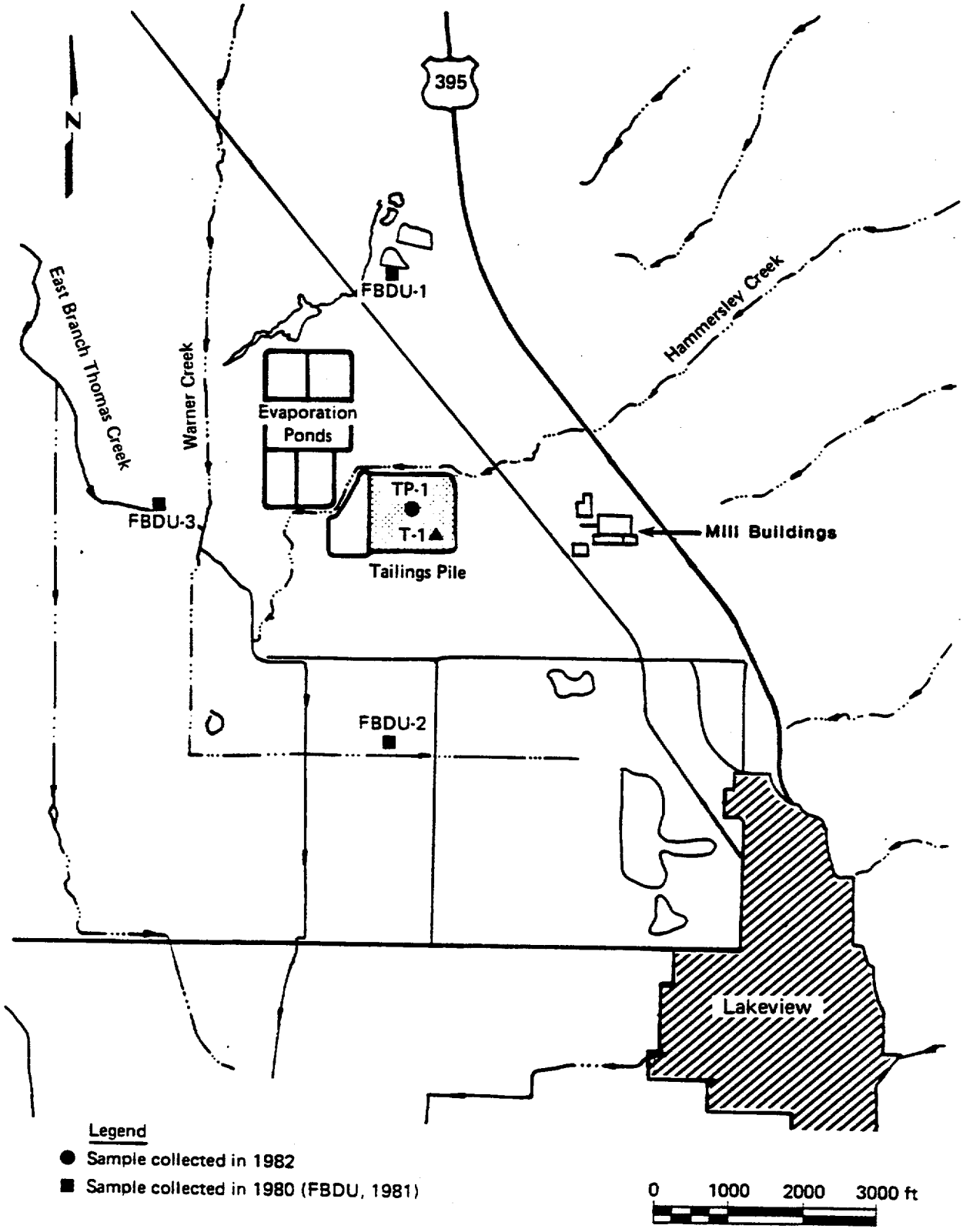


FIGURE D.2.5
LOCATION OF SOIL AND TAILINGS SAMPLES COLLECTED BY FBDU FOR ANALYSES

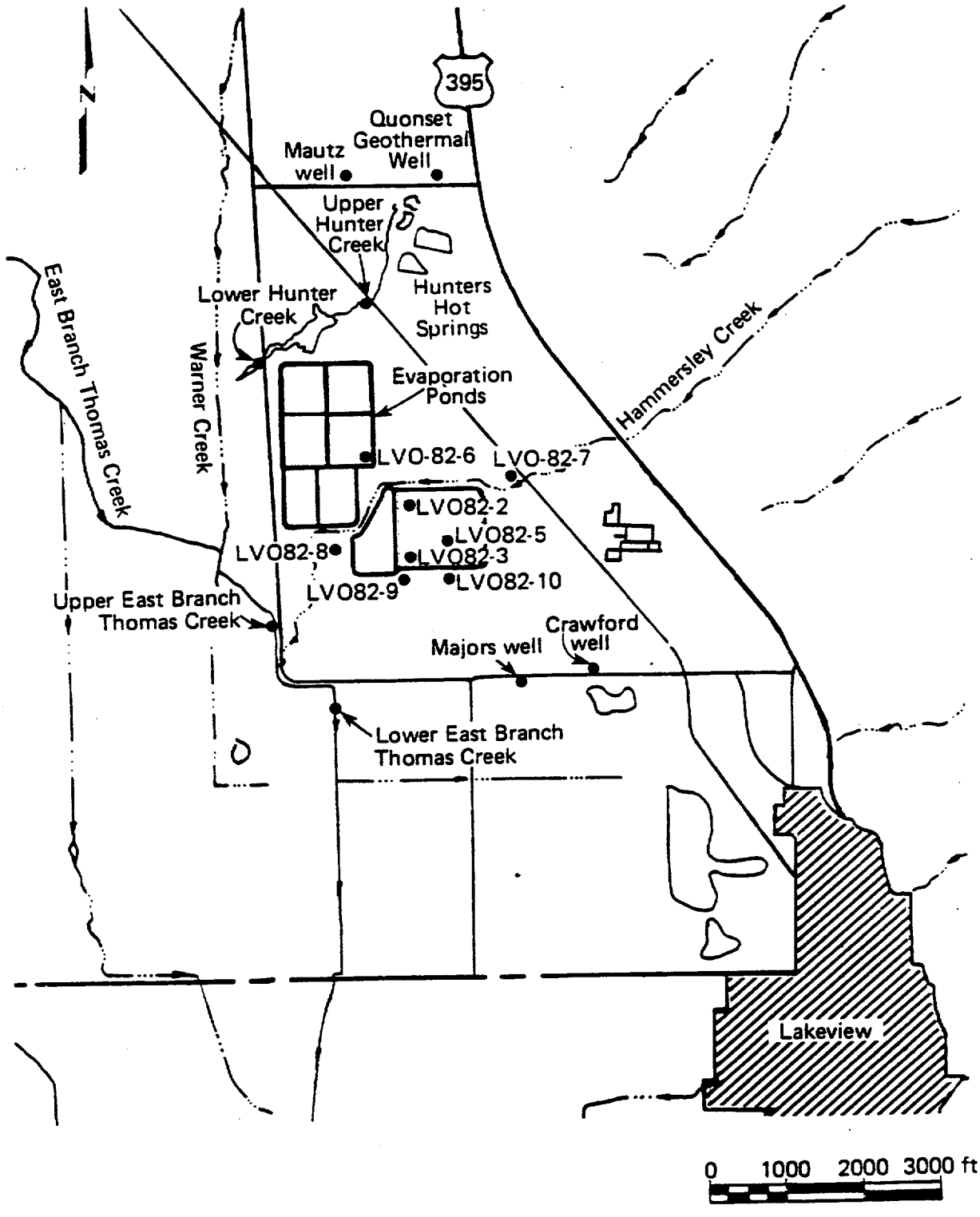


FIGURE D.2.6
FBDU WATER-QUALITY SAMPLING LOCATIONS

acidified in the field in accordance to guidelines established by the United States Geological Survey (USGS, 1977a). Monitor well samples were obtained after removing at least one casing volume of water with a pneumatic pump driven by compressed nitrogen or a peristaltic pump. Measurements of pH, electrical conductivity (Ec), alkalinity, and temperature were all taken in the field. Laboratory analyses were performed by BFEC according to standard techniques referenced in USGS (1977b).

Cover material, tailings, and underlying soil samples were obtained from hand dug test pits. Extracts of the solid samples were analyzed for Ec, pH, arsenic, molybdenum, selenium, uranium, and vanadium. A saturation extract was used to measure pH. The other constituents were measured on acid extracts. Details of the extraction procedures are not available.

The following section describes some of the details of the field data collection program conducted by the TAC. Data collection procedures are set forth in the Jacobs Engineering Standard Operating Procedures (SOP) manual available from the Jacobs Engineering Group, Albuquerque Operations Office.

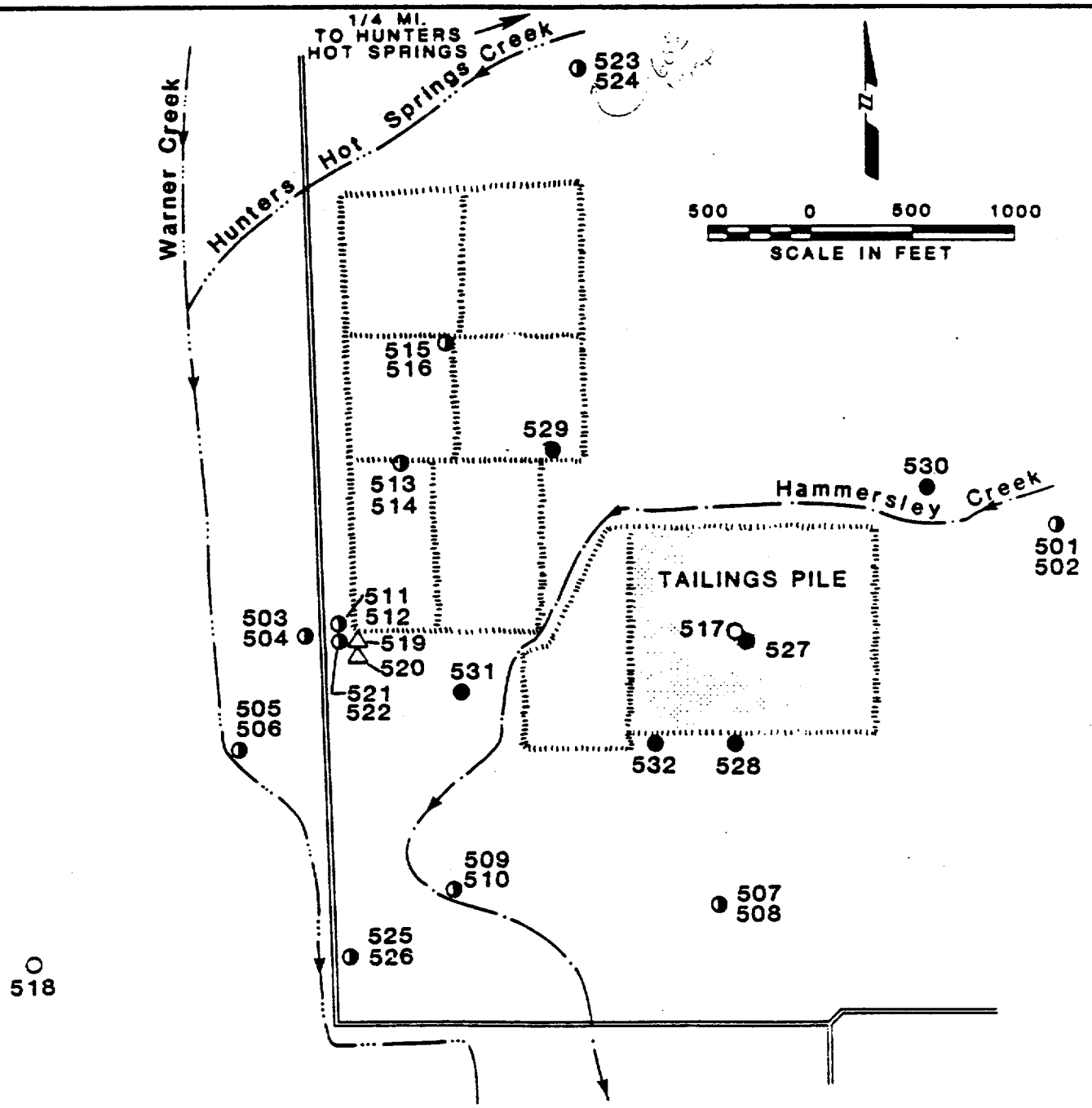
The TAC drilling program consisted of 26 boreholes at the processing site and 16 boreholes at each of the alternate sites. Locations of the holes are shown in Figures D.2.7, D.2.8, and D.2.9. Processing site well information is presented in Table D.2.2.

Lakeview processing site

In order to improve accuracy in locating and completing monitor wells and to define the extent of ground-water contamination, electromagnetic induction (EM) and surface electrical resistivity (ER) profiling were conducted to map apparent ground conductivity at and around the Lakeview site. Three hundred sixteen (316) electromagnetic induction measurements and twenty-eight (28) electrical resistivity measurements were made on a survey grid of 150-foot centers over an area of approximately 500 acres. Geophysical instruments used were a Geonics EM 34-3 Terrain Conductivity Meter and a Soil Test R-60 Earth Resistivity Meter.

Conductivity data were processed on a Univac 1160 mainframe, Tektronix 4014 terminal, and Tektronix 4663 plotter, with a CPS-1 contouring program. Contour intervals were chosen to show trends in areas of subtle changes in conductivity while maintaining distinction in areas of major conductivity contrasts.

The 26 boreholes at the processing site were completed as monitor well pairs screened at approximate depths of 20 to 25 feet and 70 to 75 feet. Wells were screened in the most permeable zones based upon drill cuttings. Borehole logging,



LEGEND

- △ 6-INCH PUMP WELL
- ● 4-INCH MONITORING WELL
- ◑ 2-INCH MONITORING WELL PAIR
- ○ 2-INCH MONITORING WELL
- EVAPORATION POND
- INTERMITTENT FLOW
- CONTINUOUS FLOW

FIGURE D.2.7

TAC LAKEVIEW PROCESSING SITE MONITOR WELLS

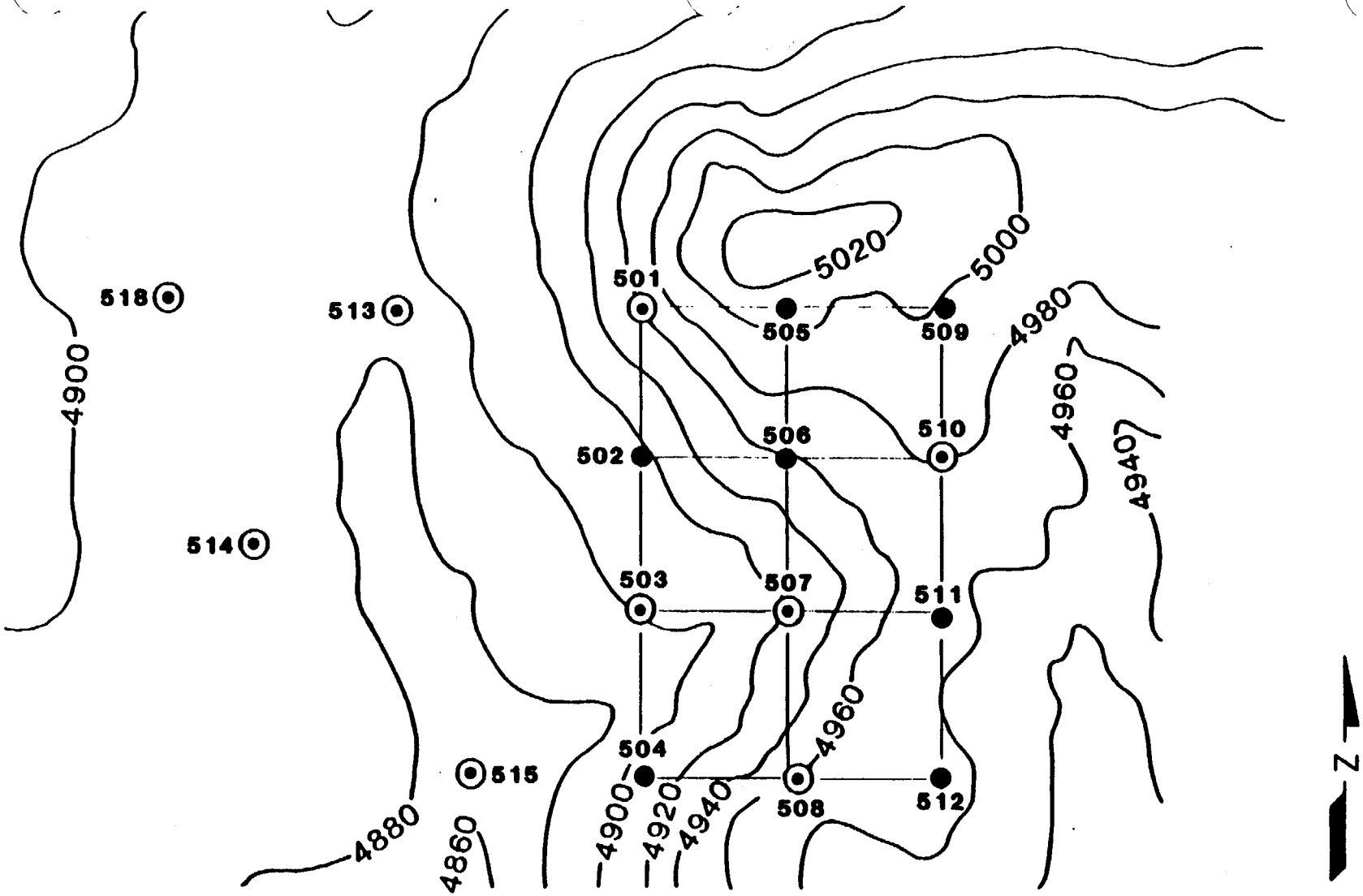


FIGURE D.2.8 TAC COLLINS RANCH SITE BORINGS

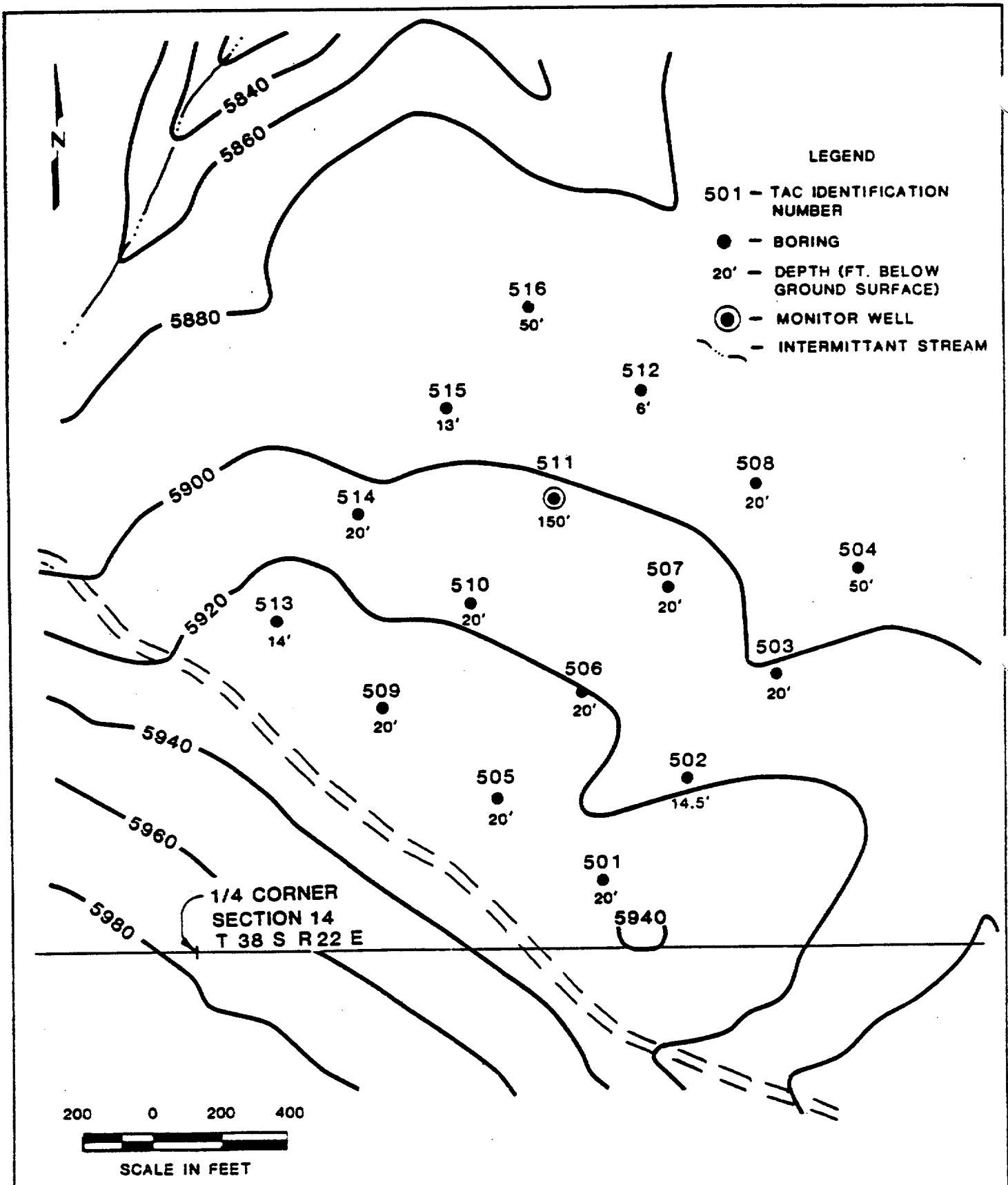


FIGURE D.2.9
TAC FLYNN RANCH SITE BORINGS

where are these samples?

soil sampling, drilling procedures, and monitoring well installation procedures are presented in the Jacobs Engineering Group, Standard Operating Procedures Manual. Wells were spaced and installed to accommodate an aquifer test in each of the screened zones. Well 521, near the pumping wells, was screened at 16 to 21 feet. Well 522 was screened at 52 to 57 feet to test for vertical response during pump testing. Slug tests were performed in 18 of the completed wells to obtain an indication of local variations in hydraulic conductivity. These tests were conducted according to procedure 8.2.10 in the Standard Operating Procedures Manual (SOP, 1984).

All wells were sampled two weeks after well development according to standards in Section 8.2.9 of the Standard Operating Procedures Manual. Additional water samples collected by the TAC included nearby surface water, FBDU wells, and domestic wells within 1.5 miles of the site.

Four pressure-vacuum soil-water samplers were installed in the corner of the southwest evaporation pond (Figure D.2.10). These were installed at one-foot depth intervals and sampled before, during, and in the latter stages of the pump test. Three suction water samplers were installed in the tailings pile near well LKV01-517. Two were placed in slime layers at 2.5- to 3.0-foot depths and one was placed in a sand layer at a 2.5-foot depth.

Near the end of September, 1984, suction-water samplers were removed from the evaporation pond and tailings pile to prevent damage to the sampler from freezing. Water-quality analyses for suction water samples are not available at present.

Collins Ranch alternate disposal site

All data collection efforts at the Collins Ranch site were initiated by the TAC as part of the alternate site selection process. To assess ground-water conditions, 16 boreholes were drilled. Nine were completed as monitor wells of which five encountered ground water. Figure D.2.8 shows the locations of these wells. Table D.2.3 presents monitor well information for both alternate sites. Twelve boreholes were drilled on a 400- x 300-foot grid along the ridge and the southwest side of Augur Hill aligned along the Section 11 fenceline. Another four boreholes were drilled in a small valley in Section 12 at the base of the hill. The holes were lithologically logged, disturbed soil samples were taken, and slug tests performed in five monitoring wells. Wells were sampled two weeks after development in order to define existing water chemistry. Ground-water levels will be monitored through at least June, 1985, to note seasonal fluctuations in the water table.

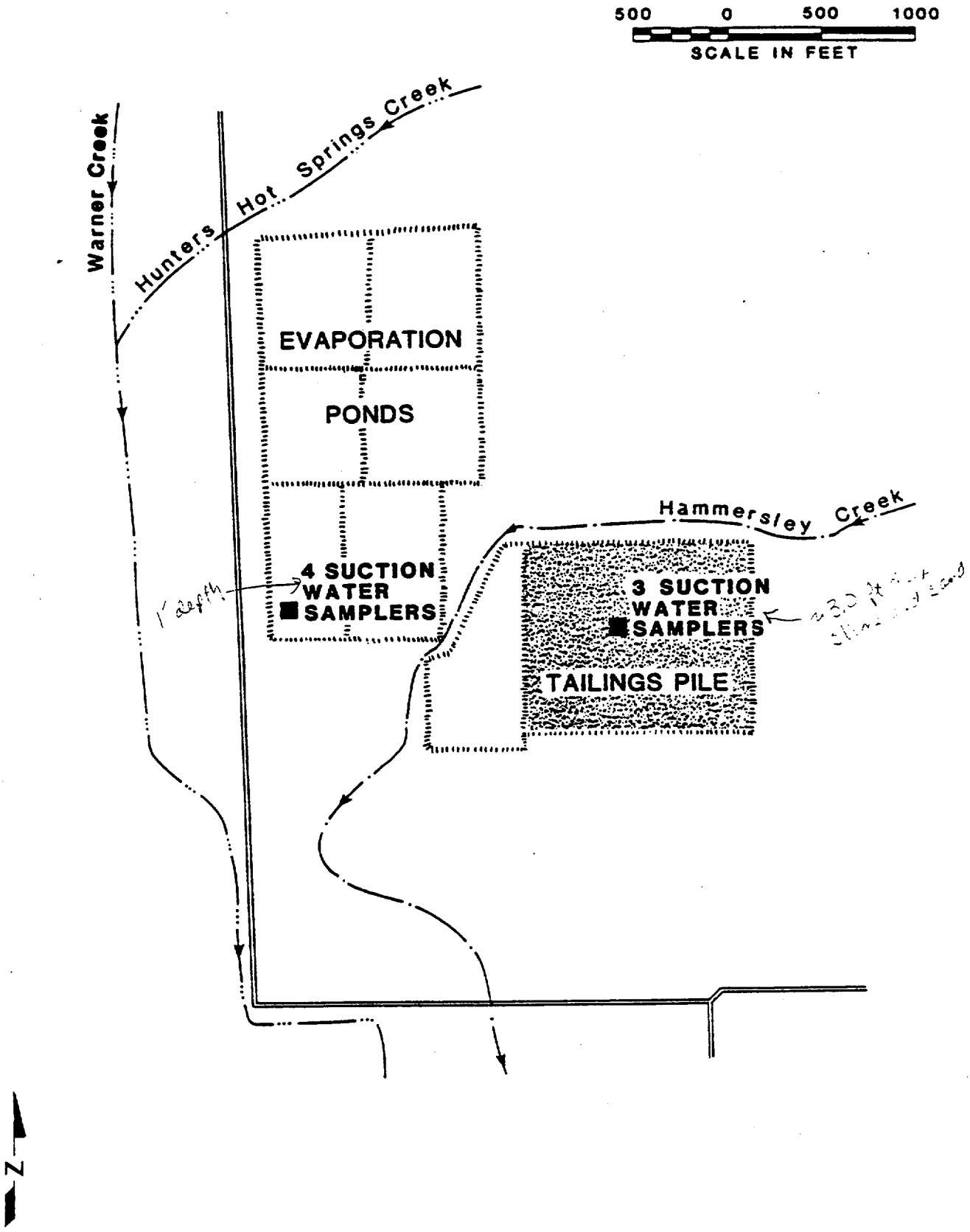


FIGURE D.2.10

SOIL SUCTION WATER SAMPLERS AT THE LAKEVIEW PROCESSING SITE

Table D.2.3 Collins Ranch and Flynn Ranch alternate disposal site monitor well information

Site code[a]	Location ID	Well installer	Well diameter (in.)	Total depth (ft)	Surface elevation (ft. MSL)	Top of casing (ft. MSL)	Screened interval	
							Begin depth (ft below ground water)	Length (ft)
LKV02	501	TAC	2.000	48.00	4953.82	4956.09	42.00	5.00
LKV02	503	TAC	2.000	47.00	4905.86	4907.54	36.00	5.00
LKV02	507	TAC	2.000	78.00	4929.32	4931.72	71.00	5.00
LKV02	508	TAC	2.000	91.00	4922.71	4924.81	84.00	5.00
LKV02	510	TAC	2.000	127.00	4984.63	4986.30	120.00	5.00
LKV02	513	TAC	2.000	27.00	4890.35	4891.97	20.00	5.00
LKV02	514	TAC	2.000	22.00	4886.46	4888.08	15.50	5.00
LKV02	515	TAC	2.000	27.00	4874.28	4875.81	20.00	5.00
LKV02	516	TAC	2.000	22.00	4892.69	4894.37	15.50	5.00
LKV03	511	TAC	2.000	152.00	5904.89	5907.07	147.00	5.00

[a]LKV02 indicates Collins Ranch alternate disposal site.
LKV03 indicates Flynn Ranch alternate disposal site.

Flynn Ranch alternate disposal site

Sixteen boreholes were drilled as shown in Figure D.2.9. One 150-foot hole was completed as a monitor well and encountered no water. The holes were lithologically logged and packer tests were conducted in three of the holes. Packer test methods are outlined in Section 8.2.11 of the Standard Operating Procedures Manual.

Borrow sites

No hydrologic data were collected at the proposed borrow sites proximal to the Collins Ranch and Flynn Ranch sites. Borings and tests pits were completed at borrow sites in order to collect lithologic and soil property information. The procedures used and the data collected are on file at the UMTRA Project Office in Albuquerque, New Mexico.

D.2.3 DATA SUMMARY

The ensuing sections summarize collected data and report assessments of the geology, hydrogeology, ground-water hydraulics, and ground-water quality. Preliminary site investigation by FBDU centered on the tailings pile and the immediate surrounding area. Hydrologic investigation by the TAC extended the field investigation 2,000 feet downgradient beyond the site boundary and included investigatory drilling at two alternate disposal sites. GECR collected geochemical data at the processing site, adjacent area, and background sites within the Goose Lake Valley. Each source of data is used in developing a conception of the existing ground-water regime and as a basis for predicting future impacts resulting from remedial action plans.

See ?.D11

D.2.3.1 Geology

The Lakeview site and alternate disposal sites are located within the Great Basin section of the basin and range physiographic province. This northwest part of the basin and range is cut by a series of northwest-trending faults bounding blocks that form a series of horsts and grabens. The Lakeview processing site is located within the Goose Lake graben bounded by the Fremont Mountains to the west and the Warner Mountains one mile to the east. The Collins Ranch alternate disposal site is on the western edge of the valley at the base of the Fremont Mountains. The Flynn Ranch alternate disposal site is located in the adjacent Warner Valley located on the eastern side of the Warner Mountains. The valleys contain mostly Tertiary-Quaternary alluvial deposits and lacustrine sediments, and the horst blocks are composed of Miocene to Pliocene tuffs, basalt flows, and glassy rhyolitic extrusions (Peterson, 1959).

Lakeview processing site

The Lakeview uranium mill site is approximately 0.5 mile west of the Goose Lake graben fault that separates the valley and the Warner Mountains. Lithologic logs from twelve 75-foot borings in the immediate site area show sequences of discontinuous lenses of silty to sandy clays and silty sands with fine gravel. A sample borehole log is shown in Figure D.2.11. This sequence of fine-grained sediments continues to a depth of at least 2000 feet below the site, becoming more consolidated with depth (Brown et al., 1980). The sediments are interfingered and discontinuous. Attempts to develop a generalized geologic profile were unsuccessful. Deposits could not be correlated between four boreholes less than 20 feet apart located outside the western edge of the evaporation ponds (Figure D.2.7).

The site lies within a designated Known Geothermal Resource Area (KGRA), and geothermal activity is generally associated with the major mountain front fault systems which form the horst and graben topography (Blackwell et al., 1978). This part of the basin and range province is an area of high heat flow with convective upwelling along major faults. Geothermal anomalies have been observed in the form of a geyser 0.4 mile north of the site, known as Hunters Hot Springs. Water temperatures of 60°C encountered in TAC well 524 immediately north of the evaporation ponds and a four-inch blow hole opening through snow on the southeast evaporation pond observed on January 27, 1984, also are indications of geothermal activities in the area.

Collins Ranch alternate disposal site

Lithology at the Collins Ranch alternate disposal site is similar to the Lakeview processing site, with a prevalence of finer grained sediments. Attempts to develop generalized stratigraphic profiles across the site proved unsuccessful due to the complexity of the materials encountered. In general, the subsurface conditions at the site consist of interfingered and layered silty sands, sandy silts, and surficial lenses of high plasticity clays. These materials, encountered to depths of 127 feet, form the slopes of Augur Hill, and represent a remnant pediment of outwash deposits from the nearby Fremont Mountains. Depth to bedrock is undetermined, but depth of Quaternary sediments is estimated to be 1000 feet, based upon depth of sediments encountered along the eastern edge of the Goose Lake Basin. Lithologic borehole logs are on file in the UMTRA Project Office, Albuquerque, New Mexico. The complexity of the deposits prevented the development of a generalized geologic profile of the site.

Flynn Ranch alternate disposal site

The Flynn Ranch alternate disposal site is underlain by Miocene and Pliocene basalt flows (Walker, 1963) that compose

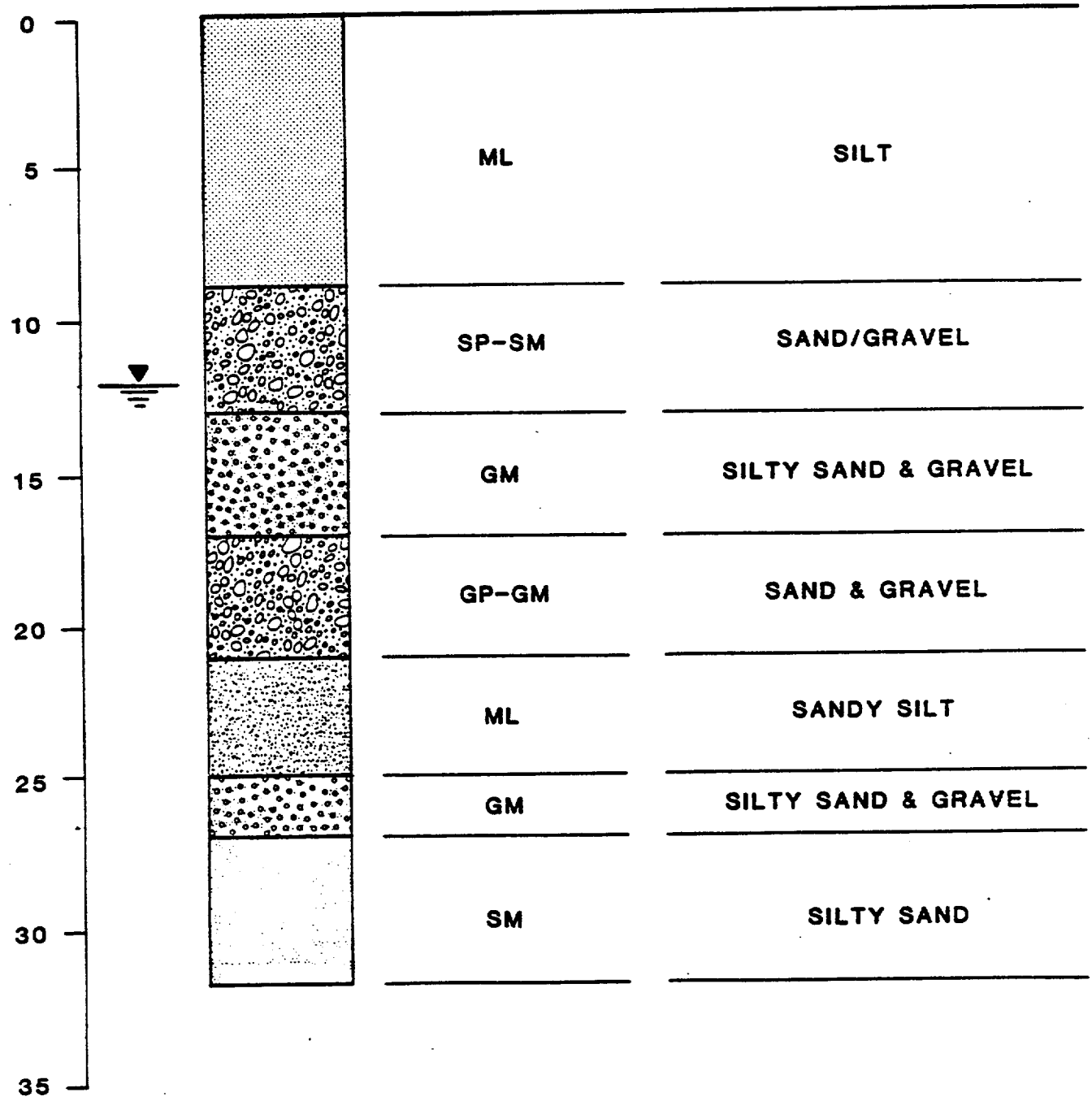


FIGURE D.2.11

SAMPLE BOREHOLE LOG FOR LAKEVIEW PROCESSING SITE

the Warner Mountain horst block. Borehole logs up to 152 feet show the site is covered by two to six feet of clayey sands or sandy clay resting upon a series of thin (20 to 35 feet) basalt flows. The upper half of each flow consists of moderately to very weathered, reddish brown, fractured basalts, and the lower half is composed of dark grey vesicular, slightly to very fractured basalts, with some voids up to three feet. Below 20 feet, fractures are clay filled. A sample lithologic log is shown in Figure D.2.12.

D.2.3.2 Hydrogeology

Lakeview processing site

Ground water in the valley fill deposits at the Lakeview processing site occurs under unconfined to confined conditions. Characterization efforts of the TAC field program centered upon the zone above 100 feet, within the predictable limits of vertical contaminant migration. Within this zone, ground water occurs under unconfined to semi-confined conditions within the unconsolidated deposits. FBDU monitor wells were screened generally in a zone from nine to 25 feet, and TAC monitor wells were paired, with screened zones set at 20 to 25 feet and 70 to 75 feet. Water levels taken from the total monitor well array show from two to 12 feet difference in water levels in well pairs indicating a small downward vertical hydraulic potential that decreases from northeast to southwest across the site. Ground-water movement within the sediments also is influenced in some areas by upward moving geothermal water. This is noted in TAC well pair 523 and 524 (Figure D.2.7) where only a difference of 0.13 foot in water levels was noted and measured water temperatures were 41°C and 60°C, respectively.

Contours of water-level measurements from wells screened within the shallow zone result in a potentiometric map indicating ground-water movement from the northeast to the southwest under a hydraulic gradient of 0.01 (Figure D.2.13). Recharge to the shallow aquifer occurs via snowmelt, precipitation, irrigation seepage, and upward moving geothermal water along fault zones. Local discharge occurs via shallow domestic wells and along surface-water channels that drain the basin to Goose Lake.

There are approximately 20 to 40 domestic wells in Sections 4 and 9, T39S, R20E, the processing site section, and south adjacent section (Kapustka, 1974). Differences in water levels between shallow (100 feet deep) and deep (450 feet deep) wells are not great, hence strong vertical flow gradients are unlikely, and the entire sequence of sediments behaves as a single leaky aquifer system (USEPA, 1974). Two 24-hour aquifer tests conducted by the TAC in the 20 to 25 foot zone and in the 70- to 75-foot zone showed communication between the two zones in the immediate area of the pumped

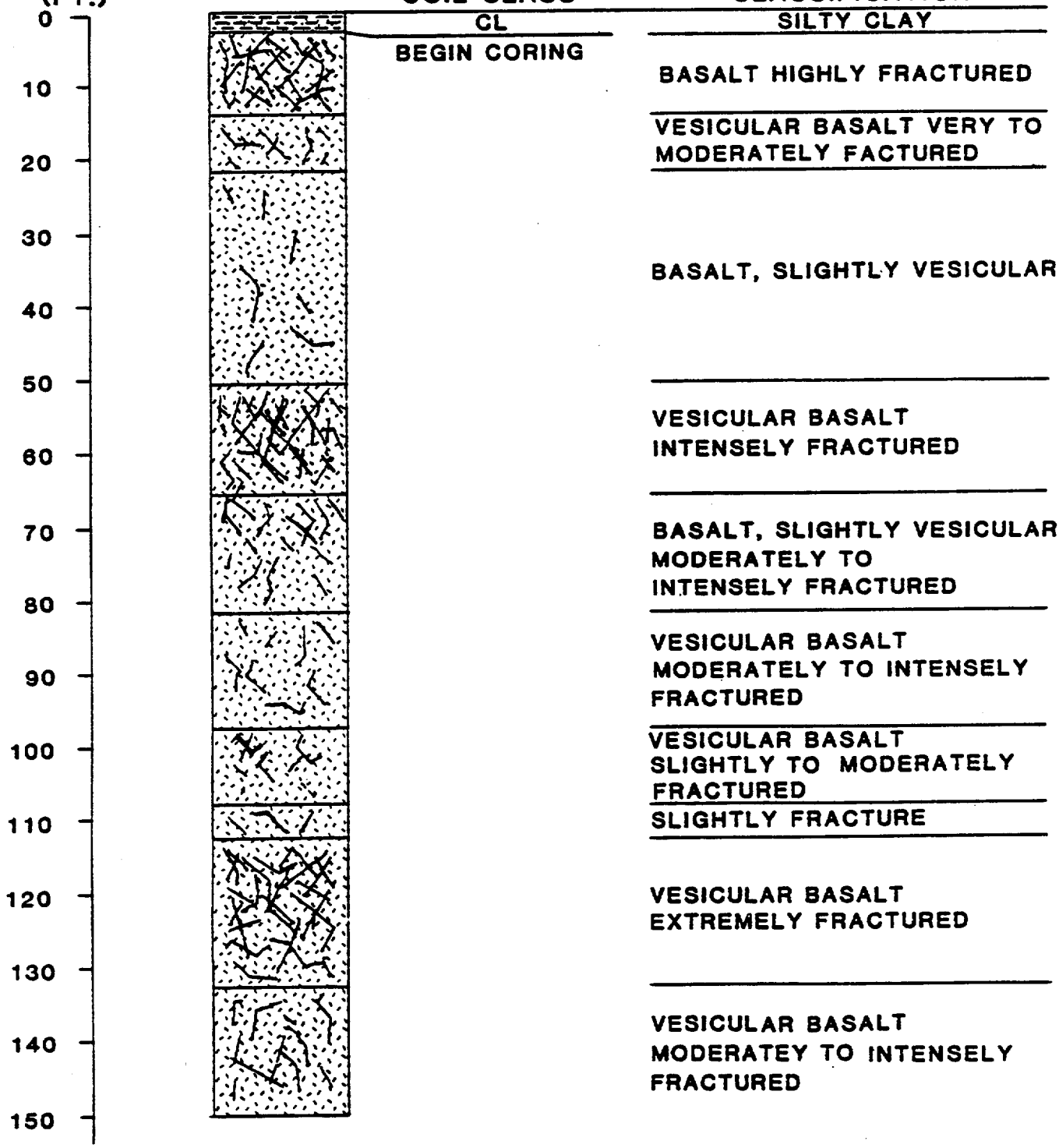
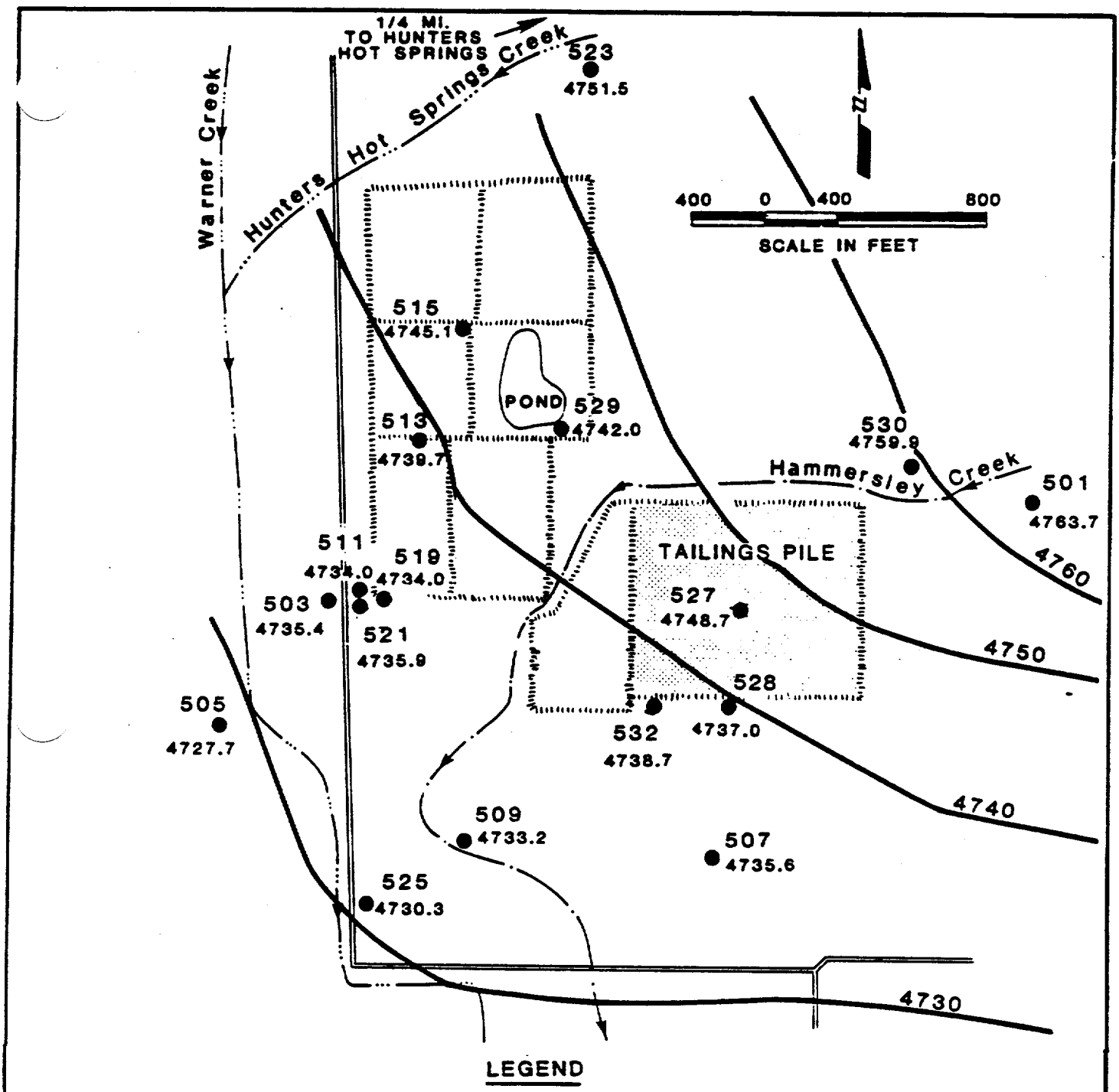


FIGURE D.2.12

SAMPLE BOREHOLE LOG FOR FLYNN RANCH



LEGEND

- EVAPORATION POND
- INTERMITTENT FLOW
- CONTINUOUS FLOW
- 4740 – WATER LEVEL CONTOUR (FT. M.S.L.)
- 507 – LOCATION ID
- ● – MONITOR WELL – SCREENED IN SHALLOW ZONE
- 4735.6 – WATER LEVEL ELEVATION (FT. M.S.L.)

DATE?

FIGURE D.2.13
POTENTIOMETRIC SURFACE OF SHALLOW AQUIFER AT THE LAKEVIEW PROCESS SITE

wells. Water level changes up to 0.42 foot were noted in the unstressed system within a 25-foot radius of the pumped well while pumping from the shallow or deeper zone.

Collins Ranch alternate disposal site

Ground water was encountered in five of the nine boreholes completed as monitor wells. Four shallow wells (22 to 27 feet) in the valley, just west of the site boundary, show water-table conditions with depths to ground water from seven to 18 feet (December, 1984). One 78-foot well drilled near the course of a broad drainage channel on the southwest slope of Augur Hill showed ground water at 76 feet below ground surface. Based upon the five measured water levels (in December, 1984), a potentiometric map was constructed (Figure D.2.14). Ground water moves from northwest to south-southeast under a hydraulic gradient of approximately 0.018. The ground-water flow direction appears to be opposite the topographic slope indicating most recharge is from the Fremont Mountains to the west, rather than the small areal drainage divide immediately above the proposed disposal site. In order to evaluate seasonal ground-water fluctuations, water levels will be measured weekly to monthly through at least June, 1985.

Flynn Ranch alternate disposal site

All sixteen boreholes drilled on a 1200-foot grid at the Flynn Ranch site encountered no ground water. The lithology logged from the 150-foot monitor well LKV03-511 (Figure D.2.12) show that vesicular zones, highly weathered zones, and unhealed cooling fractures and voids are potential pervious zones for water movement. The apparent absence of shallow ground water may indicate that most local precipitation and snowmelt is lost through evaporation and surface-water runoff. Alternatively, structural barriers such as tilting or faulting may create areas with discontinuous, lowered ground-water levels.

D.2.3.3 Ground-water hydraulics

Flow direction, hydraulic gradient, hydraulic conductivity, storativity, porosity, and vertical-horizontal flow relationships are required to model lateral and vertical flow for prediction of short- and long-term impacts. Information on flow direction and hydraulic gradient for each of the sites has been presented in Section D.2.3.2. Hydraulic parameters such as hydraulic conductivity, storativity, and porosity define the water-yielding capacity of an aquifer. Both pumping tests and slug tests have been conducted at the Lakeview processing site. Slug tests and packer tests have been conducted respectively at the Collins Ranch and Flynn Ranch alternate disposal sites.

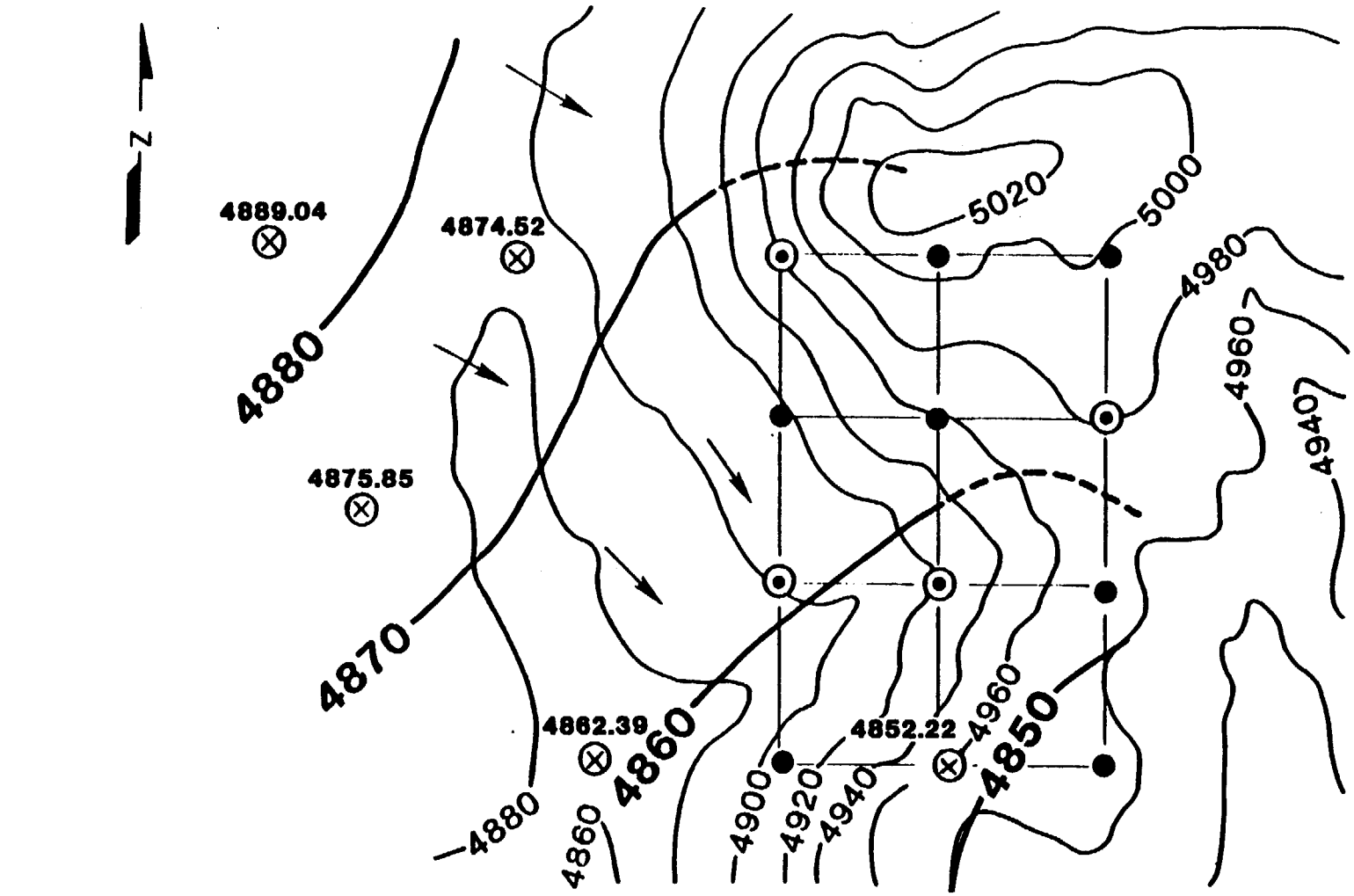


FIGURE D.2.14 POTENTIOMETRIC SURFACE AT COLLINS RANCH SITE

Lakeview processing site

A 24-hour aquifer test (pump test) with 24-hour recovery was conducted in each of two screened zones. Results from the aquifer tests represent average local hydraulic conditions within the radius of influence of the pumping well. Results of the tests are presented in Table D.2.4 and test summaries in Table D.2.5. The average calculated transmissivity is 74 ft^2/day in the deeper zone and 13.6 ft^2/day in the shallow zone. The storage coefficient represents the volume of water released from storage per unit of surface area of the aquifer per unit change in head. The average calculated storage coefficient for the deeper zone is 4.5×10^{-4} and the shallow zone is 2.0×10^{-4}. Storage values for the shallow system are somewhat low indicating that ground water in shallow-screened wells in the vicinity of LKV01-519 (pumping well) is under semi-confined conditions. Hydraulic conductivity (K), the capacity of the formation to transmit water, was measured from slug test data, and results are presented in Table D.2.6. These hydraulic conductivities represent local hydraulic capacities over the screened zone tested. The tests indicate the relative hydraulic variability between tested intervals. An average calculated value of hydraulic conductivity is 3.04 ft/day for the shallow zone and 2.37 ft/day for the deeper zone. These values fall within the range of hydraulic conductivities reported for silt losses and silty sands presented in Freeze and Cherry (1979).

Hydraulic conductivity values determined from aquifer test data analyses averaged 1.4 ft/day in the shallow zone and 4.4 ft/day in the deeper zone. An average of slug test results showed higher hydraulic conductivity in the shallow zone (3.0 ft/day) and lower hydraulic conductivities in the deeper zone (2.4 ft/day). Differences in results may be attributed to differences in the radial extent of the aquifer tested in each method. Slug tests only test a small radial zone immediately around the well screen. The aquifer tests tested a radial zone of a hundred feet and were influenced by vertical leakage based upon measured drawdowns in observation wells. The apparent reversal of relative hydraulic conductivities between shallow and deep zones indicates that vertical leakage may be a significant component in deeper saturated zones. All data and calculations are on file at the UMTRA Project, Albuquerque Operations Office.

Are these available?

Collins Ranch alternate disposal site

Table D.2.7 displays results and Table D.2.8 summarizes averages from five slug tests conducted at the Collins Ranch alternate disposal site. An averaged value of hydraulic conductivity is 0.64 ft/day for sediments above 87 feet at the site. These finer grained deposits are slightly less permeable than deposits underlying the processing site.

Table D.2.4 Results of Lakeview aquifer test

Deep Test
Q = 12.40 gpm (flow meter method)

Well ID	Screened interval (ft from ground surface)	Radial distance from pumped well (ft)	Drawdown after 24 hours (ft)
LKV-520	70-85	0	23.0
LKV-522	52-57	25	2.34
LKV-512	82-87	25	11.61
LKV-504	73-78	140	6.74
LKV-506	77-82	460	0.53
LKV-519	30-40	6	0.25
LKV-521	16-21	30	0.13
LKV-511	27-32	25	0.20
LKV-503	20-25	140	-0.35[a]

Shallow Test
Q = 0.60 gpm (bucket and stopwatch method)

LKV-519	30-40	0	9.62
LKV-511	27-32	25	3.93
LKV-521	16-21	30	0.97
LKV-503	20-25	140	0.63
LKV-505	23-28	460	0.05
LKV-520	70-85	6	0.42
LKV-522	52-57	25	0.15
LKV-512	82-87	25	0.37

[a]Indicates water level rise rather than drawdown.

Table D.2.5 Lakeview aquifer test summary

Deep Test/pumped well: LKV-520
screen 70-85 feet

Q = 12.4 gpm
s = 23.0 ft

Well ID	Screened interval (dfg) ft	Radial distance from pump well (ft)	Method of analysis	Transmissivity (ft^2/d)	Hydraulic conductivity, K (ft/day)[b]	Storage coefficient S
LKV-522	52-57	25	Jacob-Cooper	250	5.7	2.8×10^{-2}
LKV-522	52-57	25	Boulton	264	6.0	5.0×10^{-2}
LKV-512[a]	82-87	25	Jacob-Cooper	93 <	5.8 <	6.8×10^{-4}
LKV-512[a]	82-87	25	Boulton	91 <	5.7 <	8.4×10^{-4}
LKV-504[a]	73-78	140	Jacob-Cooper	98 <	5.4 <	2.6×10^{-4}
LKV-504[a]	73-78	140	Hantush	14 <	0.78<	4.0×10^{-6}
LKV-506[a]	77-82	460	Jacob-Cooper	624	8.9	1.2×10^{-3}

$\overline{S} = 4.5 \times 10^{-4}$ $\overline{T}_{Test}$ 74 ft^2/d $\overline{K}_{Test} = 4.4$ ft/d

Shallow Test/pumped well: LKV-519
screen 30-40 feet

Q = .60 gpm
s = 9.6 ft

LKV-511[a]	27-32	25	Jacob-Cooper	6.3 <	1.26 <	1.7×10^{-4}
LKV-511[a]	27-32	25	Theis	4.6 <	0.92 <	3.1×10^{-4}
LKV-521	16-21	30	Jacob-Cooper	175	10.9	4.9×10^{-3}
LKV-521	16-21	30	Boulton	46	2.8	2.8×10^{-3}
LKV-503	20-25	140	Jacob-Cooper	118	7.4	8.9×10^{-6}
LKV-503	20-25	140	Boulton	30 <	1.9 <	1.2×10^{-4}

$\overline{S} = 2.0 \times 10^{-4}$ $\overline{T}_{Test} = 13.6$ ft^2/d $\overline{K}_{Test} = 1.36$ ft/d

[a]Screened over interval of pumping well.
<Indicates value was used in determining average value.
[b]Calculated by dividing transmissivity by the estimated saturated thickness of the aquifer.

Table D.2.6 Lakeview slug test results

Well ID	Interval	$K_{(screened\ interval)}$[a]			T	
		SK[b]	BR	HSV	SK	BR[c]
		(ft/day)			(ft^2/day)	
LKV01-502	80-85	0.25	0.52	0.13	1.24	2.6
LKV01-512	82-87	14.0[d]	2.46	16.3	70.2[d]	12.3
LKV01-514	70-75	0.04	0.37	0.30	0.21	1.85
LKV01-516	72-77	11.6	--	--	58.0	--
LKV01-522	52-57	2.52[d]	2.6	6.1	12.6[d]	13
LKV01-524	70-75	0.62	0.30	0.35	3.10	1.50
LKV01-517	70-75	9.25[d]	1.85	1.9	47.6[d]	9.25
LKV01-526	63-68	0.24	0.39	0.45	1.2	1.95
LKV01-501	20-25	12.4[d]	4.8	5.6	61.9[d]	24.0
LKV01-503	20-25	1.03	0.31	0.99	5.16	1.55
LKV01-505	23-28	7.44	0.13	21.9	37.2[d]	0.65
LKV01-511	27-32	2.28	1.67	10.1	11.4	8.35
LKV01-513	17-22	0.74	0.93	1.45	3.7	4.65
LKV01-515	20-25	1.06	3.7	3.7	5.3	18.5
LKV01-521	16-21	0.57	1.1	3.1	2.9	5.5
LKV01-523	20-25	--	1.43	2.9	--	7.15
LKV01-525	24-29	6.24[d]	--	--	31.2[d]	--
LKV01-518	24-29	116.7[d]	2.1	9.03[e]	583.4[d]	10.5

[a] SK is Skibitzke Method of analysis; BR is Bouwer-Rice Method of analysis; HSV is Hvorslev Method of analysis.
[b] Calculated by: T/screened interval [L].
[c] Calculated by: multiplying K by the length of screened zone.
[d] Indicates time (t) is too short for valid analysis by Skibitzke Method.
[e] Few data points for analysis.

Table D.2.7 Collins Ranch slug test results

Well ID	Screened interval (ft)	Hydraulic conductivity K (ft/day)[a]			Transmissivity T (ft^2/d)	
		SK[b]	BR	HSV	SK	BR[c]
LKV02-508	84-89	3.17[d]	0.73	1.8	15.87[d]	3.65
LKV02-513	20-25	1.46[d]	0.90	0.78	7.28[d]	4.5
LKV02-514	15.5-20.5	0.69	0.70	0.42	3.44	3.5
LKV02-515	20-25	3.9[d]	0.92	2.1	19.56[b]	5.6
LKV02-516	15.5-20.5	0.05	0.08	0.15	0.25	0.40

[a]SK is Skibitzke Method of analysis; BR is Bouwer-Rice Method of analysis; HSV is Hvorslev Method of analysis.

[b]Calculated by T/screened interval (ft).

[c]Calculated by multiplying K by the length of screened interval.

[d]Indicates short time (t <20 min) for valid analysis by Skibitzke.

Table D.2.8 Collins Ranch slug test summary

Well ID	Average hydraulic conductivity K (ft/d)	Average transmissivity T (ft^2/d)
LKV02-508	1.3	3.7
-513	0.84	4.5
-514	0.56	3.5
-515	1.5	4.6
-516	0.12	0.40
=========	=====	====
Geometric average for all tested wells[a]	0.64 ft/day	2.5 ft^2/day

[a]Geometric average is used since each interval tested in the wells can be considered a homogeneous isotopic layer, with a unique K, and the whole system may be better represented by the geometric mean of all K's.

Flynn Ranch alternate disposal site

Packer tests were conducted in three of the boreholes at the Flynn Ranch alternate disposal site. These tests measured the capacity of a localized zone between packers to accept water pumped under pressure into the unsaturated formation. Two tests in borehole LKV03-04 at an interval from seven to 14 feet and in borehole LKV03-16 at an interval from 38 to 43 feet gave horizontal hydraulic conductivities of 0.13 and 0.82 ft/day, respectively. Another test in borehole LKV03-13 in the seven- to 14-foot interval produced "no take" readings before the pressure blew the packer. Discussion of results and the analytical methods are presented in Section D.2.4.1.

D.2.3.4 Ground-water quality

Ground-water quality data were reviewed with respect to current and projected water use and with respect to Federal and State of Oregon water-quality standards. These standards are presented in Table D.2.9. An evaluation of local water use is presented in Section D.2.5. Relative differences in concentrations of dissolved species between upgradient and downgradient wells often represent tangible evidence of the extent of plume migration from the processing site. Assessment of ground-water quality at alternate disposal sites provides a baseline data base for predictive geochemical mixing models and for future surveillance and monitoring programs. Collected data are presented in this section and geochemical analysis of the data is presented in Section D.2.4.2.

Lakeview processing site

Water-quality data collected in the Lakeview area include GECR background surface-water samples, TAC and FBDU monitor well samples, and TAC and FBDU domestic well and surface-water samples. Table D.2.10 presents designated location identification numbers and corresponding location descriptions for TAC and FBDU sampling programs. Locations of domestic wells and surface-water samples (ID numbers 533-609) are shown in Figure D.2.15. Table D.2.11 and Table D.2.12 present results of chemical and radiometric analyses of TAC samples and FBDU samples from ground-water monitor wells installed within and immediately outside the Lakeview processing site (Figure D.2.7 and Figure D.2.3). Analytical results are in agreement except for elevated concentrations of constituents in samples LV082-2 and LV082-3 which were boreholes in the tailings pile not completed as monitor wells. Table D.2.13 tabulates results of chemical and radiometric analyses of domestic wells sampled within a mile of the Lakeview processing site from July, 1982, and from August, 1984, by FBDU and the TAC, respectively (Figure ~~D.2.~~6).

Table D.2.9 Applicable Federal and State of Oregon water-quality standards

Parameter	Federal drinking[a] water standards		Oregon water-quality[b] standards for Goose and Summer Lakes Basin
	Primary	Secondary	
Antimony	0.01	--	--
Arsenic	0.05	--	0.01
Barium	1.0	--	1.0
Cadmium	0.01	--	0.003
Chromium	0.05	--	0.02
Copper	--	1.0	0.005
Fluoride	1.4-2.4	--	1.0
Lead	0.05	--	0.05
Mercury	0.002	--	--
Nitrate	10.0	--	--
Selenium	0.01	--	--
Silver	0.05	--	--
Zinc	--	5.0	0.01
Chloride	--	250.0	--
Iron	--	0.3	0.1
Manganese	--	0.05	0.05
pH (units)	--	6.5-8.5	7.0-9.0
Sulfate	--	250	--
TDS	--	500	--
Boron	--	1.00	0.50
Cyanide	--	--	0.005
Phenols (totals)	--	--	0.001
Uranium (Health Advisory Level) (in picocuries per liter)	10.0	--	--
Radium-226-228 combined (in picocuries per liter)	5.0	--	--
Gross alpha (in picocuries per liter)	15.0	--	--
Gross beta (in picocuries per liter)	50.0	--	

[a] All values in milligrams per liter (mg/l) unless otherwise noted. Ref. USEPA, 1976.

[b] All values in milligrams per liter (mg/l) unless otherwise noted. Ref. ODEQ, Oregon Administrative Rules, Chapter 340, Division 41 - January 1982.

Table D.2.10 Location designations and descriptions of Lakeview sampling sites

Location ID	Sample type[a]	Description
LKV01-501 through LKV01-526	g	TAC monitor wells installed within and adjacent to the Lakeview processing site boundary
LKV01-527 through LKV01-532	g	FBDU monitor wells installed within and adjacent to the Lakeview processing site tailings pile
LKV01-533	g	Owen domestic well
LKV01-534	g	Maisano domestic well
LKV01-535	g	McDonald domestic well
LKV01-536	g	Crawford domestic well
LKV01-537	g	Kerr domestic well
LKV01-538	g	Mautz domestic well
LKV01-539	g	Majors domestic well
LKV01-605	s	Confluence of Thomas and Warner Creeks
LKV01-606	s	Thomas Creek, upper east branch
LKV01-607	s	Thomas Creek, lower east branch
LKV01-608	s	Lower Hunters Creek
LKV01-609	s	Upper Hunters Creek

[a] g = ground-water sample.
s = surface-water sample.

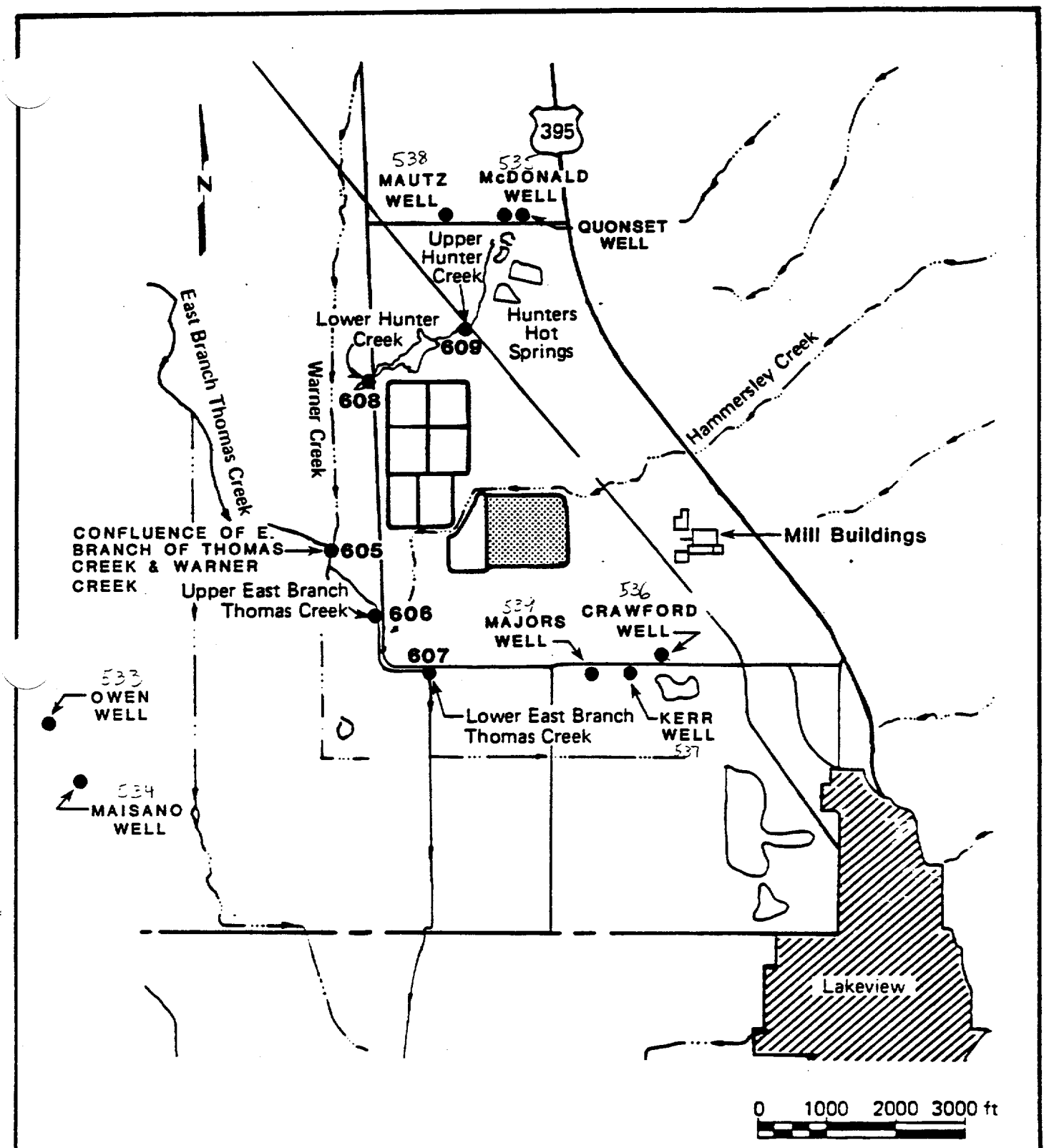


FIGURE D.2.15

OFF SITE WATER-QUALITY SAMPLING LOCATIONS
LAKEVIEW SITE

TABLE D-7.11
CONCENTRATIONS OF MAJOR AND TRACE CONSTITUENTS IN GROUND WATER
SAMPLED FROM WELLS IN THE IMMEDIATE AREA OF THE FAIRVIEW
PROCESSING SITE, (AUGUST, 1984)

CONSTITUENT	SYM	UNIT OF MEASURE	LKV01 501 LOG DATE 082484	LKV01 502 LOG DATE 082384	LKV01 503 LOG DATE 090584	LKV01 504 LOG DATE 082884	LKV01 505 LOG DATE 082784	LKV01 506 LOG DATE 082984
SILVER	AG	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
ALUMINUM	AL	MG/L	< 0.100000	< 0.100000	< 0.100000	0.200000	< 0.100000	< 0.100000
ALKALINITY	ALK	MG/L CACO3	118.000000	104.000000	402.000000	81.000000	621.000000	148.000000
ARSENIC	AS	MG/L	< 0.010000	< 0.010000	0.060000	< 0.010000	0.020000	0.020000
BORON	B	MG/L	0.050000	0.200000	33.700000	3.130000	33.300000	5.360000
BARIUM	BA	MG/L	< 0.100000	< 0.100000	< 0.100000	< 0.100000	< 0.100000	< 0.100000
CALCIUM	CA	MG/L	19.900000	21.400000	302.000000	5.230000	145.000000	18.100000
CADMIUM	CD	MG/L	< 0.001000	< 0.001000	< 0.001000	< 0.001000	< 0.001000	< 0.001000
CHLORIDE	CL	MG/L	1.000000	2.000000	1100.000000	94.000000	520.000000	160.000000
COBALT	CO	MG/L	< 0.050000	< 0.050000	< 0.050000	< 0.050000	< 0.050000	< 0.050000
CHROMIUM	CR	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
COPPER	CU	MG/L	< 0.020000	< 0.020000	< 0.020000	< 0.020000	< 0.020000	< 0.020000
CONDUCTANCE	EC	UMHO/CM	222.000000	328.000000	9480.000000	977.000000	5590.000000	1440.000000
COND,IN-SITU	ECD	UMHO/CM	222.000000	----------	9500.000000	931.000000	5660.000000	1530.000000
FLUORIDE	F	MG/L	< 0.200000	0.320000	3.240000	2.760000	1.980000	2.860000
IRON	FE	MG/L	< 0.030000	< 0.030000	1.210000	0.140000	0.030000	0.030000
GROSS ALPHA	GA	PCI/L	----------	----------	----------	----------	----------	----------
BICARBONATE	HCO	MG/L	----------	----------	----------	----------	----------	----------
MERCURY	HG	MG/L	< 0.000200	< 0.000200	< 0.000200	< 0.000200	< 0.000200	< 0.000200
POTASSIUM	K	MG/L	2.400000	4.940000	20.400000	3.470000	12.800000	10.900000
MAGNESIUM	MG	MG/L	6.750000	6.130000	54.300000	1.590000	40.900000	3.080000
MANGANESE	MN	MG/L	0.050000	0.170000	10.900000	0.150000	3.800000	0.060000
MOLYBDENUM	MO	MG/L	< 0.010000	< 0.010000	0.060000	0.010000	0.180000	0.040000
SODIUM	NA	MG/L	14.100000	29.200000	1990.000000	188.000000	1106.000000	280.000000
AMMONIUM	NH4	MG/L	0.100000	0.100000	1.100000	0.500000	0.800000	0.400000
NICKEL	NI	MG/L	< 0.040000	< 0.040000	< 0.040000	< 0.040000	< 0.040000	< 0.040000
NITRATE	NO3	MG/L	4.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
LEAD	PB	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
PB-210	PBO	PCI/L	< 1.200000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
PH	PH	SU	7.000000	8.040000	6.840000	7.420000	7.220000	8.930000
PO-210	PO0	PCI/L	< 0.500000	< 0.500000	5.000000	4.400000	1.200000	< 0.500000
PHOSPHATE	PO4	MG/L	0.390000	0.990000	0.370000	0.340000	0.560000	0.700000
RA-226	RA6	PCI/G	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
RA-228	RAB	PCI/L	----------	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
ANTIMONY	SB	MG/L	< 0.003000	< 0.003000	0.027000	< 0.003000	0.021000	0.008000
SELENIUM	SE	MG/L	< 0.005000	< 0.005000	< 0.005000	< 0.005000	< 0.005000	< 0.005000
SILCON	SI	MG/L	20.900000	15.800000	28.500000	28.900000	24.000000	25.300000
TIN	SN	MG/L	< 0.005000	< 0.005000	0.037000	< 0.005000	0.020000	< 0.005000
SULFATE	SO4	MG/L	3.000000	31.000000	2900.000000	190.000000	1500.000000	260.000000
STRONTIUM	SR	MG/L	< 0.100000	0.400000	3.200000	< 0.100000	0.900000	0.300000
TOTAL SOLIDS	TDS	MG/L	206.000000	195.000000	7060.000000	649.000000	3976.000000	897.000000
TH-230	THO	PCI/G	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
TEMP,IN SITU	TMD	C-DEGREE	10.100000	12.800000	15.000000	10.600000	9.400000	10.600000
TEMPERATURE	TMP	C - DEGREE	13.000000	15.000000	14.000000	14.000000	14.000000	14.000000
ORG. CARBON	TOC	MG/L	0.500000	1.100000	8.700000	1.100000	4.600000	1.500000
URANIUM	U	MG/L	----------	----------	----------	----------	----------	----------
U-234	U4	PCI/L	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
U-238	U8	PCI/L	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
VANADIUM	V	MG/L	----------	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
ZINC	ZN	MG/L	0.018000	0.007000	0.019000	0.008000	0.008000	0.024000

TABLE D-2.14
CONCENTRATIONS OF MAJOR AND TRACE CONSTITUENTS IN GROUND WATER SAMPLES FROM WELLS IN THE IMMEDIATE AREA OF THE LAKEVIEW PROCESSING SITE, (AUGUST, 1984)

CONSTITUENT	SYM	UNIT OF MEASURE	LKV01 507 LOG DATE 081984	LKV01 508 LOG DATE 081984	LKV01 509 LOG DATE 081984	LKV01 510 LOG DATE 081984	LKV01 511 LOG DATE 090784	LKV01 512 LOG DATE 090784
SILVER	AG	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
ALUMINUM	AL	MG/L	< 0.100000	< 0.100000	< 0.100000	< 0.100000	< 0.100000	< 0.100000
ALKALINITY	ALK	MG/L CACO3	151.000000	155.000000	216.000000	145.000000	321.000000	92.000000
ARSENIC	AS	MG/L	< 0.010000	< 0.010000	0.060000	< 0.010000	< 0.010000	< 0.010000
BORON	B	MG/L	0.130000	0.240000	2.900000	0.280000	16.500000	3.550000
BARIUM	BA	MG/L	< 0.100000	< 0.100000	< 0.100000	< 0.100000	< 0.100000	< 0.100000
CALCIUM	CA	MG/L	130.000000	21.000000	12.000000	3.110000	287.000000	6.940000
CADMIUM	CD	MG/L	< 0.001000	< 0.001000	< 0.001000	< 0.001000	< 0.001000	< 0.001000
CHLORIDE	CL	MG/L	25.000000	3.000000	13.000000	3.000000	1500.000000	81.000000
COBALT	CO	MG/L	< 0.050000	< 0.050000	< 0.050000	< 0.050000	< 0.050000	< 0.050000
CHROMIUM	CR	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
COPPER	CU	MG/L	< 0.020000	< 0.020000	< 0.020000	< 0.020000	< 0.020000	< 0.020000
CONDUCTANCE	EC	UMHO/CM	1230.000000	2920.000000	551.000000	355.000000	9360.000000	855.000000
COND, IN SITU	ECD	UMHO/CM	1270.000000	356.000000	567.000000	355.000000	9360.000000	859.000000
FLUORIDE	F	MG/L	0.270000	0.380000	5.990000	0.570000	2.580000	2.870000
IRON	FE	MG/L	< 0.030000	< 0.030000	0.030000	0.570000	0.150000	0.010000
GROSS ALPHA	GA	PCI/L	---	---	---	---	---	---
BICARBONATE	HCO	MG/L	---	---	---	---	---	---
MERCURY	HG	MG/L	< 0.000200	< 0.000200	< 0.000200	0.000200	< 0.000200	< 0.000200
POTASSIUM	K	MG/L	20.800000	3.950000	9.540000	2.950000	23.300000	7.980000
MAGNESIUM	MG	MG/L	40.200000	5.690000	2.070000	0.710000	63.400000	1.570000
MANGANESE	MN	MG/L	0.740000	0.100000	0.020000	0.010000	9.200000	0.020000
MOLYBDENUM	MO	MG/L	< 0.010000	< 0.010000	0.010000	< 0.010000	0.060000	0.010000
SODIUM	NA	MG/L	58.500000	30.500000	98.100000	60.700000	1890.000000	162.000000
AMMONIUM	NH4	MG/L	0.100000	0.100000	< 0.100000	0.100000	1.800000	0.200000
NICKEL	NI	MG/L	< 0.040000	< 0.040000	< 0.040000	< 0.040000	< 0.040000	< 0.040000
NITRATE	NO3	MG/L	2.000000	< 1.000000	1.000000	< 1.000000	< 1.000000	< 1.000000
LEAD	PB	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
PB-210	PBO	PCI/L	< 1.000000	< 1.000000	< 1.000000	< 1.200000	< 1.000000	< 1.000000
PH	PH	SU	7.470000	8.180000	8.460000	8.500000	7.170000	8.060000
PO-210	POO	PCI/L	< 0.500000	< 0.500000	1.000000	< 0.500000	< 0.500000	< 0.500000
PHOSPHATE	PO4	MG/L	0.980000	0.920000	3.500000	0.390000	0.380000	0.560000
RA-226	RA6	PCI/G	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
RA-228	RAB	PCI/L	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
ANTIMONY	SB	MG/L	< 0.003000	< 0.003000	< 0.003000	< 0.003000	0.028000	0.004000
SELENIUM	SE	MG/L	< 0.005000	< 0.005000	< 0.005000	< 0.005000	< 0.005000	< 0.005000
SILICON	SI	MG/L	21.800000	25.500000	25.000000	28.800000	23.700000	29.400000
TIN	SN	MG/L	< 0.005000	< 0.005000	< 0.005000	< 0.005000	0.029000	< 0.005000
SULFATE	SO4	MG/L	455.000000	7.000000	30.000000	14.000000	2300.000000	160.000000
STRONTIUM	SR	MG/L	0.600000	0.100000	0.100000	0.100000	2.800000	< 0.100000
TOTAL SOLIDS	TDS	MG/L	874.000000	208.000000	344.000000	248.000000	6598.000000	526.000000
TH-230	THO	PCI/G	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
TEMP, IN SITU	TMD	C-DEGREE	9.700000	11.700000	9.800000	10.000000	9.600000	10.600000
TEMPERATURE	TMP	C - DEGREE	14.000000	14.000000	14.000000	14.000000	15.000000	11.000000
ORG. CARBON	TOC	MG/L	2.100000	1.100000	2.200000	1.400000	7.400000	0.800000
URANIUM	U	MG/L	---	---	---	---	---	---
U-234	U4	PCI/L	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
U-238	U8	PCI/L	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
VANADIUM	V	MG/L	0.040000	< 0.010000	0.020000	< 0.010000	< 0.010000	< 0.010000
ZINC	ZN	MG/L	< 0.005000	0.012000	0.005000	< 0.005000	0.017000	0.015000

TABLE D-7.11
CONCENTRATIONS OF MAJOR AND TRACE CONSTITUENTS IN GROUND WATER
SAMPLED FROM WELLS IN THE IMMEDIATE AREA OF THE TAKEVIEW
PROCESSING SITE, (AUGUST, 1984)

CONSTITUENT	SYM	UNIT OF MEASURE	LKV01 513 LOG DATE 090984	LKV01 514 LOG DATE 091084	LKV01 515 LOG DATE 090984	LKV01 516 LOG DATE 090984	LKV01 517 LOG DATE 091284	LKV01 518 LOG DATE 100484
SILVER	AG	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
ALUMINUM	AL	MG/L	< 0.100000	0.100000	< 0.100000	0.200000	< 0.100000	< 0.100000
ALKALINITY	ALK	MG/L CACO3	64.000000	120.000000	123.000000	128.000000	130.000000	148.000000
ARSENIC	AS	MG/L	0.070000	0.060000	0.010000	0.010000	0.020000	< 0.010000
BORON	B	MG/L	22.100000	1.490000	4.020000	0.360000	0.080000	5.240000
BARIUM	BA	MG/L	0.100000	< 0.100000	< 0.100000	< 0.100000	< 0.100000	0.090000
CALCIUM	CA	MG/L	468.000000	3.800000	18.800000	2.920000	33.400000	90.600000
CADMIUM	CD	MG/L	< 0.001000	< 0.001000	< 0.001000	< 0.001000	0.006000	< 0.001000
CHLORIDE	CL	MG/L	2300.000000	26.000000	230.000000	12.000000	8.000000	640.000000
COBALT	CO	MG/L	< 0.050000	< 0.050000	< 0.050000	< 0.050000	< 0.050000	< 0.050000
CHROMIUM	CR	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
COPPER	CU	MG/L	< 0.020000	< 0.020000	< 0.020000	< 0.020000	< 0.020000	< 0.020000
CONDUCTANCE	EC	UMHO/CM	11660.000000	504.000000	1500.000000	370.000000	373.000000	3180.000000
COND.,IN-SITU	ECD	UMHO/CM	11720.000000	602.000000	1523.000000	502.000000	453.000000	----------
FLUORIDE	F	MG/L	4.500000	2.350000	1.100000	0.550000	0.220000	1.000000
IRON	FE	MG/L	15.500000	0.050000	0.010000	0.100000	< 0.030000	< 0.030000
GROSS ALPHA	GA	PCI/L	----------	----------	----------	----------	----------	----------
BICARBONATE	HCO	MG/L	----------	----------	----------	----------	----------	----------
MERCURY	HG	MG/L	< 0.000200	< 0.000200	< 0.000200	< 0.000200	< 0.000200	< 0.000200
POTASSIUM	K	MG/L	31.100000	4.900000	5.850000	4.650000	3.810000	21.200000
MAGNESIUM	MG	MG/L	72.500000	0.771000	2.710000	0.625000	11.800000	32.700000
MANGANESE	MN	MG/L	13.900000	0.020000	0.200000	< 0.010000	0.160000	1.940000
MOLYBDENUM	MO	MG/L	< 0.010000	0.020000	< 0.010000	0.010000	< 0.010000	< 0.010000
SODIUM	NA	MG/L	2090.000000	110.000000	285.000000	70.800000	24.900000	533.000000
AMMONIUM	NH4	MG/L	1.200000	0.200000	0.400000	0.100000	0.100000	0.600000
NICKEL	NI	MG/L	< 0.040000	< 0.040000	< 0.040000	< 0.040000	< 0.040000	< 0.040000
NITRATE	NO3	MG/L	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
LEAD	PB	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
PB-210	PB0	PCI/L	< 1.100000	< 1.100000	1.600000	< 1.000000	< 1.100000	< 1.100000
PH	PH	SU	6.630000	8.420000	7.770000	8.440000	8.210000	7.970000
PO-210	P00	PCI/L	0.900000	2.600000	1.000000	< 0.500000	< 0.200000	< 1.000000
PHOSPHATE	P04	MG/L	< 0.150000	0.920000	0.460000	0.520000	0.660000	0.620000
RA-226	RA6	PCI/G	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
RA-228	RA8	PCI/L	----------	----------	----------	----------	----------	----------
ANTIMONY	SB	MG/L	0.025000	< 0.003000	0.006000	< 0.003000	< 0.003000	0.006000
SELENIUM	SE	MG/L	< 0.005000	< 0.005000	< 0.005000	< 0.005000	< 0.005000	< 0.005000
SILICON	SI	MG/L	27.900000	27.300000	26.000000	36.300000	24.400000	22.500000
TIN	SN	MG/L	< 0.005000	< 0.005000	< 0.005000	< 0.005000	< 0.005000	< 0.005000
SULFATE	S04	MG/L	2200.000000	58.000000	180.000000	31.000000	36.000000	510.000000
STRONTIUM	SR	MG/L	4.000000	< 0.100000	0.100000	< 0.100000	0.200000	0.700000
TOTAL SOLIDS	TDS	MG/L	7692.000000	354.000000	880.000000	294.000000	240.000000	1900.000000
TH-230	TH0	PCI/G	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
TEMP.,IN SITU	TMD	C DEGREE	9.100000	10.600000	10.700000	12.300000	10.900000	----------
TEMPERATURE	TMP	C - DEGREE	14.000000	14.000000	16.000000	16.000000	14.000000	14.000000
ORG. CARBON	TOC	MG/L	< 0.100000	3.600000	1.100000	3.200000	3.600000	1.800000
URANIUM	U	MG/L	----------	----------	----------	----------	----------	----------
U-234	U4	PCI/L	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
U-238	U8	PCI/L	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
VANADIUM	V	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
[illegible]	ZN	MG/L	0.021000	0.00[illegible]	0.007000	0.010000	0.011000	0.010000

TABLE D-7.11
CONCENTRATIONS OF MAJOR AND TRACE CONSTITUENTS IN GROUND WATER
SAMPLES FROM WELLS IN THE IMMEDIATE AREA OF THE LAKEVIEW
PROCESSING SITE, (AUGUST, 1984)

CONSTITUENT	SYM	UNIT OF MEASURE	LKV01 519 LOG DATE 081484	LKV01 519 LOG DATE 081584	LKV01 520 LOG DATE 084684	LKV01 521 LOG DATE 090784	LKV01 522 LOG DATE 090884	LKV01 523 LOG DATE 082084
SILVER	AG	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	----------	< 0.010000
ALUMINUM	AL	MG/L	< 0.100000	< 0.100000	< 0.100000	< 0.100000	----------	< 0.100000
ALKALINITY	ALK	MG/L CACO3	300.000000	288.000000	72.000000	328.000000	374.000000	79.000000
ARSENIC	AS	MG/L	0.010000	0.010000	< 0.010000	0.070000	----------	< 0.010000
BORON	B	MG/L	18.600000	18.800000	3.320000	57.300000	----------	4.640000
BARIUM	BA	MG/L	< 0.100000	< 0.100000	< 0.100000	< 0.100000	----------	< 0.100000
CALCIUM	CA	MG/L	326.000000	314.000000	3.080000	540.000000	----------	9.200000
CADMIUM	CD	MG/L	< 0.001000	< 0.001000	< 0.001000	< 0.001000	----------	< 0.001000
CHLORIDE	CL	MG/L	1800.000000	1600.000000	107.000000	2400.000000	----------	92.000000
COBALT	CO	MG/L	< 0.050000	0.050000	< 0.050000	< 0.050000	----------	< 0.050000
CHROMIUM	CR	MG/L	0.070000	0.060000	< 0.010000	< 0.010000	----------	< 0.010000
COPPER	CU	MG/L	< 0.020000	< 0.020000	< 0.020000	< 0.020000	----------	< 0.020000
CONDUCTANCE	EC	UMHO/CM	9270.000000	8910.000000	8480.000000	14600.000000	3270.000000	1020.000000
COND. IN-SITU	ECD	UMHO/CM	----------	----------	----------	14550.000000	2760.000000	1020.000000
FLUORIDE	F	MG/L	2.120000	2.200000	2.970000	4.860000	----------	3.240000
IRON	FE	MG/L	0.640000	0.840000	0.030000	6.000000	----------	< 0.030000
GROSS ALPHA	GA	PCI/L	----------	----------	----------	----------	----------	----------
BICARBONATE	HCO	MG/L	----------	----------	----------	----------	----------	----------
MERCURY	HG	MG/L	0.000300	0.000300	< 0.000200	< 0.000200	----------	< 0.000200
POTASSIUM	K	MG/L	25.600000	23.000000	3.020000	31.000000	----------	7.390000
MAGNESIUM	MG	MG/L	69.800000	68.500000	0.912000	71.900000	----------	0.642000
MANGANESE	MN	MG/L	10.700000	10.600000	0.120000	13.200000	----------	0.020000
MOLYBDENUM	MO	MG/L	0.010000	< 0.010000	< 0.010000	0.440000	----------	0.030000
SODIUM	NA	MG/L	1840.000000	1820.000000	164.000000	3090.000000	----------	179.000000
AMMONIUM	NH4	MG/L	2.000000	1.800000	0.300000	1.800000	----------	0.300000
NICKEL	NI	MG/L	0.060000	0.080000	< 0.040000	< 0.040000	----------	< 0.040000
NITRATE	NO3	MG/L	< 1.000000	< 1.000000	< 1.000000	< 1.000000	----------	< 1.000000
LEAD	PB	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	----------	< 0.010000
PB-210	PBO	PCI/L	< 1.000000	< 1.000000	< 1.000000	< 1.000000	----------	< 1.000000
PH	PH	SU	7.060000	7.080000	8.070000	7.270000	7.090000	8.360000
PO-210	POO	PCI/L	< 0.500000	< 0.500000	< 0.500000	< 0.500000	----------	< 0.500000
PHOSPHATE	PO4	MG/L	< 0.150000	< 0.150000	0.310000	0.510000	----------	0.360000
RA-226	RA6	PCI/G	< 1.000000	< 1.000000	< 1.000000	< 1.000000	----------	< 1.000000
RA-228	RA8	PCI/L	< 1.000000	< 1.000000	< 1.000000	< 1.000000	----------	< 1.000000
ANTIMONY	SB	MG/L	0.020000	0.031000	< 0.003000	0.047000	----------	0.006000
SELENIUM	SE	MG/L	< 0.005000	< 0.005000	< 0.005000	< 0.005000	----------	< 0.005000
SILICON	SI	MG/L	27.400000	26.500000	30.800000	26.600000	----------	46.700000
TIN	SN	MG/L	0.073000	0.069000	< 0.005000	0.058000	----------	< 0.005000
SULFATE	SO4	MG/L	2600.000000	2400.000000	159.000000	4600.000000	----------	200.000000
STRONTIUM	SR	MG/L	1.400000	1.100000	< 0.100000	4.800000	----------	< 0.100000
TOTAL SOLIDS	TDS	MG/L	6940.000000	6714.000000	546.000000	11470.000000	----------	657.000000
TH-230	THO	PCI/G	< 1.000000	< 1.000000	< 1.000000	< 1.000000	----------	< 1.000000
TEMP. IN-SITU	TMD	C-DEGREE	----------	----------	----------	8.900000	10.200000	43.500000
TEMPERATURE	TMP	C - DEGREE	20.000000	16.000000	13.000000	16.000000	13.000000	41.000000
ORG. CARBON	TOC	MG/L	7.600000	7.300000	< 0.100000	14.500000	----------	1.300000
URANIUM	U	MG/L	----------	----------	----------	----------	----------	----------
U-234	U4	PCI/L	< 1.000000	< 1.000000	< 1.000000	< 1.000000	----------	< 1.000000
U-238	U8	PCI/L	< 1.000000	< 1.000000	< 1.000000	< 1.000000	----------	< 1.000000
VANADIUM	V	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	----------	< 0.010000
ZINC	ZN	MG/L	0.252000	0.174000	< 0.005000	0.077000	----------	< 0.005000

TABLE D.2.11
CONCENTRATIONS OF MAJOR AND TRACE CONSTITUENTS IN GROUND WATER SAMPLED FROM WELLS IN THE IMMEDIATE AREA OF THE TSR VIEW PROCESSING SITE, (AUGUST, 1984)

CONSTITUENT	SYM	UNIT OF MEASURE	PAR VALUE TRV01 524 LOG DATE 082784	PAR VALUE TRV01 525 LOG DATE 090584	PAR VALUE TRV01 526 LOG DATE 092084	PAR VALUE TRV01 527 LOG DATE 091284	PAR VALUE TRV01 528 LOG DATE 091184
SILVER	AG	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
ALUMINUM	AL	MG/L	< 0.100000	< 0.100000	0.300000	< 0.100000	1.000000
ALKALINITY	ALK	MG/L CACO3	89.000000	234.000000	148.000000	35.600000	36.900000
ARSENIC	AS	MG/L	0.110000	0.020000	0.020000	< 0.010000	< 0.010000
BORON	B	MG/L	4.460000	10.000000	3.480000	0.110000	0.280000
BARIUM	BA	MG/L	< 0.100000	< 0.100000	< 0.100000	< 0.100000	< 0.100000
CALCIUM	CA	MG/L	7.850000	32.800000	7.870000	528.000000	370.000000
CADMIUM	CD	MG/L	< 0.001000	< 0.001000	< 0.001000	< 0.001000	0.001000
CHLORIDE	CL	MG/L	97.000000	300.000000	71.000000	10.000000	21.000000
COBALT	CO	MG/L	< 0.050000	< 0.050000	< 0.050000	< 0.050000	0.050000
CHROMIUM	CR	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
COPPER	CU	MG/L	< 0.020000	< 0.020000	< 0.020000	< 0.020000	< 0.020000
CONDUCTANCE	EC	UMHO/CM	1150.000000	2250.000000	823.000000	2780.000000	2670.000000
COND.IN-SITU	ECD	UMHO/CM	1470.000000	2260.000000	757.000000	2780.000000	----------
FLUORIDE	F	MG/L	3.400000	2.310000	1.520000	0.120000	1.000000
IRON	FE	MG/L	< 0.030000	0.040000	0.250000	< 0.030000	0.160000
GROSS ALPHA	GA	PCI/L	----------	----------	----------	----------	----------
BICARBONATE	HCO	MG/L	----------	----------	----------	----------	----------
MERCURY	HG	MG/L	< 0.000200	< 0.000200	< 0.000200	< 0.000200	< 0.000200
POTASSIUM	K	MG/L	14.400000	16.200000	3.610000	0.760000	1.960000
MAGNESIUM	MG	MG/L	0.641000	8.870000	1.970000	192.000000	149.000000
MANGANESE	MN	MG/L	0.010000	0.270000	0.120000	8.300000	16.600000
MOLYBDENUM	MO	MG/L	0.110000	0.010000	0.010000	< 0.010000	< 0.010000
SODIUM	NA	MG/L	173.000000	433.000000	164.000000	96.200000	123.000000
AMMONIUM	NH4	MG/L	0.400000	0.400000	0.500000	0.100000	0.200000
NICKEL	NI	MG/L	< 0.040000	< 0.040000	< 0.040000	0.110000	0.100000
NITRATE	NO3	MG/L	< 1.000000	< 1.000000	1.000000	3.000000	< 1.000000
LEAD	PB	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
PB-210	PBO	PCI/L	< 1.000000	< 1.000000	< 1.000000	< 1.300000	1.100000
PH	PH	SU	7.950000	7.550000	8.040000	5.700000	5.580000
PO-210	POO	PCI/L	< 0.500000	< 0.500000	1.500000	< 1.200000	< 0.200000
PHOSPHATE	PO4	MG/L	0.750000	1.490000	0.530000	0.240000	0.280000
RA-226	RA6	PCI/G	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
RA-228	RA8	PCI/L	< 1.000000	< 1.000000	< 1.000000	----------	----------
ANTIMONY	SB	MG/L	0.008000	0.010000	< 0.003000	0.007000	0.006000
SELENIUM	SE	MG/L	< 0.005000	< 0.005000	< 0.005000	< 0.005000	< 0.005000
SILICON	SI	MG/L	50.400000	20.900000	26.400000	39.600000	45.900000
TIN	SN	MG/L	< 0.005000	< 0.007000	< 0.005000	< 0.005000	< 0.005000
SULFATE	SO4	MG/L	220.000000	400.000000	140.000000	2300.000000	1700.000000
STRONTIUM	SR	MG/L	< 0.100000	< 0.300000	< 0.100000	1.700000	0.900000
TOTAL SOLIDS	TDS	MG/L	663.000000	1308.000000	580.000000	3118.000000	2562.000000
TH-230	TH0	PCI/G	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
TEMP.IN-SITU	TMD	C-DEGREE	62.300000	10.100000	10.800000	----------	----------
TEMPERATURE	TMP	C - DEGREE	60.000000	15.000000	13.000000	14.000000	16.000000
ORG. CARBON	TOC	MG/L	2.900000	2.600000	3.900000	1.700000	1.900000
URANIUM	U	MG/L	----------	----------	----------	----------	----------
U-234	U4	PCI/L	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
U-238	U8	PCI/L	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
VANADIUM	V	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
ZINC	ZN	MG/L	< 0.005000	0.007000	0.011000	0.033000	0.029000

Are these really zero?

T 6.2.11
ICENTRATIONS OF MAJOR AND TRACE CONSTITUENTS IN GROUN ER
MPLED FROM WELLS IN THE IMMEDIATE AREA OF THE LAKEVIEW
PROCESSING SITE, (AUGUST, 1984)

CONSTITUENT	SYM	UNIT OF MEASURE	LKV01 529 LOG DATE 091084	LKV01 530 LOG DATE 082384	LKV01 531 LOG DATE 090884	LKV01 532 LOG DATE 091484
SILVER	AG	MG/L	< 0.010000	< 0.010000	----------	----------
ALUMINUM	AL	MG/L	< 0.100000	< 0.100000	----------	----------
ALKALINITY	ALK	MG/L CACO3	326.000000	85.000000	188.000000	----------
ARSENIC	AS	MG/L	0.070000	< 0.010000	----------	----------
BORON	B	MG/L	40.300000	0.230000	----------	----------
BARIUM	BA	MG/L	< 0.100000	< 0.100000	----------	----------
CALCIUM	CA	MG/L	301.000000	24.600000	----------	----------
CADMIUM	CD	MG/L	0.007000	< 0.001000	----------	----------
CHLORIDE	CL	MG/L	1600.000000	6.000000	----------	----------
COBALT	CO	MG/L	< 0.050000	< 0.050000	----------	----------
CHROMIUM	CR	MG/L	0.020000	< 0.010000	----------	----------
COPPER	CU	MG/L	< 0.020000	< 0.020000	----------	----------
CONDUCTANCE	EC	UMHO/CM	39.000000	279.000000	----------	----------
COND, IN-SITU	ECD	UMHO/CM	----------	279.000000	2170.000000	2670.000000
FLUORIDE	F	MG/L	6.270000	< 0.200000	----------	----------
IRON	FE	MG/L	0.420000	< 0.030000	----------	----------
GROSS ALPHA	GA	PCI/L	----------	----------	----------	----------
BICARBONATE	HCO	MG/L	----------	----------	----------	----------
MERCURY	HG	MG/L	0.000600	< 0.000200	----------	----------
POTASSIUM	K	MG/L	30.700000	0.650000	----------	----------
MAGNESIUM	MG	MG/L	52.000000	5.710000	----------	----------
MANGANESE	MN	MG/L	5.600000	0.010000	----------	----------
MOLYBDENUM	MO	MG/L	0.320000	< 0.010000	----------	----------
SODIUM	NA	MG/L	4310.000000	14.500000	----------	----------
AMMONIUM	NH4	MG/L	0.400000	0.200000	----------	----------
NICKEL	NI	MG/L	< 0.040000	< 0.040000	----------	----------
NITRATE	NO3	MG/L	< 1.000000	< 1.000000	----------	----------
LEAD	PB	MG/L	0.020000	< 0.010000	----------	----------
PB-210	PBO	PCI/L	1.300000	< 1.000000	----------	----------
PH	PH	SU	7.000000	6.470000	7.400000	5.580000
PO-210	PUO	PCI/L	0.600000	< 0.500000	----------	----------
PHOSPHATE	PO4	MG/L	0.200000	0.390000	----------	----------
RA-226	RA6	PCI/G	< 1.000000	< 1.000000	----------	----------
RA-228	RA8	PCI/L	----------	< 1.000000	----------	----------
ANTIMONY	SB	MG/L	0.056000	< 0.001000	----------	----------
SELENIUM	SE	MG/L	0.008000	< 0.001000	----------	----------
SILICON	SI	MG/L	23.500000	21.500000	----------	----------
TIN	SN	MG/L	< 0.005000	< 0.005000	----------	----------
SULFATE	SO4	MG/L	7300.000000	14.000000	----------	----------
STRONTIUM	SR	MG/L	3.800000	< 0.100000	----------	----------
TOTAL SOLIDS	TDS	MG/L	13836.000000	173.000000	----------	----------
TH 230	THO	PCI/G	< 1.000000	< 1.000000	----------	----------
TEMP, IN SITU	TMD	C-DEGREE	----------	10.000000	16.000000	10.700000
TEMPERATURE	TMP	C - DEGREE	17.000000	14.000000	16.000000	10.000000
ORG. CARBON	TOC	MG/L	11.700000	2.300000	----------	----------
URANIUM	U	MG/L	----------	----------	----------	----------
U 234	U4	PCI/L	1.000000	< 1.000000	----------	----------
U 238	U8	PCI/L	< 1.000000	< 1.000000	----------	----------
VANADIUM	V	MG/L	0.010000	0.020000	----------	----------
ZINC	ZN	MG/L	0.000000	0.011000	----------	----------

Table D.2.12 Concentrations of major and trace constituents in ground water samples collected by FBDU from wells in the immediate area of the Lakeview processing site (August, 1982)

Parameter	Units	Sample identification[a] LV082-2	LV082-3	(LKV01-527) LV082-5	(LKV04-529) LV082-6	(LKV01-530) LV082-7	(LKV01-531) LV082-8	(LVK01-532) LV082-9[c]	(LKV01-528) LV082-10
Date	--	7/28/82	7/30/82	8/17/82	8/17/82	8/17/82	8/17/82	8/17/82	8/17/82
Field measurements									
Temperature	°C	22	--	15	19	18	21	12	13
pH	units	7.2	5.6	7.6	6.9	8.9	7.5	6.6	7.1
Electrical conductivity	umhos/cm at 25°	425	--	2240	20200	2960	1780	2710	2110
Alkalinity as $CaCO_3$	mg/l	260	b	97	391	756[e]	256	106	151
Laboratory measurments									
Aluminum	mg/l	<0.10	9.0	<0.100	0.330	0.496	0.120	0.117	<0.100
Arsenic	mg/l	0.012	0.13	0.013	0.056	0.017	0.050	0.011	<0.010
Barium	mg/l	<0.10	--	<0.10	--	0.74	--	<0.10	--
Bicarbonate	mg/l	317	--	118	477	f	312	129	184
Cadmium	mg/l	<0.010	--	<0.005	--	<0.005	--	<0.005	--
Calcium	mg/l	511	329	410	510	240	23	490	330
Chloride	mg/l	12	60	7	d	36	29	26	36
Chromium	mg/l	<0.010	--	<0.010	--	<0.010	--	<0.010	--
Copper	mg/l	0.017	--	0.019	--	0.016	--	<0.010	--
Fluoride	mg/l	6	5	<1	d	<1	<1	<1	<1
Gross alpha activity	pCi/l	67	--	20	--	13	--	47	--
Iron	mg/l	<0.05	320	<0.05	0.31	<0.05	0.16	0.05	<0.05

Table D.2.12 Concentrations of major and trace constituents in ground water samples collected by FBDU from wells in the immediate area of the Lakeview processing site (August, 1982) (Concluded)

Parameter	Units	Sample identification[a]							
		LV082-2	LV082-3	(LKV01-527) LV082-5	(LKV04-529) LV082-6	(LKV01-530) LV082-7	(LKV01-531) LV082-8	(LVK01-532) LV082-9[c]	(LKV01-528) LV082-10
Date	--	7/28/82	7/30/82	8/17/82	8/17/82	8/17/82	8/17/82	8/17/82	8/17/82
Lead	mg/l	<0.010	--	<0.010	--	<0.010	--	<0.010	--
Magnesium	mg/l	290	1010	130	80	<1	7	180	110
Mercury	mg/l	<0.002	--	<0.002	--	<0.002	--	<0.002	--
Molybdenum	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrate	mg/l	8	<1	<1	d	<1	<1	3	<1
Potassium	mg/l	1.0	2.1	1	44	10	10	16	3
Radium-226	pCi/l	<2	5	<2	<2	<2	<2	<2	<2
Radium-228	pCi/l	<2	--	<2	--	<2	--	<2	--
Selenium	mg/l	0.007	0.001	<0.010	0.243	<0.010	<0.010	<0.010	<0.010
Silica	mg/l	23	35	24	25	3.7	21	24	21
Silver	mg/l	<0.005	--	<0.010	--	<0.010	--	<0.010	--
Sodium	mg/l	285	798	78	5760	69[f]	414	123	100
Solids, dissolved (calculated)	mg/l	3980	11800	2290	d	992[f]	933	2680	1960
Sulfate	mg/l	2684	9250	1579	d	179	273	1757	1264
Thorium, natural	mg/l	<0.1	--	<0.1	--	<0.1	--	<0.1	--
Uranium, natural	mg/l	0.017	0.030	0.001	0.008	<0.001	0.001	0.002	0.002
Vanadium	mg/l	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

[a] Not corrected for temperature.
[b] Insufficient sample for alkalinity analysis; assumed to be minimal based on ion balance.
[c] TAC sample designation ID's in parenthesis.
[d] Lost anion sample during shipment.
[e] Represents carbonate alkalinity only and converts to a carbonate concentration of 454 mg/l.
[f] Bicarbonate assumed to be minimal based on ion balance, pH, and standard species-distribution diagram (Ref. Hem, 1970).

TABLE D.2.13
RESULTS OF CHEMICAL AND RADIOMETRIC ANALYSIS OF DOMESTIC WELL SAMPLES COLLECTED IN THE LAKEVIEW AREA.

CONSTITUENT	SYM	UNIT OF MEASURE	LKV01 533 LOG	LKV01 533 DATE 082884	LKV01 534 LOG	LKV01 534 DATE 082484	LKV01 535 LOG	LKV01 535 DATE 082084	LKV01 536 LOG	LKV01 536 DATE 072882	LKV01 536 LOG	LKV01 536 DATE 082084	LKV01 537 LOG	LKV01 537 DATE 082184
SILVER	AG	MG/L	<	0.010000	<	0.010000	<	0.010000		---------	<	0.010000	<	0.010000
ALUMINUM	AL	MG/L	<	0.100000	<	0.100000	<	0.100000	<	0.100000	<	0.100000	<	0.100000
ALKALINITY	ALK	MG/L CACO3		169.000000		138.000000		161.000000		160.000000		146.000000		205.000000
ARSENIC	AS	MG/L	<	0.010000	<	0.010000	<	0.010000		0.011000	<	0.010000	<	0.010000
BORON	B	MG/L		0.190000		0.150000		0.160000		---------		0.060000		0.080000
BARIUM	BA	MG/L	<	0.100000	<	0.100000	<	0.100000		---------	<	0.100000	<	0.100000
CALCIUM	CA	MG/L		29.700000		30.100000		65.900000		30.000000		28.600000		38.700000
CADMIUM	CD	MG/L	<	0.001000	<	0.001000	<	0.001000		---------	<	0.001000	<	0.001000
CHLORIDE	CL	MG/L		2.000000		3.000000		34.000000		1.000000		3.700000		21.000000
COBALT	CO	MG/L	<	0.050000	<	0.050000	<	0.050000		---------	<	0.050000	<	0.050000
CHROMIUM	CR	MG/L	<	0.010000	<	0.010000	<	0.010000		---------	<	0.010000	<	0.010000
COPPER	CU	MG/L	<	0.020000	<	0.020000	<	0.020000		---------	<	0.020000	<	0.020000
CONDUCTANCE	EC	UMHO/CM		344.000000		314.000000		566.000000		365.000000		283.000000		409.000000
FLUORIDE	F	MG/L	<	0.200000	<	0.200000	<	0.200000	<	1.000000		0.250000		0.290000
IRON	FE	MG/L		0.030000	<	0.030000	<	0.030000		2.900000		0.170000		0.280000
BICARBONATE	HCO	MG/L		---------		---------		---------		195.000000		---------		---------
MERCURY	HG	MG/L	<	0.000200	<	0.000200	<	0.000200		---------	<	0.000200		0.000200
POTASSIUM	K	MG/L		5.050000		4.040000		2.900000		1.300000		1.100000		0.940000
MAGNESIUM	MG	MG/L		10.900000		10.300000		11.900000		9.000000		9.520000		13.800000
MANGANESE	MN	MG/L		0.060000	<	0.010000	<	0.010000		---------		0.160000		2.210000
MOLYBDENUM	MO	MG/L	<	0.010000	<	0.010000	<	0.010000	<	0.050000	<	0.010000	<	0.010000
SODIUM	NA	MG/L		24.500000		18.300000		22.500000		17.000000		16.600000		27.200000
AMMONIUM	NH4	MG/L		0.200000	<	0.100000	<	0.100000		---------		0.100000		0.200000
NICKEL	NI	MG/L	<	0.040000	<	0.040000		0.070000		---------	<	0.040000	<	0.040000
NITRATE	NO3	MG/L		5.000000		6.000000		23.000000	<	1.000000	<	1.000000	<	1.000000
LEAD	PB	MG/L	<	0.010000	<	0.010000	<	0.010000		---------	<	0.010000	<	0.010000
PB-210	PBO	PCI/L	<	1.000000		1.200000	<	1.200000		---------	<	1.200000	<	1.200000
PH	PH	SU		6.820000		6.900000		7.440000		7.800000		7.490000		7.400000
PO-210	POO	PCI/L	<	0.500000	<	0.500000	<	0.500000		---------	<	0.500000	<	0.500000
PHOSPHATE	PO4	MG/L	<	0.150000		0.530000	<	0.150000		---------		0.610000		1.530000
RA-226	RA6	PCI/G	<	1.000000	<	1.000000	<	1.000000	<	2.000000	<	1.000000	<	1.000000
RA-228	RA8	PCI/L	<	1.000000	<	1.000000	<	1.000000		---------	<	1.000000		---------
ANTIMONY	SB	MG/L	<	0.003000	<	0.003000	<	0.003000		---------	<	0.003000	<	0.003000
SELENIUM	SE	MG/L	<	0.005000	<	0.005000	<	0.005000	<	0.005000	<	0.005000	<	0.005000
SILICON	SI	MG/L		31.700000		33.200000		21.600000		23.000000		25.200000		24.900000
TIN	SN	MG/L	<	0.005000	<	0.005000	<	0.005000		---------	<	0.005000	<	0.005000
SULFATE	SO4	MG/L		10.000000		12.000000		70.000000	<	5.000000		13.000000		14.000000
STRONTIUM	SR	MG/L		0.200000		0.200000		0.400000		---------	<	0.100000		0.100000
TOTAL SOLIDS	TDS	MG/L		267.000000		229.000000		368.000000		182.000000		204.000000		290.000000
TH-230	THO	PCI/G	<	1.000000	<	1.000000	<	1.000000		---------	<	1.000000	<	1.000000
TEMPERATURE	TMP	C - DEGREE		14.000000		13.000000		20.000000		23.000000		14.000000		14.000000
ORG. CARBON	TOC	MG/L		2.100000		4.900000		0.500000		---------		0.600000		2.700000
URANIUM	U	MG/L		---------		---------		---------	<	0.001000		---------		---------
U-234	U4	PCI/L	<	1.000000	<	1.000000	<	1.000000		---------	<	1.000000	<	1.000000
U-238	U8	PCI/L	<	1.000000	<	1.000000	<	1.000000		---------	<	1.000000	<	1.000000
VANADIUM	V	MG/L	<	0.010000	<	0.010000		0.010000	<	0.050000		0.040000	<	0.010000
ZINC	ZN	MG/L		0.123000		0.022000		0.098000		---------	<	0.005000		0.014000

TABLE D-[illegible]3
RESULT[illegible] CHEMICAL AND RADIOMETRIC ANALYSIS OF DOMESTIC WELL
SAMPLES[illegible]LECTED IN THE LAKEVIEW AREA.

CONSTITUENT	SYM	UNIT OF MEASURE	LKV01 538 LOG DATE 072882	LKV01 538 LOG DATE 082084
SILVER	AG	MG/L	--------	< 0.010000
ALUMINUM	AL	MG/L	< 0.100000	< 0.100000
ALKALINITY	ALK	MG/L CACO3	75.000000	59.900000
ARSENIC	AS	MG/L	0.014000	0.020000
BORON	B	MG/L	--------	5.470000
BARIUM	BA	MG/L	--------	< 0.100000
CALCIUM	CA	MG/L	7.000000	5.570000
CADMIUM	CD	MG/L	--------	< 0.001000
CHLORIDE	CL	MG/L	45.000000	94.000000
COBALT	CO	MG/L	--------	< 0.050000
CHROMIUM	CR	MG/L	< 0.010000	< 0.010000
COPPER	CU	MG/L	< 0.010000	< 0.020000
CONDUCTANCE	EC	UMHO/CM	1050.000000	1070.000000
FLUORIDE	F	MG/L	4.000000	3.800000
IRON	FE	MG/L	< 0.050000	0.070000
BICARBONATE	HCO	MG/L	92.000000	--------
MERCURY	HG	MG/L	--------	< 0.000200
POTASSIUM	K	MG/L	6.900000	6.800000
MAGNESIUM	MG	MG/L	< 1.000000	0.210000
MANGANESE	MN	MG/L	--------	0.010000
MOLYBDENUM	MO	MG/L	< 0.050000	0.010000
SODIUM	NA	MG/L	207.000000	199.000000
AMMONIUM	NH4	MG/L	--------	0.200000
NICKEL	NI	MG/L	--------	< 0.040000
NITRATE	NO3	MG/L	< 1.000000	< 1.000000
LEAD	PB	MG/L	--------	< 0.010000
PB-210	PBO	PCI/L	--------	< 1.200000
PH	PH	SU	7.400000	8.150000
PO-210	POO	PCI/L	--------	< 0.500000
PHOSPHATE	PO4	MG/L	--------	< 0.150000
RA-226	RA6	PCI/G	< 2.000000	< 1.000000
RA-228	RA8	PCI/L	--------	< 1.000000
ANTIMONY	SB	MG/L	--------	0.007000
SELENIUM	SE	MG/L	< 0.005000	< 0.005000
SILCON	SI	MG/L	45.000000	51.900000
TIN	SN	MG/L	--------	< 0.005000
SULFATE	SO4	MG/L	227.000000	240.000000
STRONTIUM	SR	MG/L	--------	< 0.100000
TOTAL SOLIDS	TDS	MG/L	647.000000	690.000000
TH-230	THO	PCI/G	--------	< 1.000000
TEMPERATURE	TMP	C - DEGREE	26.000000	26.000000
ORG. CARBON	TOC	MG/L	--------	0.100000
URANIUM	U	MG/L	< 0.001000	--------
U-234	U4	PCI/L	--------	< 1.000000
U-238	U8	PCI/L	--------	< 1.000000
VANADIUM	V	MG/L	< 0.050000	< 0.010000
ZINC	ZN	MG/L	--------	< 0.005000

GECR sampled and analyzed a suite of predominantly surface waters within 4.5 miles of the processing site. Results of the analyses are in Table D.2.14. Figures D.2.1 and D.2.2 show sample locations and Table D.2.15 gives location descriptions. Surface-water samples were collected by FBDU and by the TAC from ephemeral and perennial streams within 0.5 mile of the site. Locations are shown in Figure D.2.15 and results from July, 1982, (FBDU) and August, 1984, (TAC) are presented in Table D.2.16.

GECR geochemical data from solid samples, water extracts, and acid extracts of tailings and soils in the immediate area of the tailings pile are presented in depth-concentration profiles in Figures D.2.16 through D.2.21. Sample locations are presented in Figures D.2.1 and D.2.2. Hydrogeochemical interaction and controls upon the dissolution of mineral species into the ground water from tailings materials may be inferred by comparison of water-quality data with solid sample and solid extract data. Results of chemical analysis of suction water contained within the unsaturated zone of the evaporation pond will also provide quantification of potentially soluble contaminants when available from the laboratory.

Collins Ranch alternate disposal site

Chemical and radiometric analyses of water samples collected from the five TAC monitor wells and from a stock pond in Section 11 are presented in Table D.2.17. These results chemically characterize the existing ground and surface water, providing indication of chemical variability and origin of the ground water.

No ground water was encountered at the Flynn Ranch alternate disposal site and no proximal surface-water samples were collected.

D.2.4 DATA ANALYSIS

D.2.4.1 Hydraulic data analysis

Aquifer test data from both the shallow and deeper tests conducted at the Lakeview processing site were analyzed to estimate the transmissivity and storativity of each screened zone and to estimate the vertical communication between semi-confining formation material. The average transmissivity of the shallow zone calculated from drawdown data in observation wells 511 and 503 is 13.6 ft^2/day. Average transmissivity in the deeper zone calculated from drawdown data in observation wells 504 and 512 is 74 ft^2/day. An approximate configuration of the aquifer test with total drawdowns indicated for each of the wells is shown figuratively in Figure D.2.22.

TABLE D.2.14

CONCENTRATIONS OF MAJOR AND TRACE CONSTITUENTS IN GROUND WATER AND SURFACE WATER SAMPLED BY GECR (SEPTEMBER, 1983)

GTCI = ? Samples

Presumably these are equivalent to #s in TABLE 2-15

CONSTITUENT	SYM	UNIT OF MEASURE	LKV01 (01) LOG DATE 090183	LKV01 (38) LOG DATE 090183	LKV01 739 LOG DATE 090183	LKV01 740 LOG DATE 090183	LKV01 741 LOG DATE 090183	LKV01 742 LOG DATE 090183
SILVER	AG	MG/L	0.090000	0.002000 <	0.010000 <	0.010000	0.020000 <	0.010000
ALUMINUM	AL	MG/L	7.300000	0.200000 <	0.200000 <	0.200000 <	0.200000	0.300000
ARSENIC	AS	MG/L	0.200000	0.130000 <	0.010000	0.180000 <	0.010000 <	0.010000
BARIUM	BA	MG/L	0.082000	0.002300	0.005000	0.010000	0.071000	0.048000
CALCIUM	CA	MG/L	449.000000	12.700000	13.700000	0.143000	0.136000	21.500000
CADMIUM	CD	MG/L	0.014000	0.004000 <	0.000500	0.004500 <	0.000500 <	0.000500
CHLORIDE	CL	MG/L	11.100000	171.000000	98.500000	0.014600	1.000000	4.000000
COBALT	CO	MG/L	< 0.002000	< 0.020000 <	0.002000 <	0.020000 <	0.020000 <	0.020000
CHROMIUM	CR	MG/L	0.050000	< 0.010000 <	0.001000 <	0.010000 <	0.010000 <	0.010000
CONDUCTANCE	EC	UMHO/CM	3460.000000	1280.000000	1580.000000	2205.000000	140.000000	250.000000
REDOX POTENT	EH	MVOLTS	370.000000	180.000000	325.000000	270.000000	230.000000	330.000000
IRON	FE	MG/L	1.890000	0.290000	0.010000	0.080000	4.570000	0.460000
POTASSIUM	K	MG/L	5.300000	0.300000	2.600000	8.700000	5.500000	4.700000
MAGNESIUM	MG	MG/L	237.000000	< 0.300000 <	0.300000 <	0.300000	5.100000	7.800000
MANGANESE	MN	MG/L	7.440000	0.050000	0.010000	0.020000	0.280000	0.160000
MOLYBDENUM	MO	MG/L	---------	0.030000	0.030000	0.030000	0.020000 <	0.020000
SODIUM	NA	MG/L	285.000000	285.000000	150.000000	0.021000	8.600000	15.000000
NICKEL	NI	MG/L	0.110000	0.110000 <	0.020000 <	0.020000 <	0.020000 <	0.020000
LEAD	PB	MG/L	0.019000	0.019000 <	0.005000 <	0.005000 <	0.005000 <	0.005000
PH	PH	SU	6.900000	8.000000	8.200000	8.100000	6.900000	7.300000
SELENIUM	SE	MG/L	< 0.001000	< 0.010000 <	0.010000 <	0.010000 <	0.010000 <	0.010000
SILICON	SI	MG/L	33.000000	68.000000	32.000000	67.000000	25.000000	17.000000
SULFATE	SO4	MG/L	2640.000000	218.000000	158.000000	191.000000 <	5.000000 <	5.000000
STRONTIUM	SR	MG/L	1.760000	0.222000	0.142000	0.267000	0.136000	0.174000
URANIUM	U	MG/L	280.000000	0.000400	0.000400	0.001900 <	0.001000 <	0.000100
VANADIUM	V	MG/L	0.100000	< 0.020000 <	0.020000 <	0.020000 <	0.020000 <	0.020000

? well #1 on Fig. D.2.1 on tailings pile.

TABLE D-7.11
CONCENTRATIONS OF MAJOR AND TRACE CONSTITUENTS IN GROUND WATER AND SURFACE WATER SAMPLED BY GTCR (SEPTEMBER, 1983)

CONSTITUENT	SYM	UNIT OF MEASURE	LKV01 743 LOG DATE 090183	LKV01 744 LOG DATE 090183	LKV01 745 LOG DATE 090183	LKV01 746 LOG DATE 090183	LKV01 747 LOG DATE 090183	LKV01 749 LOG DATE 090183
SILVER	AG	MG/L	< 0.010000	< 0.010000	0.020000	< 0.010000	< 0.010000	< 0.010000
ALUMINUM	AL	MG/L	0.300000	0.300000	0.300000	0.300000	0.300000	< 0.200000
ARSENIC	AS	MG/L	< 0.010000	0.030000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
BARIUM	BA	MG/L	0.005000	0.024000	< 0.013000	0.032000	< 0.015000	0.033000
CALCIUM	CA	MG/L	2.910000	17.000000	30.800000	28.700000	14.300000	17.300000
CADMIUM	CD	MG/L	0.002200	0.000900	0.001000	< 0.000500	< 0.000500	< 0.000500
CHLORIDE	CL	MG/L	78.500000	4.000000	3.000000	3.000000	1.900000	1.700000
COBALT	CO	MG/L	< 0.020000	< 0.020000	< 0.020000	< 0.020000	< 0.020000	< 0.020000
CHROMIUM	CR	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
CONDUCTANCE	EC	UMHO/CM	870.000000	300.000000	275.000000	260.000000	150.000000	185.000000
REDOX POTENT	EH	MVOLTS	270.000000	325.000000	300.000000	335.000000	290.000000	310.000000
IRON	FE	MG/L	0.170000	0.130000	0.760000	0.390000	0.200000	0.220000
POTASSIUM	K	MG/L	3.200000	4.400000	3.100000	10.000000	5.200000	4.700000
MAGNESIUM	MG	MG/L	< 0.300000	7.300000	11.000000	11.000000	5.400000	7.700000
MANGANESE	MN	MG/L	< 0.030000	1.940000	1.500000	0.080000	0.120000	0.030000
MOLYBDENUM	MO	MG/L	< 0.030000	0.030000	< 0.020000	< 0.020000	0.030000	0.040000
SODIUM	NA	MG/L	180.000000	66.000000	29.000000	15.000000	12.000000	12.000000
NICKEL	NI	MG/L	< 0.020000	< 0.020000	0.040000	< 0.020000	< 0.020000	< 0.020000
LEAD	PB	MG/L	< 0.005000	< 0.005000	0.010000	< 0.005000	< 0.005000	< 0.005000
PH	PH	SU	8.500000	7.300000	7.300000	7.900000	9.200000	8.600000
SELENIUM	SE	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
SILICON	SI	MG/L	0.420000	26.000000	28.000000	22.000000	15.000000	16.000000
SULFATE	SO4	MG/L	19.000000	< 5.000000	6.000000	< 5.000000	6.000000	< 5.000000
STRONTIUM	SR	MG/L	0.020000	0.124000	0.102000	0.215000	0.100000	0.164000
URANIUM	U	MG/L	< 0.000100	< 0.000100	< 0.000100	< 0.000100	0.000100	0.000200
VANADIUM	V	MG/L	< 0.020000	< 0.020000	< 0.020000	< 0.020000	< 0.020000	< 0.020000

TABLE D-7.14
CONCENTRATIONS OF MAJOR AND TRACE CONSTITUENTS IN GROUND WATER
AND ACE WATER SAMPLED BY GEUR (SEPTEMBER, 1983)

CONSTITUENT	SYM	UNIT OF MEASURE	LKV01 750 LOG DATE 090183	LKV01 751 LOG DATE 090183	LKV01 753 LOG DATE 090183	LKV01 754 LOG DATE 090183	LKV01 755 LOG DATE 090183	LKV01 757 LOG DATE 090183
SILVER	AG	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	----------
ALUMINUM	AL	MG/L	1.700000	< 0.020000	< 0.020000	< 0.020000	1.000000	----------
ARSENIC	AS	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	----------
BARIUM	BA	MG/L	0.601000	0.014000	0.015000	0.310000	0.116000	----------
CALCIUM	CA	MG/L	22.500000	8.250000	0.163000	16.000000	40.800000	----------
CADMIUM	CD	MG/L	< 0.000500	0.000800	< 0.000500	< 0.000500	0.000500	----------
CHLORIDE	CL	MG/L	1.900000	1.900000	5.000000	0.800000	4.000000	----------
COBALT	CO	MG/L	0.020000	< 0.020000	< 0.020000	< 0.020000	< 0.020000	----------
CHROMIUM	CR	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	----------
CONDUCTANCE	EC	UMHO/CM	90.000000	100.000000	185.000000	170.000000	255.000000	1330.000000
REDOX POTENT	EH	MVOLTS	200.000000	300.000000	240.000000	300.000000	300.000000	320.000000
IRON	FE	MG/L	16.200000	0.240000	52.000000	0.160000	2.080000	----------
POTASSIUM	K	MG/L	6.200000	3.400000	5.400000	5.400000	4.500000	----------
MAGNESIUM	MG	MG/L	6.000000	3.300000	5.300000	7.000000	12.000000	----------
MANGANESE	MN	MG/L	1.730000	0.030000	0.300000	0.050000	0.800000	----------
MOLYBDENUM	MO	MG/L	< 0.020000	0.040000	< 0.020000	< 0.020000	< 0.020000	----------
SODIUM	NA	MG/L	11.000000	7.800000	25.000000	12.000000	43.000000	250.000000
NICKEL	NI	MG/L	< 0.020000	< 0.020000	< 0.020000	0.020000	0.020000	0.030000
LEAD	PB	MG/L	< 0.005000	< 0.005000	< 0.005000	< 0.005000	< 0.005000	< 0.005000
PH	PH	SU	6.100000	8.300000	7.600000	8.200000	9.300000	9.000000
SELENIUM	SE	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
SILICON	SI	MG/L	3.000000	15.000000	21.000000	21.000000	11.000000	75.000000
SULFATE	SO4	MG/L	< 5.000000	6.000000	< 5.000000	< 5.000000	10.000000	294.000000
STRONTIUM	SR	MG/L	0.284000	0.058000	0.070000	0.148000	0.276000	0.290000
URANIUM	U	MG/L	0.000400	0.000400	< 0.000100	< 0.000100	0.000200	< 0.000100
VANADIUM	V	MG/L	< 0.020000	< 0.020000	< 0.020000	< 0.020000	0.040000	< 0.020000

TABLE D-7.14
CONCENTRATIONS OF MAJOR AND TRACE CONSTITUENTS IN GROUND WATER
AND SURFACE WATER SAMPLED BY GEOR (SEPTEMBER, 1983)

CONSTITUENT	SYM	UNIT OF MEASURE	LKV01 758 LOG DATE 090183	LKV01 759 LOG DATE 090183	LKV01 760 LOG DATE 090183	LKV01 761 LOG DATE 090183	LKV01 762 LOG DATE 090183	LKV01 763 LOG DATE 090183
SILVER	AG	MG/L	< 0.010000	0.030000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
ALUMINUM	AL	MG/L	1.800000	0.400000	< 0.200000	< 0.200000	< 0.200000	< 0.200000
ARSENIC	AS	MG/L	0.320000	0.310000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
BARIUM	BA	MG/L	0.047000	0.029000	0.008000	0.008000	0.043000	0.012000
CALCIUM	CA	MG/L	36.900000	22.700000	11.600000	12.900000	38.900000	22.700000
CADMIUM	CD	MG/L	0.001200	0.004500	0.001300	0.001100	0.000900 <	0.000500
CHLORIDE	CL	MG/L	0.254000	201.000000	3.000000	14.000000	37.000000	2.000000
COBALT	CO	MG/L	< 0.020000	< 0.020000	< 0.020000	< 0.020000	< 0.020000	< 0.020000
CHROMIUM	CR	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
CONDUCTANCE	EC	UMHO/CM	2320.000000	1720.000000	190.000000	200.000000	610.000000	190.000000
REDOX POTENT	EH	MVOLTS	150.000000	260.000000	105.000000	310.000000	305.000000	325.000000
IRON	FE	MG/L	3.430000	0.810000	0.130000	0.400000	0.390000	0.070000
POTASSIUM	K	MG/L	22.000000	15.000000	5.600000	6.600000	10.000000	2.200000
MAGNESIUM	MG	MG/L	2.400000	1.000000	2.600000	4.000000	15.000000	6.600000
MANGANESE	MN	MG/L	0.210000	0.080000	0.030000	0.050000	0.270000	0.020000
MOLYBDENUM	MO	MG/L	< 0.020000	< 0.020000	< 0.020000	< 0.020000	< 0.020000	< 0.020000
SODIUM	NA	MG/L	480.000000	370.000000	19.000000	52.000000	84.000000	16.000000
NICKEL	NI	MG/L	< 0.020000	0.090000	0.030000	0.040000	0.030000	0.030000
LEAD	PB	MG/L	< 0.005000	< 0.005000	< 0.005000	0.005000 <	0.005000 <	0.005000
PH	PH	SU	9.300000	9.000000	9.200000	7.300000	8.300000	7.100000
SELENIUM	SE	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
SILCON	SI	MG/L	25.000000	32.000000	25.000000	25.000000	37.000000	21.000000
SULFATE	SO4	MG/L	510.000000	396.000000	< 5.000000	10.000000	39.000000	< 5.000000
STRONTIUM	SR	MG/L	0.543000	0.351000	0.070000	0.085000	0.210000	0.131000
URANIUM	U	MG/L	< 0.000100	0.000400	0.000100	0.000100	0.000300 <	0.000100
VANADIUM	V	MG/L	< 0.020000	0.040000	< 0.020000	< 0.020000	< 0.020000	< 0.020000

Presumably these #'s are equivalent to GECR #'s in Figures D.2.1 and D.2.2

Table D.2.15 Location descriptions of GECR sampling sites

Sample ID	Sample area[a]	Sample type[b]	Description
LKV01-01	S	C,W	NW corner of tailings
LKV01-05	S	C	Center of south side of tailings
LKV01-07	S	C	Center of tailings
LKV01-08	S	C	SW corner of evaporation pond adjacent to tailings
LKV01-11	S	C	NW quarter of NE evaporation pond
LKV01-16	A	C	West of SW corner of middle evaporation pond
LKV01-17	S	C	SW corner of middle evaporation ponds
LKV01-18	S	C	SW corner of SE evaporation pond
LKV01-19	A	C	Off the south edge of the SW evaporation pond
LKV01-21	A	C	NW corner of the NW evaporation pond
LKV01-23	A	C	Just off the south side of the SE corner of tailings
LKV01-26	S	C	Just off the south side of the evaporation pond adjacent to tailings
LKV01-27	A	C	East side of road, 400 m off the SW corner of the evaporation pond adjacent to tailings
LKV01-28	A	C	Along fence NW of mill site and east of tailings
LKV01-30	A	C	Just east of mill site buildings
LKV01-32	A	C	400 m east of tailings on east side of road
LKV01-34	B	C	150 m south of a stock pond that is 7 km north and 3 km west of mill site
LKV01-38	B	W	Spring just west off Highway 395, 2.5 km south of Lakeview
LKV01-39	B	W	Spring 300 m east of Highway 395 and 1.6 km south of Lakeview
LKV01-40	B	W	Hunters Hot Springs 0.8 km north of tailings
LKV01-41	B	W	Pond just north of Warner Highway, 7.2 km east and 1.6 km north of tailings
LKV01-42	B	W	Irrigation ditch 7.2 km south and 0.8 km east of tailings
LKV01-43	B	W	Well 150 m west of Highway 395, 2.5 km south of Lakeview
LKV01-44	B	W	Well along Stock Drive Road, 2.5 km west of Lakeview
LKV01-45	B	W	Well 1.6 km north and 150 m west of evaporation ponds
LKV01-46	B	W	Lake 2.5 km west of Lakeview Airport
LKV01-47	B	W	Thomas Creek where Highway 66 crosses, 3 km west of Lakeview

Table D.2.15 Location descriptions of GECR sampling sites (Concluded)

Sample ID	Sample area[a]	Sample type[b]	Description
LKV01-49	B	W	Camp Creek 2.5 km north, 1.5 km west of evaporation ponds
LKV01-50	B	W	Stock pond 7.2 km north and 2.8 miles west of mill site
LKV01-51	B	W	Thomas Creek, 4.8 km north and 4.0 km west of evaporation ponds
LKV01-53	B	W	Warner Creek at Chambers Ranch, 5.2 km north and 1.6 km north and 1.6 km east of tailings
LKV01-54	B	W	Camas Creek 8.8 km due east of tailings
LKV01-55	B	W	Pond just west of Highway 395, 4 km due north of tailings
LKV01-57	B	W	Small stream 200 m north of evaporation ponds
LKV01-58	B	W	Northernmost point of pond 180 m north of evaporation pond
LKV01-59	A	W	Southernmost point of pond 180 m north of evaporation pond
LKV01-60	A	W	Irrigation ditch 500 m south of evaporation ponds
LKV01-61	B	W	Stream along Highway 66, 1.5 km south of tailings
LKV01-62	B	W	Sewage disposal pond 3.2 km south of tailings
LKV01-63	B	W	Stream in Bullard Canyon, 0.8 km east of Lakeview
LKV01-64	A	W	Culvert on road 400 m south of tailings

[a]S - source area; A - potentially contaminated area adjacent to source area; B - background area.

[b]W - water sample; C - core sample.

TABLE D.2.16
RESULTS OF CHEMICAL AND RADIMETRIC ANALYSIS OF SURFACE WATER SAMPLES COLLECTED NEAR THE LAKEVIEW PROCESSING SITE.

FEDU & TIC Surface Samples - Fig D.2.15

CONSTITUENT	SYM	UNIT OF MEASURE	LKV01 605 LOG DATE 082284	LKV01 606 LOG DATE 070182	LKV01 606 LOG DATE 082284	LKV01 607 LOG DATE 070182	LKV01 607 LOG DATE 082284	LKV01 608 LOG DATE 070182
SILVER	AG	MG/L	< 0.010000	---------	< 0.010000	---------	< 0.010000	---------
ALUMINUM	AL	MG/L	< 0.100000	0.170000	< 0.100000	0.150000	< 0.100000	< 0.100000
ALKALINITY	ALK	MG/L CACO3	52.000000	193.000000	65.000000	134.000000	91.000000	97.000000
ARSENIC	AS	MG/L	0.010000	0.025000	0.020000	0.027000	0.050000	0.230000
BORON	B	MG/L	0.510000	---------	0.960000	---------	2.150000	---------
BARIUM	BA	MG/L	< 0.100000	< 0.100000	< 0.100000	< 0.100000	< 0.100000	---------
CALCIUM	CA	MG/L	10.200000	16.000000	11.200000	16.000000	16.400000	16.000000
CADMIUM	CD	MG/L	< 0.001000	< 0.010000	< 0.001000	< 0.010000	< 0.001000	---------
CHLORIDE	CL	MG/L	7.000000	18.000000	19.000000	19.000000	44.000000	143.000000
COBALT	CO	MG/L	< 0.050000	---------	< 0.050000	---------	< 0.050000	---------
CHROMIUM	CR	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	---------
COPPER	CU	MG/L	< 0.020000	0.013000	< 0.020000	< 0.010000	< 0.020000	---------
CONDUCTANCE	EC	UMHO/CM	224.000000	290.000000	292.000000	275.000000	561.000000	1200.000000
FLUORIDE	F	MG/L	0.520000	1.000000	0.780000	1.000000	1.580000	4.000000
IRON	FE	MG/L	0.030000	0.160000	< 0.030000	0.140000	0.040000	0.060000
GROSS ALPHA	GA	PCI/L	---------	6.000000	---------	5.000000	---------	---------
BICARBONATE	HCO	MG/L	---------	235.000000	---------	163.000000	---------	118.000000
MERCURY	HG	MG/L	< 0.000200	< 0.002000	< 0.000200	< 0.002000	< 0.000200	---------
POTASSIUM	K	MG/L	5.970000	5.800000	6.100000	5.800000	9.180000	10.100000
MAGNESIUM	MG	MG/L	1.270000	4.000000	1.530000	4.000000	4.310000	< 1.000000
MANGANESE	MN	MG/L	0.010000	---------	0.020000	---------	0.100000	---------
MOLYBDENUM	MO	MG/L	< 0.010000	< 0.050000	0.010000	< 0.050000	0.010000	< 0.050000
SODIUM	NA	MG/L	27.200000	43.000000	42.600000	40.000000	77.100000	245.000000
AMMONIUM	NH4	MG/L	0.100000	---------	0.200000	---------	0.200000	---------
NICKEL	NI	MG/L	< 0.040000	---------	< 0.040000	---------	< 0.040000	---------
NITRATE	NO3	MG/L	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
LEAD	PB	MG/L	< 0.010000	---------	< 0.010000	---------	< 0.010000	---------
PB-210	PBO	PCI/L	< 1.000000	---------	< 1.000000	---------	< 1.000000	---------
PH	PH	SU	8.040000	7.500000	7.640000	7.900000	7.080000	8.500000
PO-210	POO	PCI/L	< 0.500000	---------	< 0.500000	---------	< 0.500000	---------
PHOSPHATE	PO4	MG/L	0.280000	---------	0.280000	---------	0.660000	---------
RA-226	RA6	PCI/G	< 1.000000	< 2.000000	< 1.000000	< 2.000000	< 1.000000	< 2.000000
RA-228	RA8	PCI/L	< 1.000000	< 2.000000	< 1.000000	< 2.000000	< 1.000000	---------
ANTIMONY	SB	MG/L	< 0.003000	---------	< 0.003000	---------	< 0.003000	---------
SELENIUM	SE	MG/L	< 0.005000	< 0.005000	< 0.005000	< 0.005000	< 0.005000	< 0.005000
SILCON	SI	MG/L	35.000000	22.000000	35.300000	22.000000	29.900000	60.000000
TIN	SN	MG/L	< 0.005000	---------	< 0.005000	---------	< 0.005000	---------
SULFATE	SO4	MG/L	20.000000	35.000000	42.000000	35.000000	93.000000	266.000000
STRONTIUM	SR	MG/L	< 0.100000	---------	< 0.100000	---------	0.100000	---------
TOTAL SOLIDS	TDS	MG/L	180.000000	262.000000	250.000000	224.000000	360.000000	803.000000
TH-230	THO	PCI/G	< 1.000000	---------	< 1.000000	---------	< 1.000000	---------
TEMPERATURE	TMP	C - DEGREE	26.000000	25.000000	20.000000	24.000000	18.000000	32.000000
ORG. CARBON	TOC	MG/L	1.700000	---------	1.300000	---------	7.700000	---------
URANIUM	U	MG/L	---------	< 0.001000	---------	< 0.001000	---------	< 0.001000
U-234	U4	PCI/L	< 1.000000	---------	< 1.000000	---------	< 1.000000	---------
U-238	U8	PCI/L	< 1.000000	---------	< 1.000000	---------	< 1.000000	---------
VANADIUM	V	MG/L	< 0.010000	< 0.050000	< 0.010000	< 0.050000	< 0.010000	< 0.050000
ZINC	ZN	MG/L	< 0.005000	---------	< 0.005000	---------	0.006000	---------

TABLE D.2.16
RESULTS OF CHEMICAL AND RADIMETRIC ANALYSIS OF SURFACE WATER SAMPLES COLLECTED NEAR THE LAKEVIEW PROCEESING SITE.

CONSTITUENT	SYM	UNIT OF MEASURE		LKV01 608 LOG DATE 082684		LKV01 609 LOG DATE 070182		LKV01 609 LOG DATE 082684
SILVER	AG	MG/L	<	0.010000		--------	<	0.010000
ALUMINUM	AL	MG/L	<	0.100000	<	0.100000		0.200000
ALKALINITY	ALK	MG/L CACO3		77.000000		186.000000		74.000000
ARSENIC	AS	MG/L		0.160000		0.190000		0.190000
BORON	B	MG/L		6.550000		--------		7.000000
BARIUM	BA	MG/L	<	0.100000		--------	<	0.100000
CALCIUM	CA	MG/L		7.940000		17.000000		14.000000
CADMIUM	CD	MG/L	<	0.001000		--------	<	0.001000
CHLORIDE	CL	MG/L		120.000000		137.000000		120.000000
COBALT	CO	MG/L	<	0.050000		--------	<	0.050000
CHROMIUM	CR	MG/L	<	0.010000		--------	<	0.010000
COPPER	CU	MG/L	<	0.020000		--------	<	0.020000
CONDUCTANCE	EC	UMHO/CM		1270.000000		1170.000000		1200.000000
FLUORIDE	F	MG/L		4.630000		5.000000		4.660000
IRON	FE	MG/L		0.040000		0.060000		0.040000
GROSS ALPHA	GA	PCI/L		--------		--------		--------
BICARBONATE	HCO	MG/L		--------		227.000000		--------
MERCURY	HG	MG/L	<	0.000200		--------		0.000200
POTASSIUM	K	MG/L		8.460000		10.200000		8.860000
MAGNESIUM	MG	MG/L		0.358000		1.000000		0.291000
MANGANESE	MN	MG/L	<	0.010000		--------	<	0.010000
MOLYBDENUM	MO	MG/L		0.050000	<	0.050000		0.030000
SODIUM	NA	MG/L		235.000000		250.000000		217.000000
AMMONIUM	NH4	MG/L	<	0.100000		--------		0.200000
NICKEL	NI	MG/L	<	0.040000		--------	<	0.040000
NITRATE	NO3	MG/L	<	1.000000		--------	<	1.000000
LEAD	PB	MG/L	<	0.010000		--------	<	0.010000
PB-210	PBO	PCI/L	<	1.200000		--------	<	1.200000
PH	PH	SU		8.970000		8.300000		7.870000
PO-210	PDO	PCI/L	<	0.500000		--------	<	0.500000
PHOSPHATE	PO4	MG/L	<	0.150000		--------		0.320000
RA-226	RA6	PCI/G	<	1.000000	<	2.000000	<	1.000000
RA-228	RA8	PCI/L	<	1.000000		--------	<	1.000000
ANTIMONY	SB	MG/L		0.011000		--------		0.013000
SELENIUM	SE	MG/L	<	0.005000	<	0.005000	<	0.005000
SILCON	SI	MG/L		45.500000		45.000000		79.000000
TIN	SN	MG/L	<	0.005000		--------	<	0.005000
SULFATE	SO4	MG/L		270.000000		268.000000		270.000000
STRONTIUM	SR	MG/L		0.200000		--------		0.300000
TOTAL SOLIDS	TDS	MG/L		862.000000		846.000000		865.000000
TH-230	THO	PCI/G	<	1.000000		--------	<	1.000000
TEMPERATURE	TMP	C - DEGREE		31.000000		36.000000		25.000000
ORG. CARBON	TOC	MG/L		3.800000		--------		1.600000
URANIUM	U	MG/L		--------	<	0.001000		--------
U-234	U4	PCI/L	<	1.000000		--------	<	1.000000
U-238	U8	PCI/L	<	1.000000		--------	<	1.000000
VANADIUM	V	MG/L	<	0.010000	<	0.050000	<	0.010000
ZINC	ZN	MG/L	<	0.005000		--------	<	0.005000

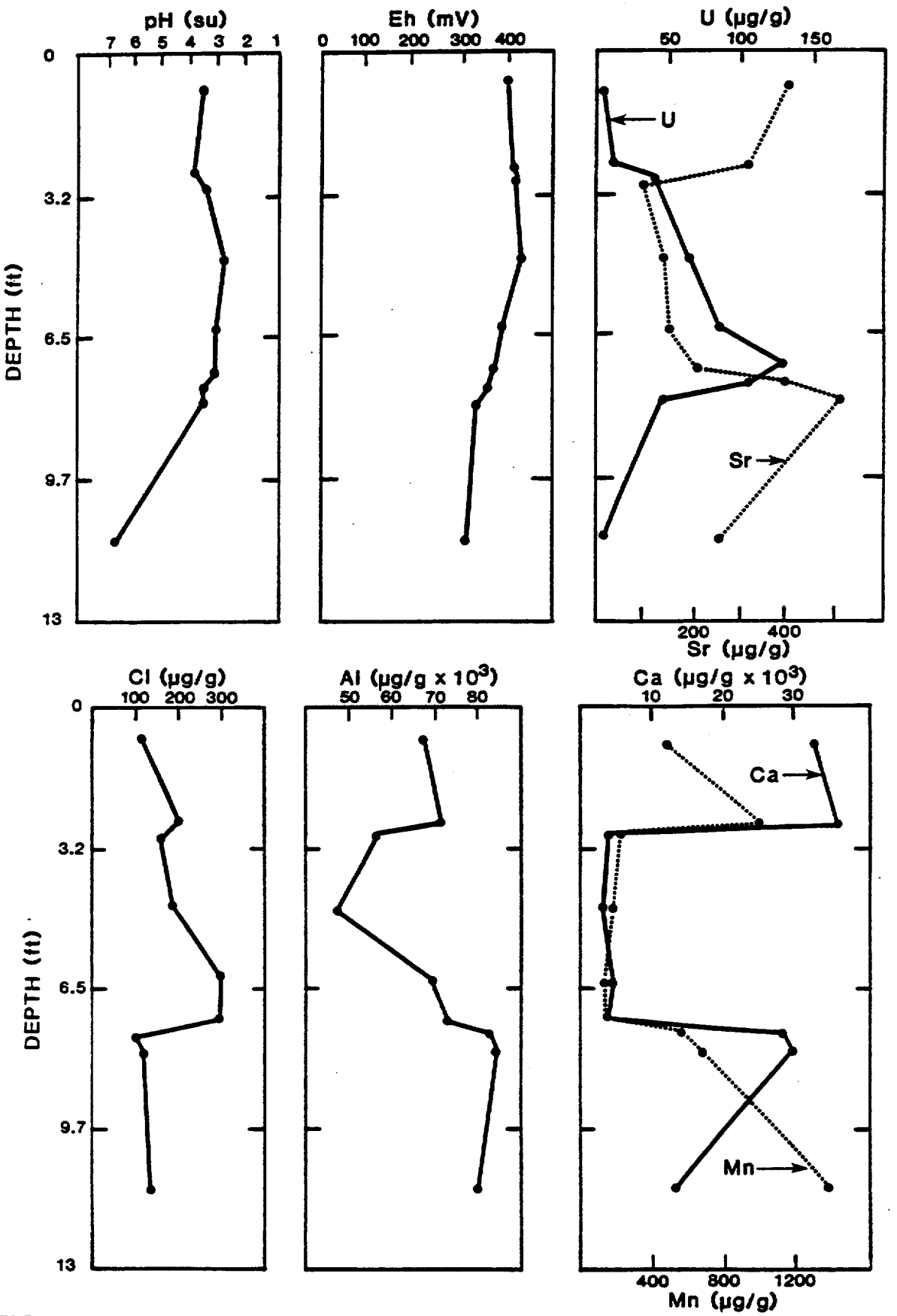


FIGURE D.2.16 CHEMICAL PROFILE OF SOLID TAILINGS SAMPLE FROM CENTER OF PILE (#7, GECR)

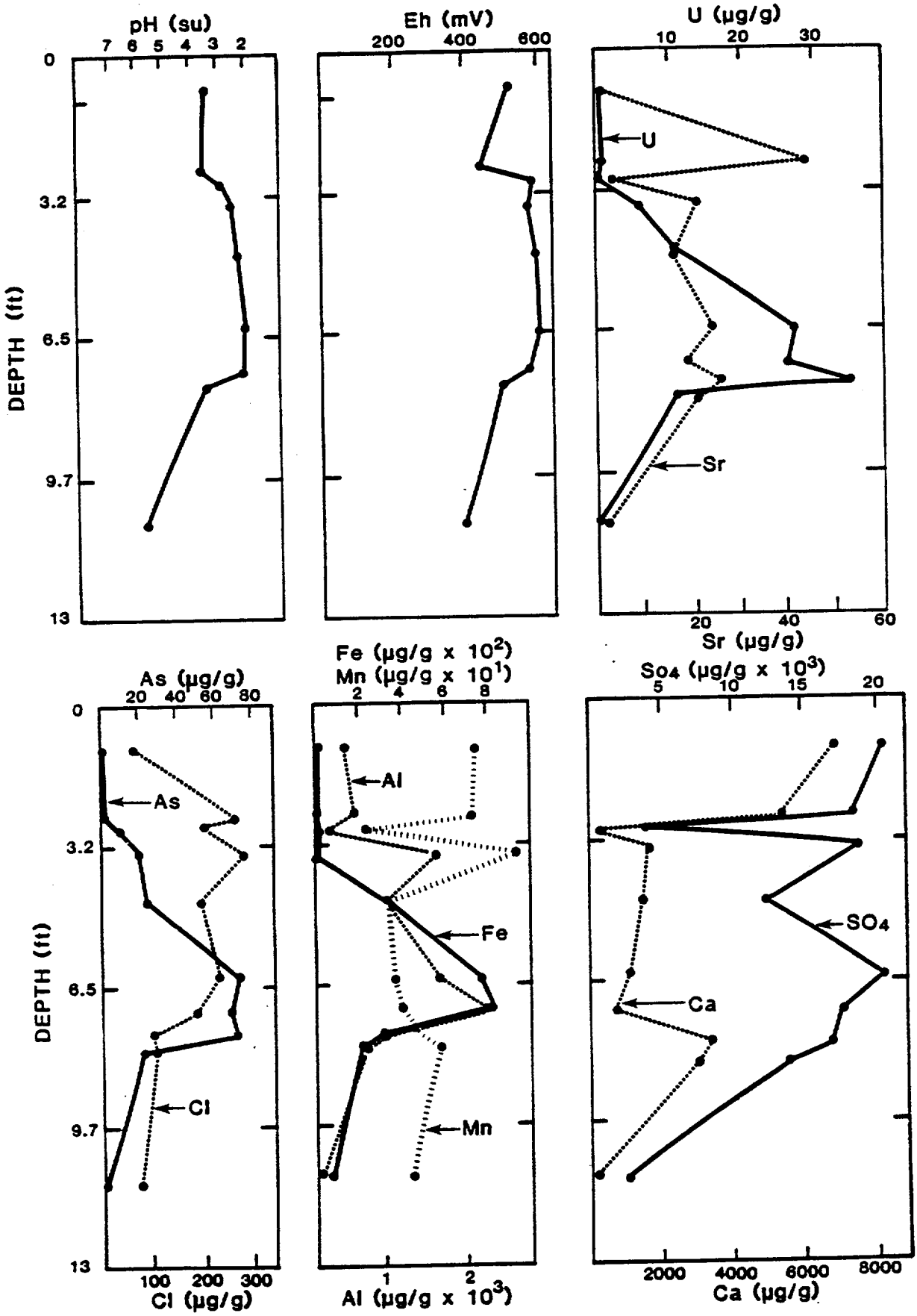


FIGURE D.2.17 CHEMICAL PROFILE OF WATER EXTRACT FROM TAILINGS SAMPLE FROM CENTER OF PILE (#7, GECR)

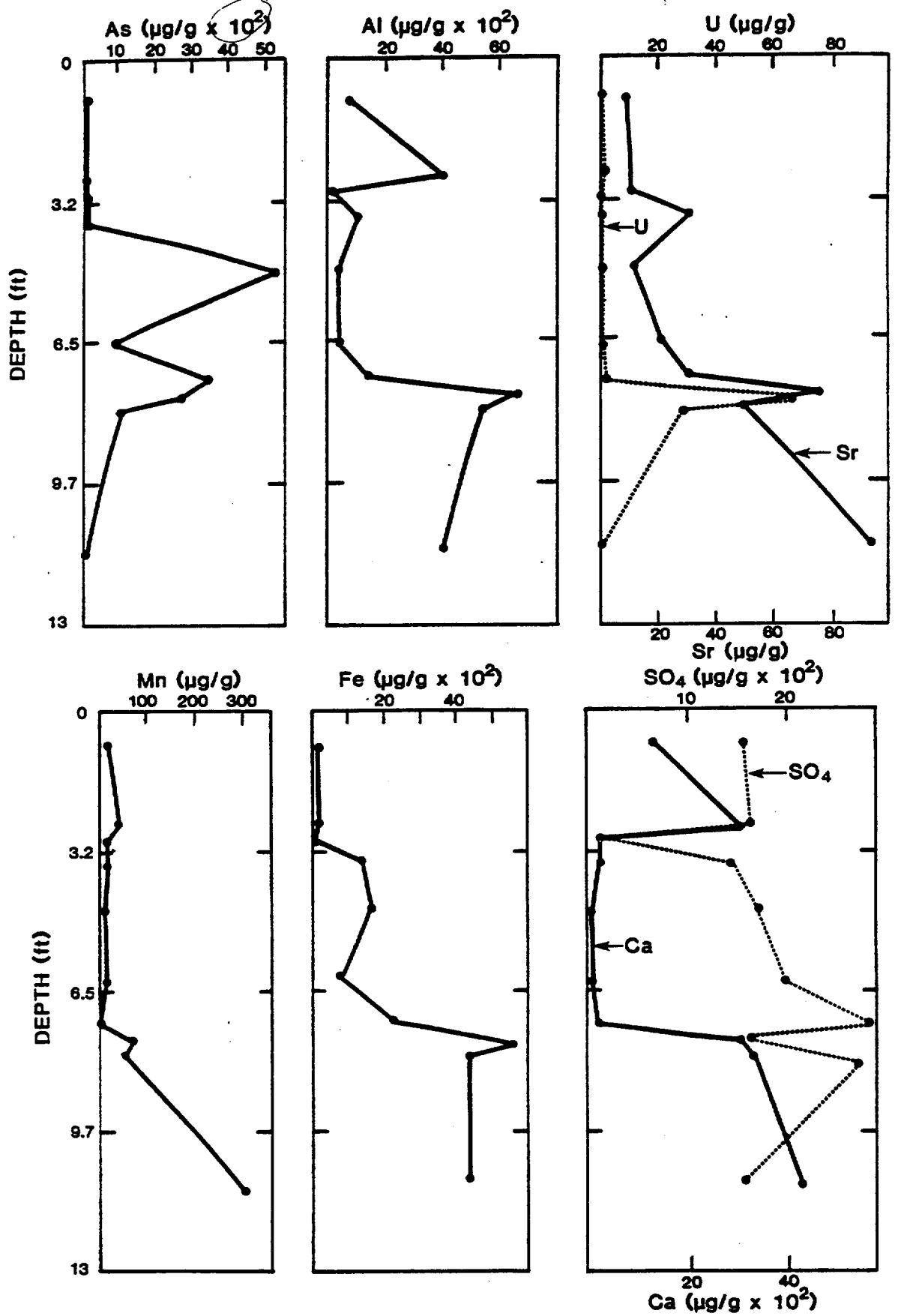


FIGURE D.2.18 CHEMICAL PROFILE OF ACID EXTRACT FROM TAILINGS SAMPLE FROM CENTER OF PILE (#7, GECR)

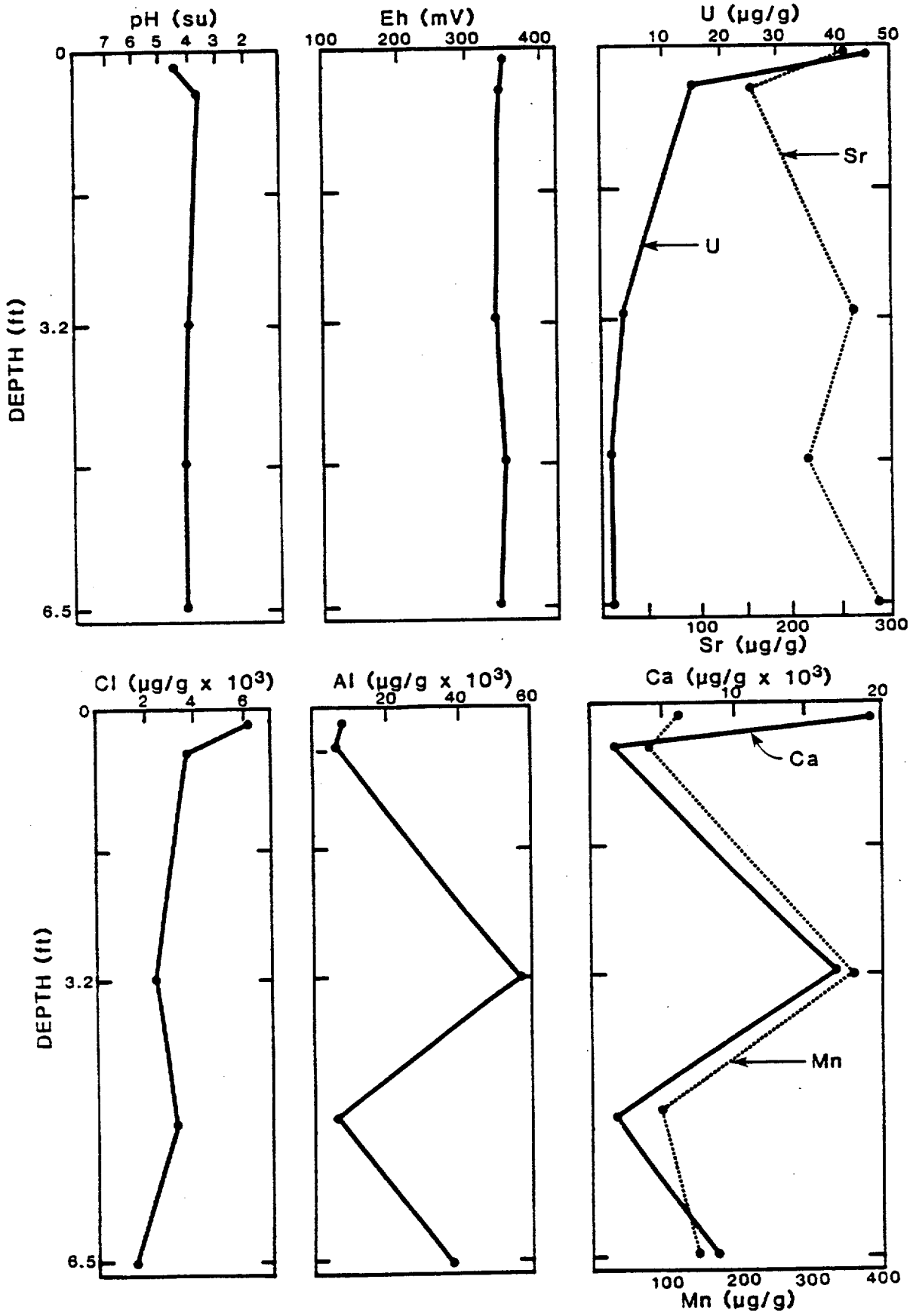


FIGURE D.2.19 CHEMICAL PROFILE OF SOLID EVAPORATION POND SUBSOILS SAMPLE (#11, GECR)

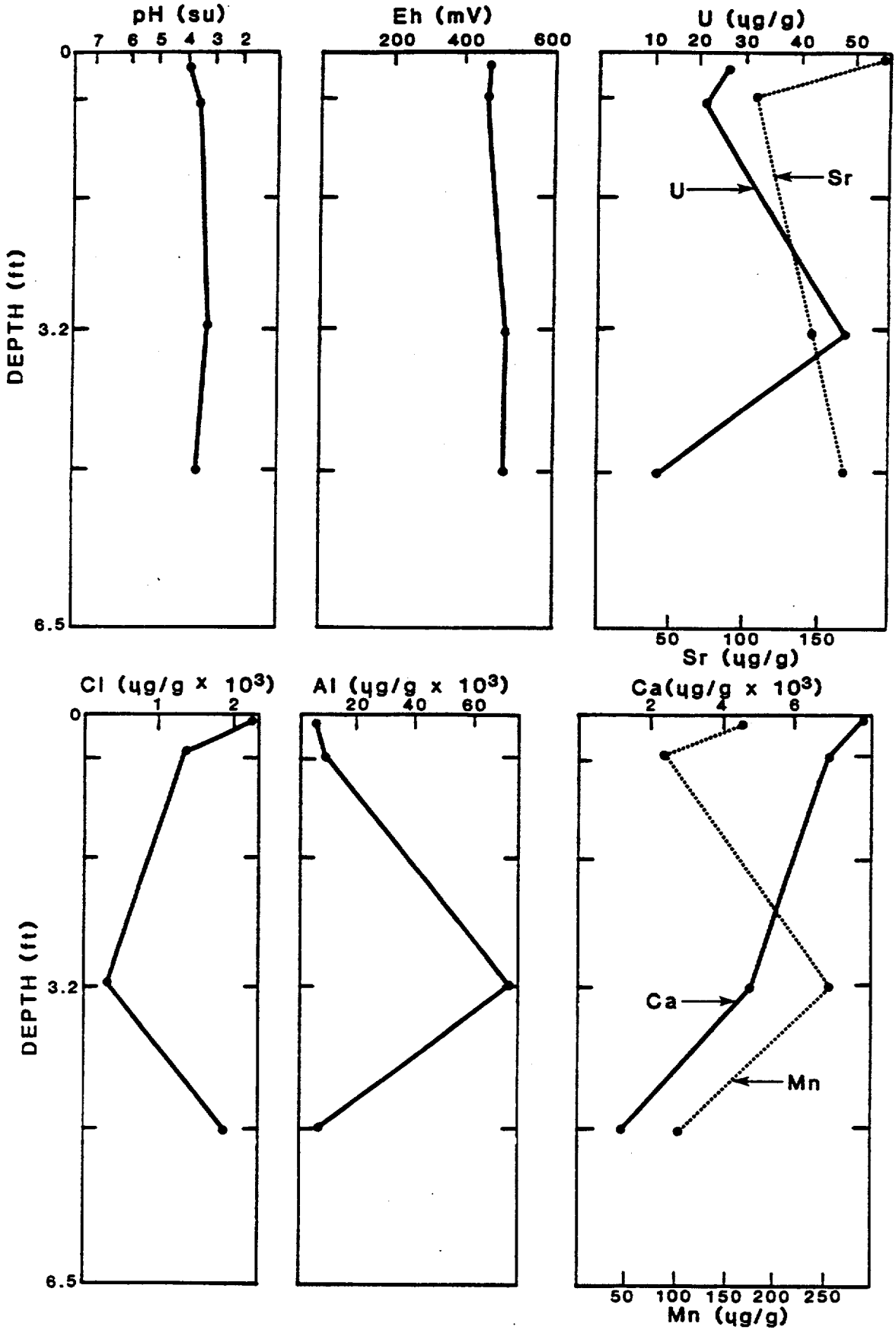


FIGURE D.2.20 CHEMICAL PROFILE OF SOLID EVAPORATION POND SUBSOILS SAMPLE (#17, GECR)

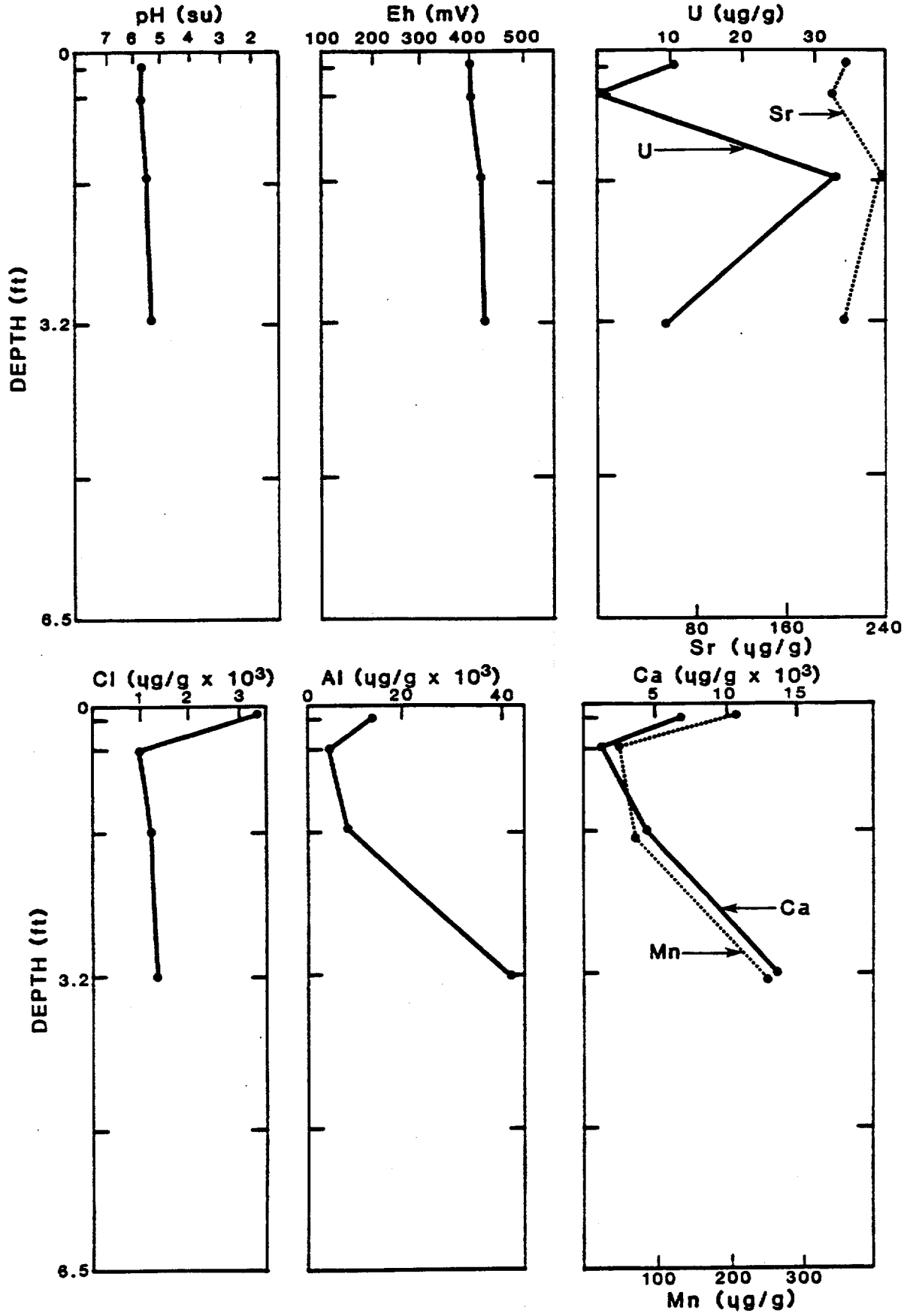
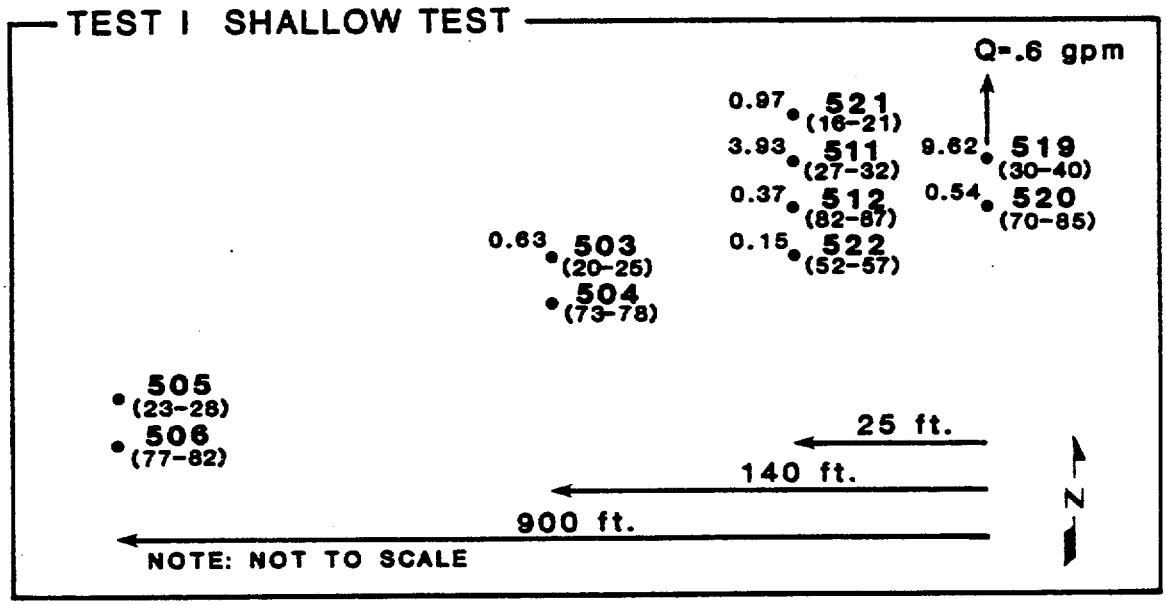


FIGURE D.2.21 CHEMICAL PROFILE OF SOLID SOIL SAMPLE OUTSIDE THE EVAPORATION PONDS (#19, GECR)

TABLE D.2.17
RESULTS OF CHEMICAL AND RADIOMETRIC ANALYSIS OF WATER SAMPLES COLLECTED AT THE COLLINS RANCH ALTERNATE DISPOSAL SITE.

CONSTITUENT	SYM	UNIT OF MEASURE	LKV02 508 LOG DATE 100284	LKV02 513 LOG DATE 100384	LKV02 514 LOG DATE 100384	LKV02 515 LOG DATE 100384	LKV02 516 LOG DATE 100284	LKV02 601 LOG DATE 091384
SILVER	AG	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
ALUMINUM	AL	MG/L	< 0.100000	< 0.100000	< 0.100000	< 0.100000	< 0.100000	< 0.100000
ALKALINITY	ALK	MG/L CACO3	144.000000	109.000000	0142.000000	142.000000	120.000000	48.000000
ARSENIC	AS	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
BORON	B	MG/L	0.110000	0.280000	0.080000	0.030000	0.200000	0.090000
BARIUM	BA	MG/L	< 0.010000	< 0.010000	< 0.010000	0.010000	< 0.010000	< 0.100000
CALCIUM	CA	MG/L	29.000000	21.700000	51.700000	36.800000	15.600000	8.900000
CADMIUM	CD	MG/L	< 0.001000	< 0.001000	< 0.001000	< 0.001000	< 0.001000	< 0.002000
CHLORIDE	CL	MG/L	4.000000	6.000000	6.000000	3.000000	3.000000	8.700000
COBALT	CO	MG/L	< 0.050000	< 0.050000	< 0.050000	< 0.050000	< 0.050000	< 0.050000
CHROMIUM	CR	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
COPPER	CU	MG/L	0.050000	0.020000	< 0.020000	< 0.020000	< 0.020000	< 0.020000
CONDUCTANCE	EC	UMHO/CM	287.000000	322.000000	389.000000	340.000000	270.000000	117.000000
FLUORIDE	F	MG/L	0.200000	0.200000	0.200000	0.100000	0.200000	0.180000
IRON	FE	MG/L	< 0.030000	< 0.030000	< 0.030000	< 0.030000	< 0.030000	0.060000
MERCURY	HG	MG/L	< 0.000200	< 0.000200	< 0.000200	0.000200	< 0.000200	< 0.000200
POTASSIUM	K	MG/L	8.010000	11.200000	10.300000	7.120000	11.300000	4.980000
MAGNESIUM	MG	MG/L	5.450000	4.480000	0.772000	9.530000	4.410000	4.120000
MANGANESE	MN	MG/L	0.020000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	0.050000
MOLYBDENUM	MO	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
SODIUM	NA	MG/L	20.900000	27.600000	21.000000	13.800000	24.100000	6.820000
AMMONIUM	NH4	MG/L	0.200000	0.200000	0.200000	0.200000	0.100000	0.200000
NICKEL	NI	MG/L	< 0.040000	< 0.040000	< 0.040000	< 0.040000	< 0.040000	< 0.040000
NITRATE	NO3	MG/L	< 1.000000	4.000000	10.000000	4.000000	7.000000	< 1.000000
LEAD	PB	MG/L	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000	< 0.010000
PB-210	PBO	PCI/L	< 1.100000	< 1.000000	< 1.000000	< 1.100000	< 1.100000	1.100000
PH	PH	SU	8.880000	8.960000	10.350000	7.140000	7.780000	7.380000
PO-210	POO	PCI/L	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 0.200000
PHOSPHATE	PO4	MG/L	0.790000	1.490000	0.530000	0.590000	2.450000	< 0.150000
RA-226	RA6	PCI/G	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
ANTIMONY	SB	MG/L	< 0.003000	< 0.003000	< 0.003000	< 0.003000	< 0.003000	< 0.003000
SELENIUM	SE	MG/L	< 0.005000	< 0.005000	< 0.005000	< 0.005000	< 0.005000	< 0.005000
SILCON	SI	MG/L	24.100000	29.300000	34.000000	32.000000	31.600000	10.000000
TIN	SN	MG/L	< 0.005000	< 0.005000	< 0.005000	< 0.005000	< 0.005000	< 0.005000
SULFATE	SO4	MG/L	13.000000	22.000000	23.000000	8.000000	7.000000	0.100000
STRONTIUM	SR	MG/L	0.100000	0.100000	0.200000	0.200000	0.100000	< 0.100000
TOTAL SOLIDS	TDS	MG/L	182.000000	190.000000	240.000000	188.000000	164.000000	88.000000
TH-230	THO	PCI/G	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
TEMPERATURE	TMP	C - DEGREE	12.000000	12.000000	14.000000	14.000000	14.000000	15.000000
ORG. CARBON	TOC	MG/L	2.400000	2.900000	2.600000	1.000000	1.700000	20.100000
U-234	U4	PCI/L	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
U-238	U8	PCI/L	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000	< 1.000000
VANADIUM	V	MG/L	0.010000	0.020000	0.050000	0.010000	0.010000	< 0.010000
ZINC	ZN	MG/L	0.012000	< 0.005000	0.005000	0.014000	0.009000	0.008000



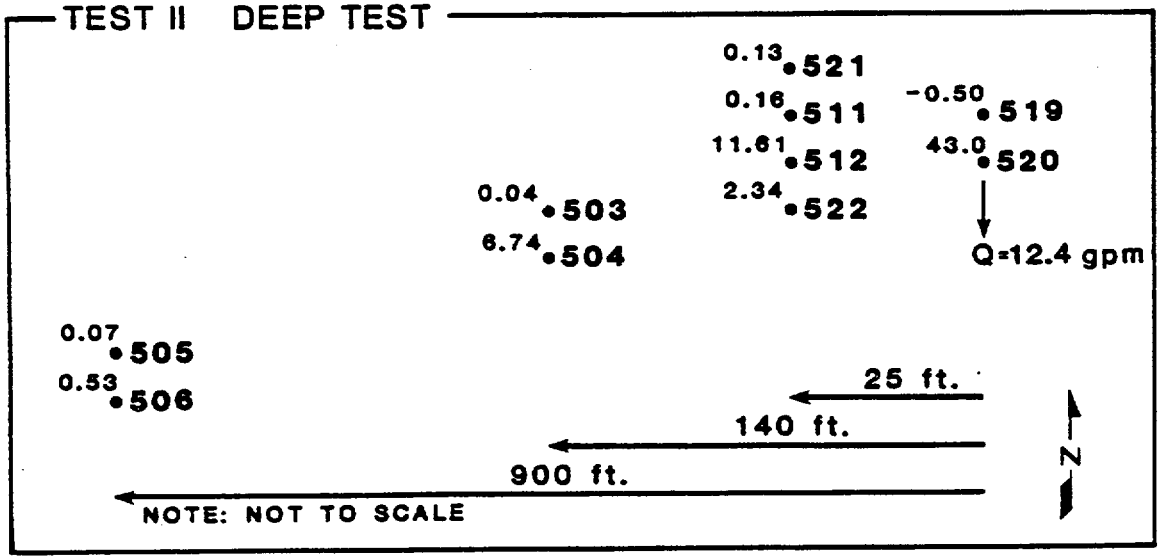


FIGURE D.2.22

WELL SPACING AND TOTAL DRAWDOWNS FOR LAKEVIEW AQUIFER TESTS

LEGEND	
0.13	TOTAL DRAWDOWN AFTER 24 HOURS
521	WELL IDENTIFICATION
(77-82)	SCREENED INTERVAL (FT.)

Pump test data also indicate hydraulic communication between the two screened zones and lithologic logs support the conclusion that the tested screened zones are both part of a multiple aquifer system where a succession of leaky aquifers are separated by aquitards of varying thicknesses and lateral extent.

Each test was conducted on a schedule of 24 hours pumping and 24 hours recovery according to methods outlined in Section 8.2.12 of the Standard Operating Procedures Manual. An average pumping rate of 12.4 gpm was maintained in the deeper system and 0.60 gpm in the shallow system. Transmissivities and storage coefficients were calculated using Theis, Hantush, and Boulton non-equilibrium methods and the Jacob-Cooper approximation. The saturated thickness was obtained from the difference between initial water-level elevation and the elevation at the bottom of the screened interval. The results are tabulated in Table D.2.5.

From the deeper test, results from observation wells 512, 504, and 506 were used to obtain representative transmissivity and storage coefficient values. These wells showed measurable drawdowns (from 11.6 to 0.5 feet) and were screened over the interval of the pumping well. From the shallow test, results from wells 511 and 503 were used to obtain representative transmissivity and storage coefficient values. These wells were screened slightly above the pumping well (519).

All calculations and time-drawdown data plots are filed in the UMTRA Project Albuquerque Operations Office. The Jacob-Cooper Method of analysis is an approximation of the Theis Method requiring that the quantity,

$$u = \frac{r^2 S}{4\pi Tt}$$

be less than 0.01. During the deep test, semi-log plots of log time versus drawdown data fell on straight line curves after 10 minutes in observation well 512 and after 75 minutes in observation well 504. Using the average transmissivity and storage coefficient values calculated from the test and setting $u = 0.01$, the Jacob-Cooper Solution remains valid for well 512 for the duration of the pumping test. Because well 504 is more distant from the pumped well, additional pumping time may have been required before approximate conditions are realized because the calculated u exceeds 0.01 for the duration of the test. Results of the Jacob-Cooper analysis of data from both wells produced very similar transmissivity and storage coefficient values (Table D.2.5).

Hantush's modified and Boulton's method were used for analyzing transient flow in a pumped semi-confined aquifer that receives leakage from semi-pervious bounding layers. The difference between the two methods is that the Hantush modified

method takes into account storage of water in the semi-pervious confining bed(s). Log-log plots of time verses drawdown were matched to Boulton Type A curves for leaky confined aquifers and to Hantush's modified type curves for leaky confined aquifers. Plotted data were fit to both types of curves and were analyzed by the method providing the "best fit." Observation well 512 was matched to a Boulton-type curve for r/B = 0.1 and the calculated transmissivity was nearly equal to results obtained by the Jacob-Cooper steady state method. Data from observation well 504 were fitted to the early part of the Hantush type curve for ß = 5.0. Results for transmissivity were seven times lower than those calculated by the Jacob-Cooper method. The more representative transmissivity for well 504 is probably closer to the Hantush value of 14 ft^2/day due to its incorporation of storage in semi-pervious confining beds. Average transmissivity from all four analyses is 74 ft^2/day and estimated hydraulic conductivity is 4.4 ft/day in the 70- to 85-foot zone.

Shallow test observation well data were plotted for wells 511 and 503. The Jacob-Cooper approximation analysis was valid for well 511 where $u < 0.01$ after 400 minutes of pumping using the calculated values for transmissivity and storage coefficient. Well 503 data were analyzed using the Boulton method for transient flow. Well 511 data also were analyzed by the Theis method for transient flow. Results (Table D.2.5) show a fairly narrow range of calculated transmissivities and storage coefficients. Averages of the three methods of analysis from two sets of drawdown data are 13.6 ft^2/day for transmissivity and 2.0×10^{-4} for storage coefficients.

Drawdown data, inclusive of all affected wells, show that the entire sequence of units behaves as a leaky multiple aquifer system. Wells screened above and below the pumping zone can be used to evaluate aquitard characteristics or vertical hydraulic conductivities through semi-confining layers (Neuman and Witherspoon, 1972). This becomes important when assessing the potential for downward migration of shallow contaminated water into ground-water flow systems. The ratio method outlined by Neuman and Witherspoon (1972), relies on the ratio between drawdown in the aquitard and drawdown in the pumped aquifer to determine the vertical hydraulic conductivity over the thickness of the semi-confining layers. If the ground-water system is designated such that the deeper screened zone from 70 to 85 feet constitutes aquifer I and the shallow screened zone from 30 to 40 feet constitutes aquifer II, the intervening zone is an aquitard with a weighted average vertical hydraulic conductivity over the 30-foot thickness. Using drawdown data from well 522 screened within the aquitard and well 512 screened within aquifer I, the ratio method gives a vertical hydraulic conductivity (K') of the confining zone equal to 0.058 ft/day. Calculations for K' are within files at the UMTRA Project Office, Albuquerque, New Mexico.

The calculated seepage velocity for the Lakeview groundwater system can be determined from the equation:

$$q_s = \frac{-K\ \nabla h}{n_e} \qquad (1)$$

q_s = seepage velocity (ft/day)

∇h = hydraulic gradient (ft/ft)

K = hydraulic conductivity (ft/day)

n_e = effective porosity

where

$K_{\text{shallow zone}} = 1.4$ ft day

$K_{z\ \text{semi-confining zone}} = 0.058$ ft/day

$K_{\text{deeper zone}} = 4.4$ ft/day

$\nabla h = 0.01$ (TAC measured water levels September 1984)

$n_e = 0.10$ (assumed value)

The calculated shallow zone seepage velocity is in the range of 0.14 ft/day or 52 ft/year and the deeper zone seepage velocity is in the range 0.44 ft/day or 160 ft/year. Because the entire aquifer sequence to a depth of 85 feet acts as a series of multiple aquifers and leaky aquitards, the horizontal velocity vector of a particle of water moving through the subsurface may range from 0.14 to 0.44 ft/day (52 to 160 ft/year).

The vertical seepage velocity may be calculated using the same equation. The average vertical head differential between the two screened zones is seven feet over the 30-foot thickness of the semi-confining zone, to produce a vertical hydraulic gradient of 0.20. Substituting K_z of 0.058 ft/day, ∇h of 0.20 and $n_e = 0.10$, the vertical velocity vector of a particle of water is 0.11 ft/day.

The local variability in hydraulic conductivities between screened zones was determined from slug test data collected from 18 TAC monitor wells. Results are listed in Table D.2.6. In these tests, a metal "slug" of known volume is suddenly removed from a well, the water level drops instantaneously, and the recovery of the water level is measured at closely spaced time intervals. Time versus residual drawdown data was plotted and analyzed by three methods; the Skibitzke Method, Bouwer-Rice Method, and Hvorslev Method. The Skibitzke Method is explained in Bentall (1963).

The method is the solution of the formula:

$$s' = q/4\,\pi Tt \qquad (2)$$

where

s' = residual drawdown (ft)

q = slug volume (ft^3)

T = transmissivity (ft^2/day)

t = time (day)

The basic assumptions are that the radius of the well is small in comparison with the extent of the aquifer, and that t is large. Results of this method were considered valid when time of recovery, t, was greater than 20 minutes. Values for residual drawdown and time were always taken as the last measurement at that well. The calculated transmissivity was used to calculate a value of hydraulic conductivity ($K = T/b$) by assuming that "b" was equivalent to the screened interval of the well. About half the wells tested recovered too quickly for a valid application of this method.

The Bouwer-Rice Method is explained in Bouwer (1978). This method considers the quantity (R_e/r_w) where R_e is the effective radius over which the drawdown is dissipated and r_w is the radius of disturbance (well radius plus radius of gravel pack). R_e was calculated for partially penetrating wells due to the stratified nature of the aquifers. The equation which yields a value of hydraulic conductivity is:

$$K = \frac{r_c^2 \ln (R_e/r_w)}{2L} \frac{1}{t} \ln\left(\frac{Yo}{Yt}\right) \qquad (3)$$

where

r_c = the inside radius of the well casing (ft)

R_e/r_w = is as described above

L = the height of the screened interval (ft)

t = time (min)

Yo = water level at first reading - initial water level at t = 0 (ft)

Yt = residual drawdown at time, t (ft)

This method produced the tightest range of hydraulic conductivities. Transmissivities were calculated by multiplying K by the length of the screened zone.

The method of Hvorslev is explained in Freeze and Cherry (1979). Hvorslev assumes a homogeneous, isotopic, infinite medium in which both soil and water are incompressible. The method utilizes a graphical solution to calculate values of hydraulic conductivity. The plotted data should comprise a straight line; however, some of the tests at Lakeview resulted in segmented lines and decreasing slopes near the end of the test. Data at intermediate times were generally used to compute the hydraulic conductivity, by reason that the "early data" probably reflect characteristics of the gravel pack and later data show a decrease in water level recovery.

Due to the inherent assumptions in the methods and the assessment of the slug test data collected, most confidence was placed upon the Bouwer-Rice method of analysis (Table D.2.18). Results produced a mean hydraulic conductivity of 1.21 ft/day in tested intervals between 50 to 85 feet and 1.80 ft/day in the tested intervals between 17 to 32 feet. These local hydraulic conductivities are in the range of values calculated by the aquifer tests.

FBDU conducted a 8.5-hour aquifer test in well 527 screened in the zone from 10 to 22 feet. No drawdown was measured in nearby observation wells 532 and 528. Drawdown data from the pumped well were matched to water table curves of Prickett (1965) and a transmissivity value of 39.8 ft^2/day was determined. Assuming an initial saturated thickness of 15.5 feet, the calculated hydraulic conductivity is 2.6 ft/day (FBD, 1983). Results fall into an intermediate range between values calculated from the TAC aquifer tests.

Slug tests conducted by FBDU in wells 527-533 produced a range of hydraulic conductivities from 0.17 ft/day to 25.6 ft/day. Disregarding extreme values, the average hydraulic conductivity is 4.0 ft/day (Table D.2.19). Methods of analysis were the Cooper Method (Cooper et al., 1967) and Bouwer-Rice Method (Bouwer and Rice, 1976). The values obtained are slightly larger than TAC values; however, the FBDU wells tested were four-inch diameter wells compared to the TAC two-inch diameter wells, and FBDU wells were completed in a shallower zone than TAC wells.

Collins Ranch alternate disposal site

Local variations in values of hydraulic conductivity of subsurface deposits at the Collins Ranch site were determined from slug test data collected from five monitor wells. The results are presented in Table D.2.7 and the data were analyzed by the same methods as the data from the processing site TAC wells. Averages of valid analyses by the three methods are

Table D.2.18 Summary of TAC slug test data analysis

		Hydraulic conductivity		
		n	Range (ft/day)	Mean
Tested interval: 50-85 feet				
Method:	Skibitzke	5	0.04-11.6	2.25
	Bouwer-Rice	7	0.30-2.6	1.21
	Hvorslev	7	0.30-16.3	3.65
Tested interval: 17-32 feet				
Method:	Skibitzke	5	0.57-2.28	1.14
	Bouwer-Rice	9	0.13-4.80	1.80
	Hvorslev	8	0.99-21.9	6.2

Table D.2.19 Summary of FBDU slug-discharge data analyses

Well number	Aquifer conditions	Preferred analytical method	Hydraulic conductivity (feet per day)	Saturated thickness (feet)	Transmissivity (square feet per day)
LKV01-					
527	Confined	a	25.6	15.5	397.0
529	Unconfined	b	2.1	14.7	30.9
530	Unconfined	b	1.1	8.9	9.8
531	Confined	a	1.3	10.0	13.2
532	Confined	a	11.3	13.0	147.0
528	Confined	a	0.17	7.5	1.3

[a]Cooper et al. (1967).
[b]Bouwer and Rice (1976).

presented in Table D.2.8. Transmissivities were calculated by multiplying K by the length of well screen. Hydraulic conductivities ranged from 0.12 ft/day to 1.5 ft/day and the average from the five wells was 0.64 ft/day.

A hydraulic gradient of 0.18 was determined from a potentiometric contour map based upon five measured ground-water levels, October, 1984. Calculated ground-water velocity using equation (1) and the values K = 0.64 ft/day, ∇h = 0.018, and n_e = 0.10 is 0.11 ft/day, or 42 ft/year.

Flynn Ranch alternate disposal site

Two packer tests at the Flynn ranch site provided semi-quantitative values of hydraulic conductivity of basaltic bedrock underlying the site. Tests were run using double packers set in open, cleaned boreholes. The method of analysis is outlined in U.S. Department of the Interior, Ground Water Manual (USDOI, 1981). It is applicable to tests run in consolidated rock using double packers and incorporates the graphical determination of a conductivity coefficient (C_u) for unsaturated materials with partially penetrating test wells. The equation for determining the hydraulic conductivity (K) is:

$$K = \frac{Q}{C_u \, rH} \qquad (4)$$

where

K = hydraulic conductivity, ft/sec under a unit gradient

Q = steady flow into the well (ft^3/sec)

C_u = conductivity coefficient for unsaturated material

r = radius of test hole (ft)

H = effective head (pressure head + elevation head - friction loss)

Calculations and parameter values are in the UMTRA Project Office, Albuquerque, New Mexico. Computed values of hydraulic conductivity were 0.13 ft/day in the interval from seven to 14 feet in borehole 4 and 0.82 ft/day in the interval from 38 to 43 feet in borehole 16. Another test in borehole 13 in the interval from seven to 14 feet was terminated when increasing injection pressure produced no-take readings. These tests actually measure the capacity of a localized zone between packers to accept water pumped into the unsaturated formation.

These values indicate that the fractured, weathered basalts have continuous and interconnected void spaces in localized zones. Results are in accordance with the hydraulic properties of basalt flows where the base or deeply weathered surfaces of flows are more than four orders of magnitude more permeable than unaltered portions of flows (Freeze and Cherry, 1979).

Any infiltrating water from beneath the stabilized pile would move into the unsaturated permeable zones and would tend to perch on the tighter "no take" zones. Unsaturated hydraulic conductivities which are a function of moisture content and negative pressure head would be considerably lower than saturated hydraulic conductivities of 0.13 feet and 0.82 ft/day measured in packer tests.

D.2.4.2 Geochemical data analysis

Geochemical data provide the quantitative evidence for assessing the movement of tailings pile chemical constituents into the ground-water system. A sequential data assessment was used at the Lakeview processing site to develop a conceptual model of the existing site hydrogeochemistry. An understanding of the baseline hydrogeochemistry at the Collins Ranch site was based upon an evaluation of chemical data collected from five monitor wells. Predictions of hydrogeochemical impacts to ground water from stabilization at Collins Ranch may then be formulated from geochemical mixing models using tailings pore water and baseline ground-water chemistry.

Lakeview processing site

The Lakeview processing site presents a unique set of geochemical factors in assessing ground-water impacts from the mill tailings operations. Ore processed at the Lakeview mill was mined from basaltic-rhyolitic igneous host rock rather than typical sandstone sedimentary rock sequences. A "low-temperature" and a geothermal system existing at the mill site provide two types of baseline or background geochemical facies that interact differently with mill process seepage, producing chemically different plumes.

The sequential data assessment outlined below was used to interpret water-quality data collected from the Lakeview area:

- o Identify centers or sources of contamination.
  - Electromagnetic survey results.
  - Major ion concentration isopleths.
- o Identify mobile species associated with the source areas.

- GECR solid and extract profiles of tailings and soil samples.

- Water chemistry of suction water samples taken from the raffinate ponds and tailings pile.

o Comparison of source area ground-water quality with background or upgradient ground-water quality.

- Tri-linear diagrams of ground-water analyses.

o Elucidate geochemical controls upon the solubility of contaminant species.

- Bivariate distributions of major ions in ground-water samples.

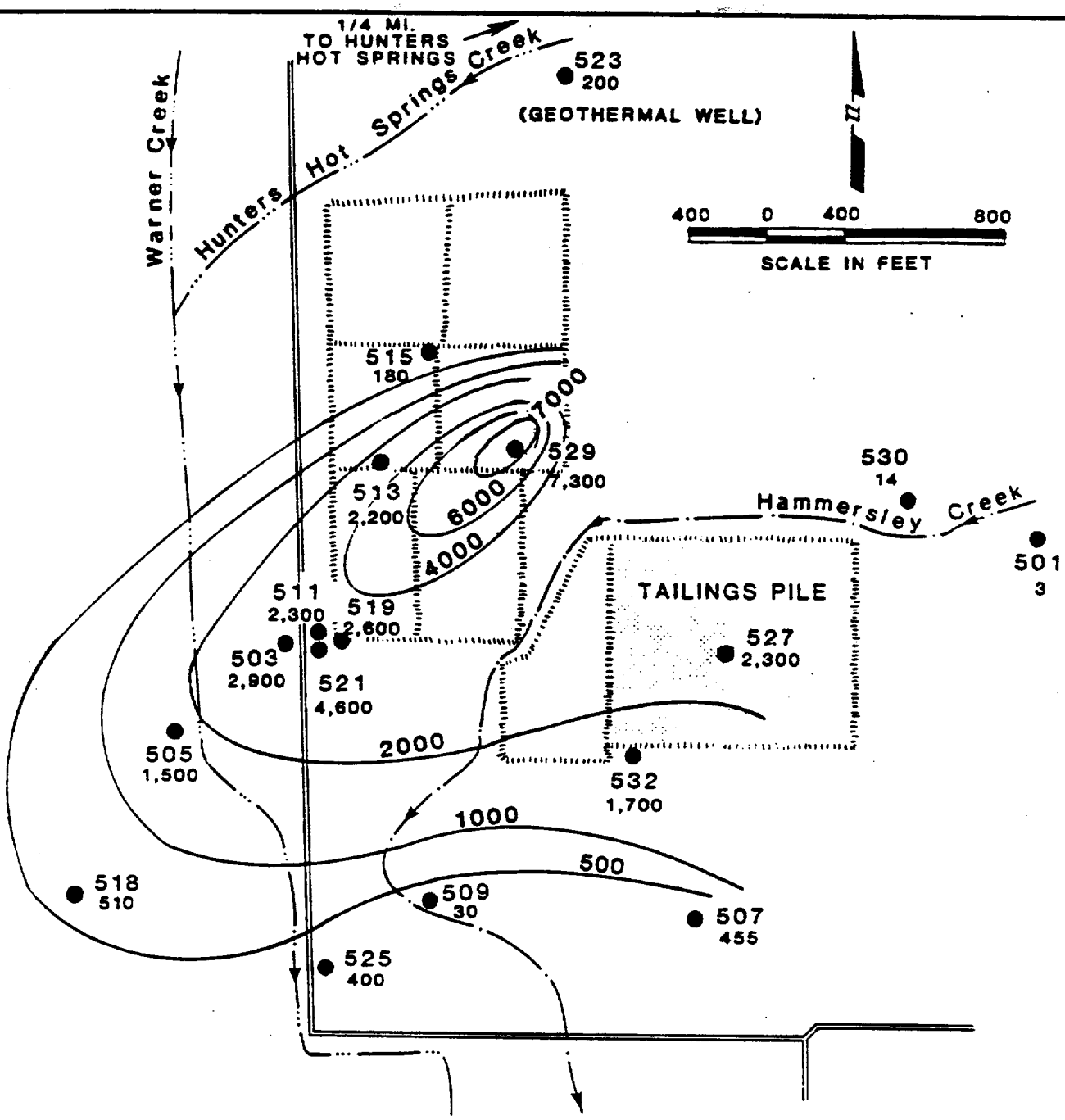
- Stable isotopes (to be incorporated when laboratory analyses are available).

- PHREEQE geochemical mixing models (to be incorporated when laboratory analyses are available).

A geophysical survey was conducted at the Lakeview processing site in June, 1984, in order to identify anomalous subsurface conductivity which could indicate changes in ground-water quality. Electrical conductivity of subsurface soil and water is related to TDS in the pore water. A contour plot of both vertical and horizontal conductivity data provides a means to indirectly detect highly conductive source areas of contamination, and, under the most ideal field conditions, to define the areal extent of a contaminant plume.

The Lakeview electromagnetic (EM) geophysical survey was conducted to optimize the location and completion interval of TAC monitor wells. Comparison of the geophysical data to later collected water-chemistry data show that the EM survey provided an accurate picture of source areas of contamination, but did not have the resolution to show the extent of contaminant "plume" migration which appears, from available water-quality data, to extend as far downgradient in the shallow zone as well 518 (Figure D.2.23). Water-quality data confirmed the geophysical surveys which showed a contaminant plume originating in the southwest evaporation pond area and extending to a depth of 20 to 25 feet beneath the ground surface (Figure D.2.24). The predominant plume is being generated beneath the evaporation ponds rather than the tailings pile.

Determination of mobile species from the source area was made by examination of GECR chemical data from acid and water extract profiles from tailings and soil samples from beneath the evaporation ponds. Methods of sample collection and



LEGEND

505 - LOCATION ID

● - MONITOR WELL SCREENED IN SHALLOW ZONE

1,500 - SULFATE CONCENTRATION (mg/l)

EVAPORATION POND

INTERMITTENT FLOW

CONTINUOUS FLOW

FIGURE D.2.23
SULFATE PLUME IN THE SHALLOW AQUIFER
LAKEVIEW SITE

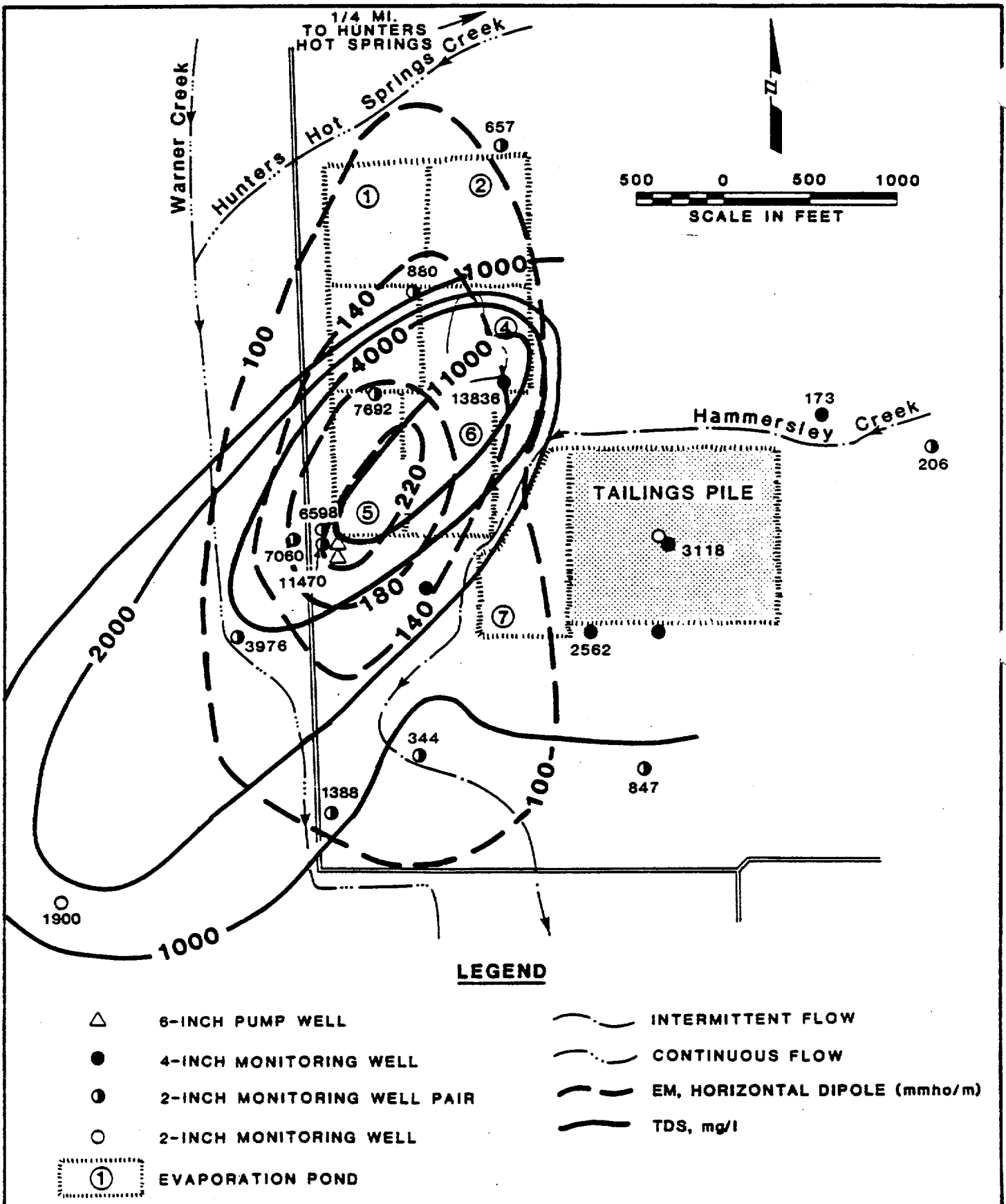


FIGURE D.2.24

COMPARISON OF RESULTS OF ELECTROMAGNETIC SURVEY AND GROUND WATER CHEMISTRY

analyses are described in Section D.2.2.2. Depth profiles are shown in Figures D.2.16 through D.2.21. The most comprehensive data were obtained for tailings-soil samples rather than evaporation pond subsurface soils, or background soils.

The tailings profiles show abrupt chemical changes at the soil-tailings interface at a depth of about seven feet below the pile. Solid sample analyses show that uranium is essentially immobilized at the chemical interface, explaining why uranium does not appear in any ground-water samples. Calcium appears to be retained in the surface solids above three feet, probably due to a salt effect. Water extract data show calcium is leached from the tailings zone, and show a good correlation with sulfate, indicating some $CaSO_4$ precipitates as gypsum ($CaSO_4 \cdot 2H_2O$) at the interface zone and enters the ground-water system depending upon degree of saturation.

Water extracts show that iron remains immobile at the tailings soil interface while manganese appears to remain soluble and to increase with depth in solid sample analyses. Under oxidizing conditions iron is likely precipitated as ferric hydroxide $Fe(OH)_3$, while manganese remains mobile in the +5 valence. Some ground-water samples in the immediate source area show exceptionally high concentrations of manganese, and upgradient samples also indicate quantities above secondary standards. Hem (1970) reports that many ground waters that carry high manganese concentrations are from thermal springs and thus Mn may be soluble in geothermal waters as well as seepage water from source areas.

Arsenic, due to its toxic nature and its naturally high concentrations in the geothermal ground water, is of special concern regarding its mobility from the processing site. Water extract profiles show that arsenic is largely immobilized near the base of the tailings with no measurable concentrations beyond a 10-foot depth. No arsenic measurements were made on subsoils beneath evaporation ponds. Despite its diminishment in tailings extract data, arsenic does appear in ground-water samples at levels above State of Oregon and Federal primary water-quality standards. Arsenic concentrations in Hunters Hot Springs upgradient from the processing site reach levels of 0.23 mg/l and exceed the highest concentrations measured in ground water beneath the processing site at a level of 0.07 mg/l. Soluble arsenic shows a greater association with the geothermal system rather than the tailings pile or evaporation ponds.

Data on water chemistry of suction water samples collected from the southwest evaporation pond are still outstanding and will provide further information on solubility of chemical species from the main source area of contamination. These analyses will represent pore water chemistry which will be used in PHREEQE mixing calculations with existing water chemistry at the Collins Ranch alternate disposal site.

Comparison of source-area ground-water quality with upgradient or "background" water-quality data obtained by sampling TAC and FBDU monitor wells shows that there are two different background geochemical types of ground water. Tri-linear diagrams show relative differences between the major-ion chemistry of a large number of samples. Figure D.2.25 plots percent equivalents of major ions. Four types of ground water may be designated from the composite tri-linear plot:

- o Low-temperature background ground water, classified as calcium-bicarbonate type water and represented by samples 501, 502, 530, and 508.
- o Geothermal upgradient ground water classified as calcium to sodium-sulfate type water and represent by geothermal water samples from wells 523 and 524.
- o Tailings pile seepage, classified as calcium-sulfate type water and represented by samples 517, 527, 528, and 507.
- o Evaporation pond seepage, classified as sodium-sulfate type water and designated by a large group of samples from the evaporation pond area and in the downgradient direction of ground-water movement.

Figure D.2.26 shows a conceptual diagram of existing ground-water chemistry around the site. A line dividing the geothermal ground-water system from the "low-temperature" system appears to transect the site area near the evaporation ponds. TAC wells 523 and 524 immediately north of the northeast corner of the evaporation ponds produced water at temperatures of 41°C and 60°C, respectively. Hunters Hot Springs, approximately 0.5 mile northeast of the evaporation ponds, produces a geyser with water temperatures of 100°C (Trauger, 1950). Several domestic wells sampled just north of the site were geothermal, including the Quonset well (535), and the Mautz well (535). All these waters exhibit sulfate as the major anion in concentrations around 200 mg/l. During a site visit in January, 1983, a blowhole in the snow on one of the middle evaporation ponds was noted.

Ground water sampled from wells 530, 501, and 502 shows a distinct shift in chemical facies to a calcium-bicarbonate type water with very low sulfate concentrations around 20 mg/l. All these sampling locations are hydraulically upgradient from the tailings pile and evaporation ponds so that background water quality appears as two types of chemical facies.

Seepage water from the evaporation pond source area may be classed as sodium-sulfate type water, similar to the geothermal water. Concentrations of sulfate in shallow ground water (20- to 25-foot zone) sampled directly beneath the evaporation pond source area range from 3,000 to 7,000 mg/l. However, moving in the downgradient direction of plume migra-

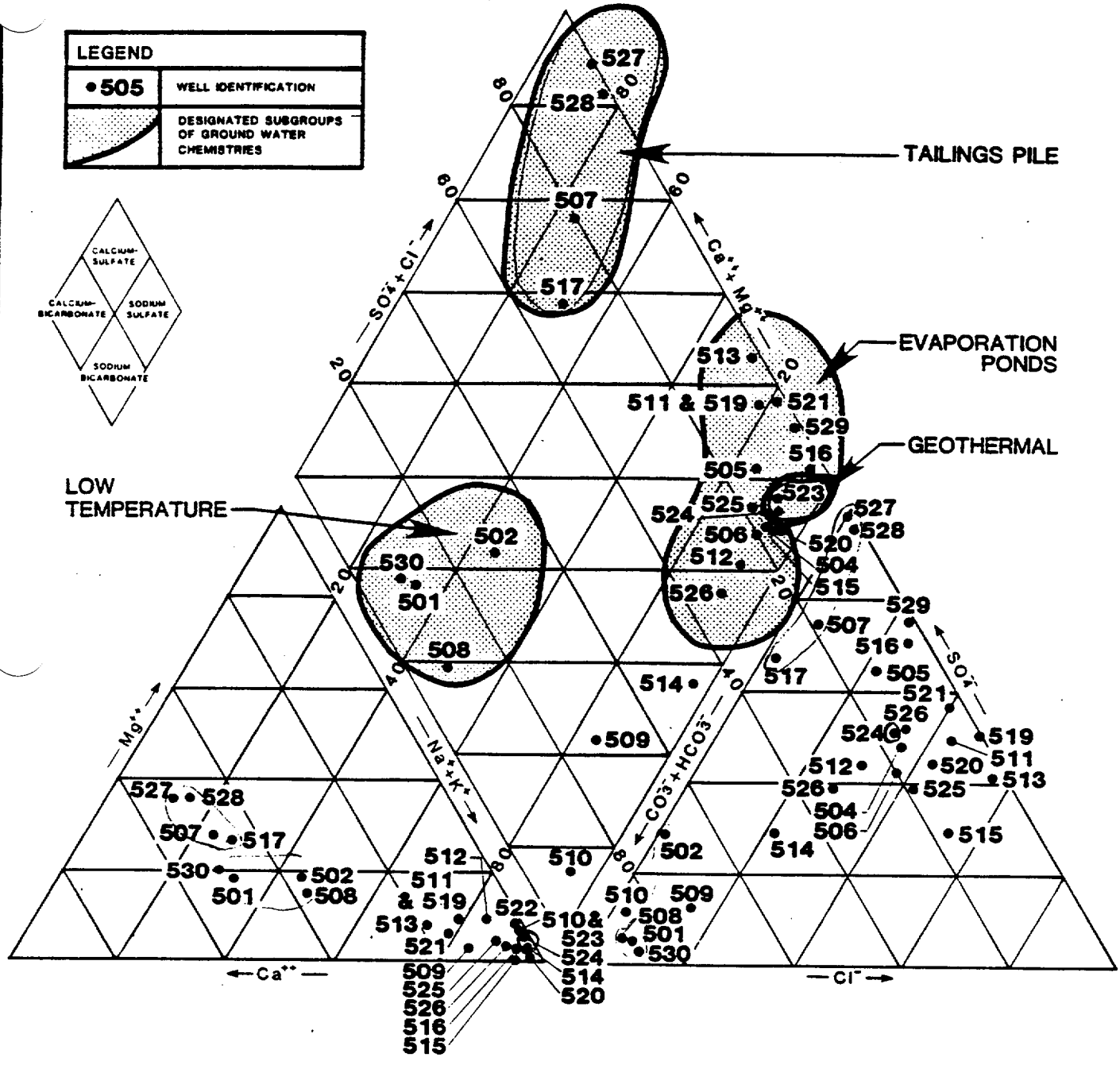


FIGURE D.2.25

TRILINEAR DIAGRAM OF MAJOR ION CHEMISTRIES FOR GROUND WATER IN AREA OF LAKEVIEW PROCESS SITE

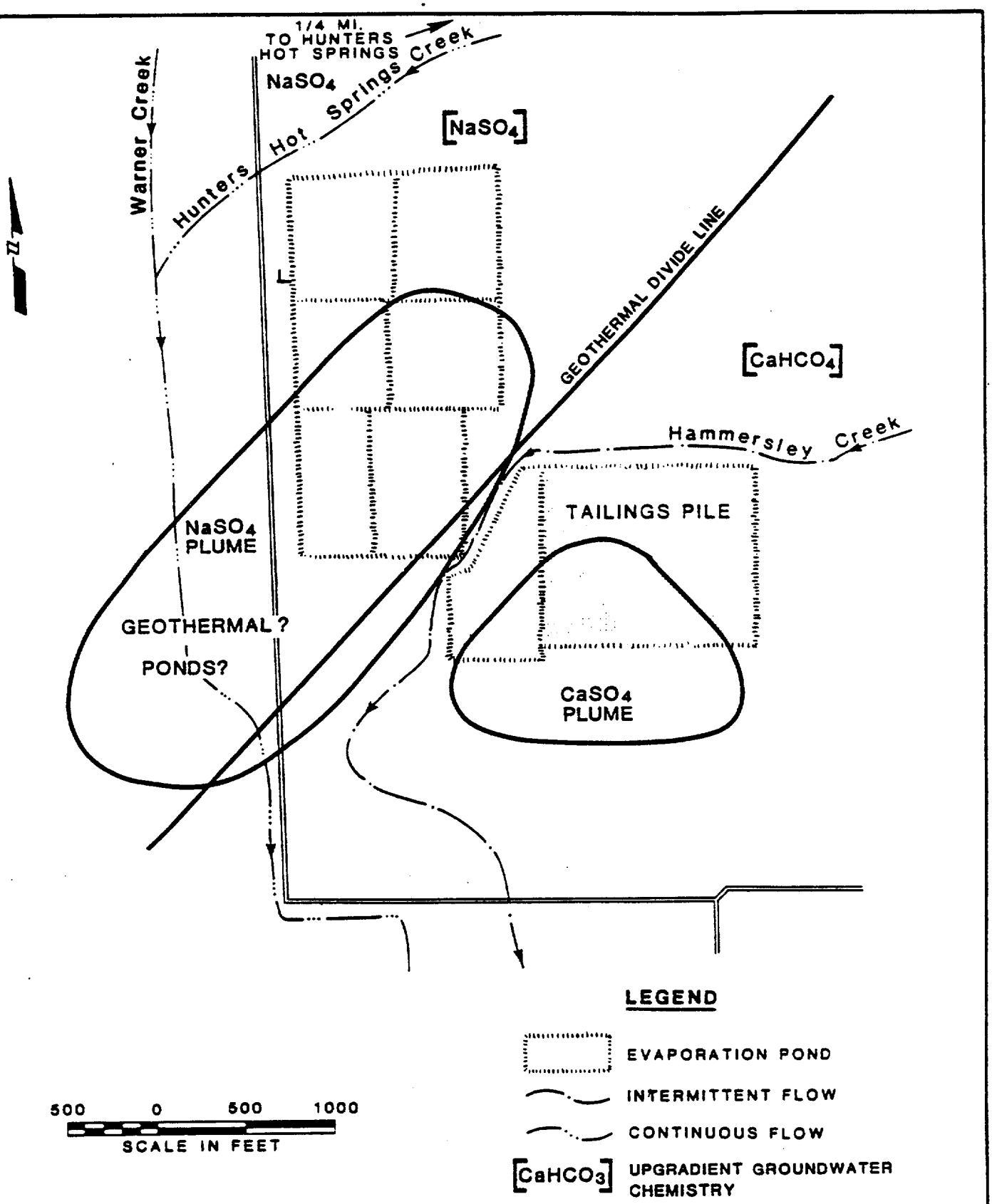


FIGURE D.2.26

CONCEPTUAL MODEL OF EXISTING GROUND WATER CHEMISTRY AT THE LAKEVIEW PROCESSING SITE

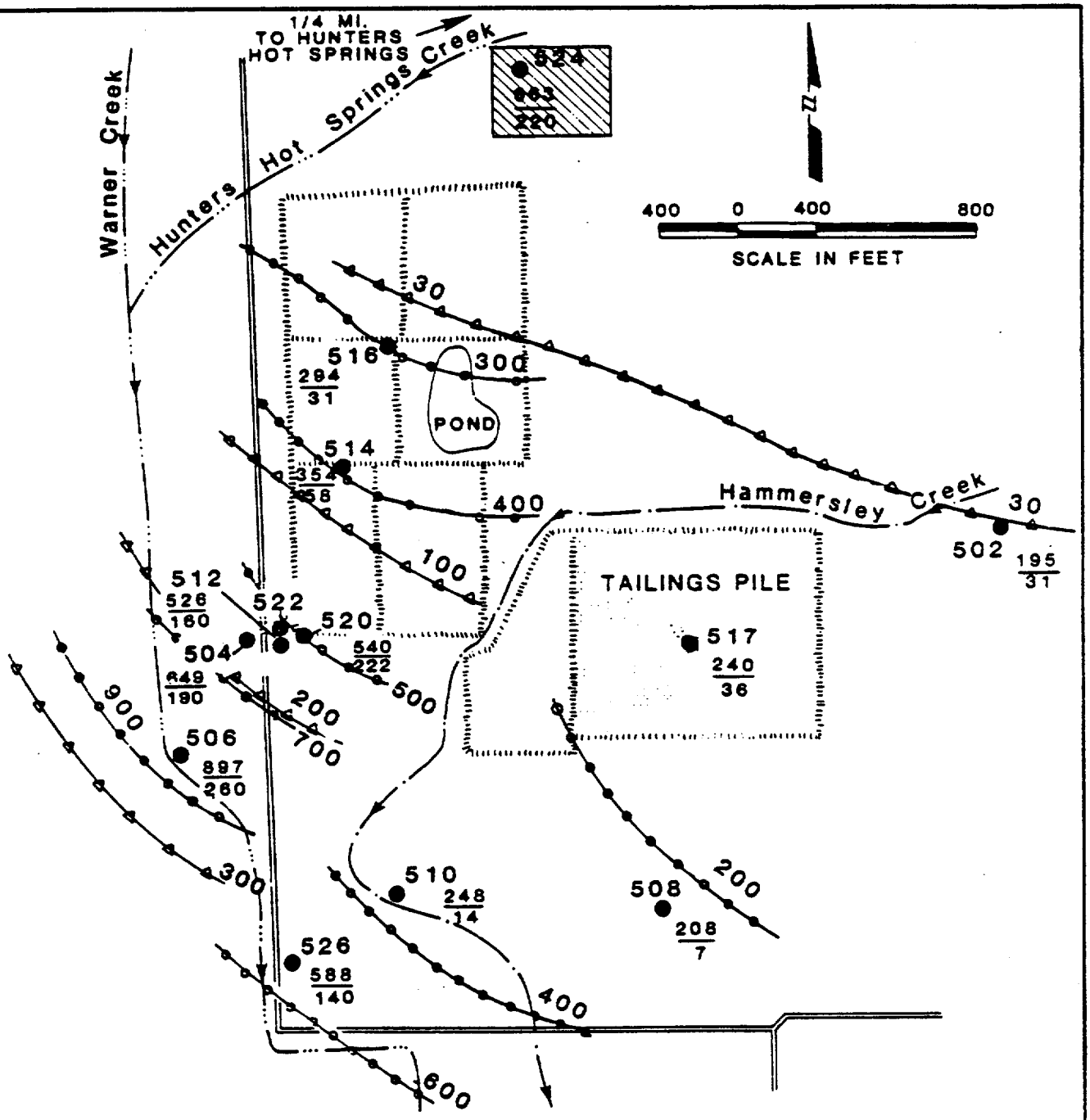
tion, as sulfate concentrations decrease to 500 mg/l in well 518 (Figure D.2.23), the contributions from pond seepage versus geothermal ground water become less distinct.

Comparing relative ion concentrations between well pairs screened in the 20-to-25-foot zone versus the 70-to-75-foot zone show that seepage is primarily moving in the shallowest zone. Aquifer test results show a vertical component of ground-water movement between the shallow and deeper zones. Sulfate isopleths and TDS for wells screened in the deeper zone show both concentrations increasing in the downgradient direction of ground-water movement (Figure D.2.27). Data suggest that pond seepage is moving vertically downward as the plume travels downgradient. Lithology from borehole logs 504, 506, and 518 also indicate a decrease in clayey, silt semi-confining lenses moving southwest from the processing site.

Because the deeper ground-water system is being utilized downgradient from the site, and the extent of plume migration has not been clearly defined, a supplemental sampling program with stable isotopic analysis will be conducted in order to distinguish between geothermal and pond seepage source contributions to ground water southwest of the site. Stable isotope analysis of deuterium, oxygen-18, and dissolved sulfate-sulfur-34 will be run on selected samples. Further drilling of a 75-foot well paired with 518 and a 75-foot well 2,000 feet farther downgradient of 518 will be contingent upon results of isotope analyses, should isotope data provide unconclusive results.

Sulfate isotopic variations can in principle be used in fingerprinting the sources of sulfate in ground water. The objective is to ascertain point source contribution to variations in the isotopic composition of sulfates in ground water downgradient from the site. Sulfate isotopes include ^{34}S and ^{18}O. Different ratios of sulfur-34 and, to a lesser extent, oxygen-18, can be associated with different sources of sulfate due to fractionations during geochemical cycling of elements. Table D.2.20 shows expected ranges of ^{34}S values for sulfate of suspected origins in the Lakeview ground water.

Although isotope ratios for different sulfate sources may overlap, isotope ratios may be used locally in situations where two or three major sulfate reservoirs exist with larger, known ratio differences between sources. Previous investigations support the above criteria, and it is therefore hoped that sulfur isotope ratios will allow refinements of the previous geochemical interpretations based only on hydrologic and geochemical information. Isotopic analysis of oxygen-18 (^{18}O) and deuterium (^{2}H) in ground water can also act as a secondary tag in identifying the origin of ground water, and ratios are expected to differ between geothermal and low temperature waters.



LEGEND

508 – LOCATION ID

● – MONITOR WELL SCREENED IN DEEPER ZONE

208 – TOTAL DISSOLVED SOLIDS CONCENTRATION (mg/ℓ)

7 – SULFATE CONCENTRATION (mg/ℓ)

GEOTHERMAL WELL

EVAPORATION POND

INTERMITTENT FLOW

CONTINUOUS FLOW

TDS

SO_4

FIGURE D.2.27

TOTAL DISSOLVED SOLIDS AND SULFATE ISOPLETHS IN THE DEEPER AQUIFER LAKEVIEW SITE

Table D.2.20 Expected ranges of ^{34}S-sulfate values

Origin of sulfate	Associated Lakeview ground water	Expected range	Reference
Volcanic sulfate	Background geothermal water-well 524	+10 to +15°/oo	Holser and Kaplan (1966)
Rainwater/snow dissolved sulfate	Background non-geothermal water-well 502	-1.7 to 3.4°/oo	Ostlund, (1959)
Acid sulfate from U-mill tailings (sulfuric acid)	Pond seepage-well 521	+3.7°/oo from Kerr-McGee active leach tailings pond	Ries (1982)

The following ground-water samples will be taken and analyzed for sulfate sulfur-34, water oxygen-18, and deuterium:

Well ID	Water category
LKV01-502	Non-geothermal background
LKV01-524	Geothermal background
LKV01-521	Pond seepage
LKV01-513 and 514	In evaporation ponds near suspected geothermal boundary
LKV01-518 and 506	Unknown origin - deep wells farthest downgradient from evaporation ponds
Optional Owen or Maisano domestic wells	Completed in deeper system downgradient from site

Selected chemical analyses will be performed on the collected samples, as well as a few additional samples. Samples will be split between BFEC for chemical analyses and the University of Arizona, Isotope Geochemistry Department, Isotope Lab, for sulfur-34, oxygen-18, and deuterium analyses.

The plume emanating from the tailings pile source area is chemically different and less concentrated than the plume originating in the evaporation ponds. Calcium, rather than sodium, appears as the major cation. Differences in chemistry are due to the different types of solid solution interactions that occur as pond effluent seeps through tailings materials beneath the pile versus soil materials beneath the evaporation ponds before entering the ground-water system. Also, calcium appears as the major cation in low temperature waters upgradient of the pile while sodium dominates the geothermal water upgradient of the evaporation ponds.

In summary, there appear to be two chemical types of background ground water. The evaporation ponds have generated a larger sodium-sulfate plume than the tailings pile which has generated a calcium-sulfate type plume. Existence of background geothermal water relatively high in sulfate ions makes distinction between seepage water and geothermal water unclear. Seepage water in the shallow aquifer appears to be migrating downward as it travels downgradient with attenuation and dilution effects reducing the absolute concentrations of dissolved species between shallow and deep well pairs. Additional sampling with isotope analyses should provide more evidence for determining sources of ground water downgradient of the site and define the extent of plume migration.

The major geochemical controls upon soluble species in ground water can be summarized from bivariate species distribu-

tions and by utilizing geochemical solution equilibrium models. Calculations of aqueous phase speciation using the PHREEQE computer code should determine solubilities of major species. Data from TAC ground-water samples when available would be incorporated into the PHREEQE code to calculate the saturation index of major species.

Simple bivariate plots of major ion species may show correlations providing clues to ion speciation and geochemical controls upon solubility. Data plots of processing site ground-water samples and domestic well samples all show good correlations between alkalinity (as $CaCo_3$) versus calcium, alkalinity versus arsenic, sulfate versus arsenic, and sodium versus chloride. GECR data from surface-water samples show little correlation between sulfate and arsenic. Alkalinity appears to be controlled by calcium-carbonate equilibria. Soluble arsenic increases with both increasing sulfate activity and increasing alkalinity. Highest arsenic concentrations are found in the Hunters Hot Springs and geothermal wells that exhibit a combination of high alkalinity and relatively high sulfate concentrations. Arsenic attenuated at the tailings-soil interface is likely related to the low pH tailings effluent that would reduce solubility of arsenic and greatly limit its migration from the source areas.

Collins Ranch alternate disposal site

Five ground-water samples and one surface-water sample were collected and analyzed for chemical and radiological parameters. Results of the analyses are listed in Table D.2.17. Existing shallow ground water exhibits low TDS, high pH, and high silica, typical of ground water encountered in volcanic host rock. The chemical composition of the ground water clearly shows that the major source of shallow ground water is from the volcanic Fremont Mountains, rather than local recharge through the lacustrine, alluvial deposits at the site.

When aggressive waters, high in carbon dioxide (CO_2) and low in dissolved solids, encounter silicates high in cations such as feldspars, they leach silica and cations and the pH rises (Garrels and Christ, 1965). Basaltic rocks generate ground water with little or no buffering capacity. The buffering capacity of the ground water should be quantified by PHREEQE mixing calculations whereby low pH tailings pore water will be mixed with the existing ground water. Results should be incorporated when suction-water sample chemical data are available from the laboratory.

D.2.5 WATER USE

D.2.5.1 Lakeview processing site

Well records from the Lake County Watermaster were obtained for 97 wells within a two-mile radius of the Lakeview

processing site. Approximate locations are shown by the nearest quarter section on Figure D.2.28. Table D.2.21 lists the wells, their usage, depth, and approximate distance from the site.

There are three wells on file located downgradient adjacent to the processing site in Sections 5 and 9, Township 39S, Range 20E. These wells are denoted in Table D.2.21. Only one of these wells, Cecil Swingle, nearby Warner Creek in Section 5, was drilled less than 50 feet, the others were completed at depths from 220 to 320 feet. A scan of the 97 available well records shows a total of twelve domestic or stock wells screened above 50 feet. All, except the aforementioned well, are located more than 0.5 mile south of the processing site in Sections 9 and 15 of Township 39S, Range 20E. Yields from these wells are expected to be low, less than 15 gpm, due to the limited thickness of permeable units storing ground water. Water quality, based upon results from TAC wells screened in the shallow zone upgradient from the site, is good with low total dissolved solids (200 mg/l).

The majority of wells are screened at depths from 100 to 300 feet and are used for domestic, stock, and irrigation purposes. Two wells at 509- and 800-foot depths were previously used for industrial purposes by the Lakeview Mining Company at the mill site. Water quality from wells screened below 100 feet is influenced by the geothermal system. High temperature ground water is of sodium-sulfate type with total dissolved solids near 800 mg/l. Lower temperature ground water is of a sodium to calcium bicarbonate type with total dissolved solids around 200 mg/l (Trauger, 1950).

The city of Lakeview maintains and operates 12 municipal wells which are completed between depths of 350 and 2,050 feet (Table D.2.22). These wells can yield up to 500 gallons per minute, and all are located more than one mile south and east of the site in Sections 15 and 16 of Township 39S, Range 20E.

At the present time, the city is using six municipal wells pumping approximately 276 million gallons per year (Schear, 1985). The wells pump 300 to 400 gallons per minute and drawdowns at the wells are reported to be eight to 15 feet. Water chemistry of municipal well water is tested three times a year, and has not exceeded any State of Oregon water-quality standards. Water treatment is limited to chlorination before discharge into the delivery system. Since the termination of the Lakeview Mining Company, the major non-municipal water users are the ranchers who irrigate seasonally from June through September.

D.2.5.2 Collins Ranch alternate disposal site

The Lake County Watermaster has no well records for a three-mile area surrounding the Collins Ranch site. Maps of

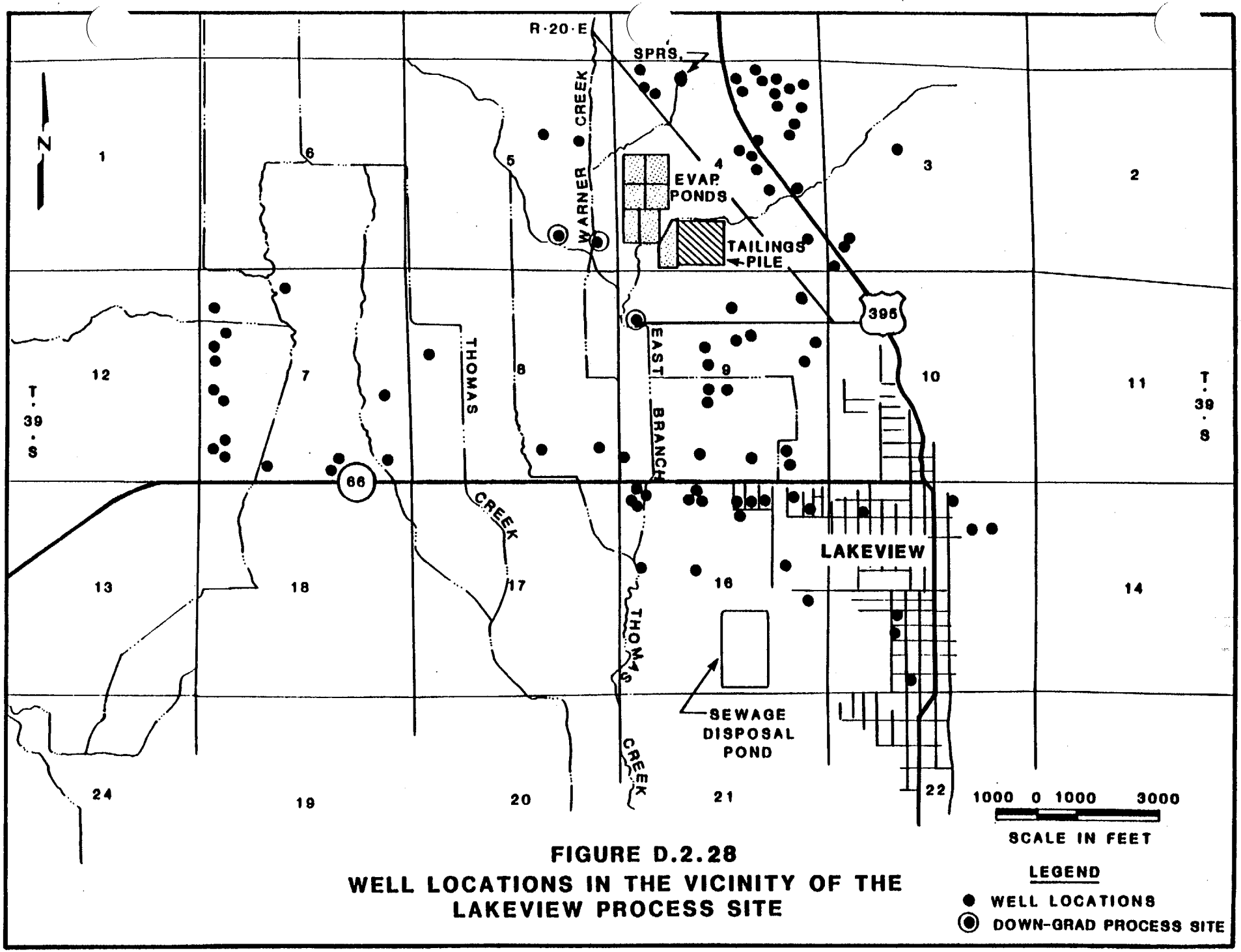


FIGURE D.2.28
WELL LOCATIONS IN THE VICINITY OF THE LAKEVIEW PROCESS SITE

Table D.2.21 Local wells in the vicinity of the Lakeview processing site, Township 39 south, Range 20 east

Well owner	Section	Location	Well depth (in feet)	Distance from site	Use of well
Northwest Geothermal	3	SE-1/4 NW-1/4	685	6000' NE	Reinjection
Middlebrooks	3	SW-1/4 SW-1/4	320	3500' E	Domestic
Lytton Plato	3	SW-1/4 SW-1/4	152	3500' E	Domestic
Marton Doron	3	SW-1/4	105	3500' E	Domestic
Church of LDS	4	NW-1/4 SE-1/4	214	2999' NE	Domestic
Marcus Dartin	4	SE-1/4 SE-1/4	176	2500' E	Domestic
Guy Muncel	4	-	160	--	Geothermal
Steve Ingledew	4	NW-1/4 NE-1/4	115	4000' N	Domestic
Bob Lake	4	NE-1/4 NE-1/4	390	4800' NE	Geothermal
E.L. Leach	4	-	415	--	-
Harry Sabin	4	NE-1/4 NE-1/4	90	4800' N	Domestic
C. Brazeal	4	NE-1/4 NE-1/4	175	4800' NE	Domestic
Jess Faha	4	NE-1/4 NE-1/4	80	4000' N	Domestic
R.C. Utley	4	NW-1/4 NE-1/4	100	4000' N	Domestic
A.M. Fish	4	NE-1/4 SE-1/4	300	3000' NE	Domestic, stock
Flood	4	SW-1/4 NE-1/4	200	2000' NE	Domestic
Walsh	4	SW-1/4 NE-1/4	120	2000' NE	Domestic
Jim Evan	4	NW-1/4 NW-1/4	--	4200' NW	Domestic, stock
Lake County	4	NW-1/4 NW-1/4	8	4200' NW	Observation
Lakeview Mining Co.	4	NW-1/4 NW-1/4	509	4200' NW	Industrial
	4	-			
E.M. Binnim	4	-	70	-	Domestic
Geldert & Vogel	4	NW-1/4 NE-1/4	360	4000' N	Municipal
J.T. McDonald	4	NE-1/4 NE-1/4	194.5	4800' NE	Domestic
Lasey & Michelson, Inc.	4	-	150	3800' NW	Domestic
Doug Tatro	4	NE-1/4 NE-1/4	180	4800' NE	Domestic
Gene Conway	4	SE-1/4	100	1500' E	-
W.W. Strawn	4	NE-1/4	100	3000' NE	Domestic
Jim Olson	4	NE-1/4	95	3000' NE	-
Warren Taylor[a]	5	S-1/2 SE-1/4	223	3400' W	Domestic
Cecil Swingle[a]	5	SE-1/4 SE-1/4	46.1	2500' W	-
Farwel Utley Realty Co.	5	SW-1/4 NE-1/4	129.9	4600' NW	Domestic, stock
Farwel Utley Realty Co.	5	SE-1/4 NW-1/4	70.7	6000' NW	Domestic
		-			
Farwel Utley Realty Co.	5		165	8600' NW	Irrigation
F.R. Caldwell	7	SE-1/4 SE-1/4	8	9500' SW	Domestic, stock
Glen Windward	7	SW-1/4 SE-1/4	75	10800' SW	Irrigation

Table D.2.21 Local wells in the vicinity of the Lakeview processing site, Township 39 south, Range 20 east (Continued)

Well owner	Section	Location	Well depth (in feet)	Distance from site	Use of well
Glen Windward	7	SW-1/4 SE-1/4	190	10800' W	Domestic
Donald Giles	7	NW-1/4 SW-1/4	70	12500' W	Domestic
G.S. Morris(?)	7	SW-1/4 SW-1/4	92	13000' W	Domestic
G.S. Morris	7	Sw-1/4 SW-1/4	565	13000' SW	Domestic
G.S. Morris	7	SW-1/4 SW-1/4	17.3	13000' SW	Domestic
J.J. Van Kevlen	7	NW-1/4 SW-1/4	105	12500' SW	Domestic, stock
J.G. Roberts	7	SW-12/4 NW-1/4		12400' SW	Domestic, stock
J.D. Venator	7	SW-1/4 NW-1/4	65	12400' SW	Domestic
D.O. Shullen Berger	7	NE-1/4 NW-1/4	500	10800' W	Irrigation
Roy Robertson	7	NE-1/4 SE-1/4	100	8700' SW	Domestic
Vinyard	7	SW-1/4 S-1/2	43	10800' SW	Domestic
Ken Boyer	7	S-1/2 SW-1/4 NW-1/4	111	12200' SW	Domestic
Mrs. Vinyard	7	SW-1/4 N-1/2-1/4	42	10800' SW	Domestic
Lytton Plato	8	SW-1/4 NW-1/4	300	7000' SE	Irrigation
Honeymille	8	SE-1/4 SE-1/4	--	6000' SE	-
Paul Ortwein	9	NE-1/4 NE-1/4	72	2900' SE	Domestic
J.W. Bayes	9	NE-1/4 SW	90	3000' SE	-
E.L. Stewart	9	SE-1/4 SE-1/4	--	6000' SE	-
Lake County Fairgrounds	9	W-1/2 SE-1/4 SE-1/4	330	600' SE	Test
Lake County Fair Board	9	SE-1/4 SE-1/4	--	5500' SE	-
Bill Smith	9	NE-1/4 SW-1/4	--	3000' SE	Domestic
Jack Neal	9	SE-1/4 NE-1/4	82	3700' S	Domestic, stock
Jack Lang	9	SE-1/4 NE-1/4	20	3700' SE	Domestic
Curtis Smith	9	SW-1/4 NE-1/4	37	2800' SE	Domestic
Helen Colgar	0	SW-1/4 NE-1/4	20	2800' SE	Domestic, stock
Steve Bailey	9	SE-1/4 NW-1/4	110	2500' S	Domestic
Dennis Geany[a]	9	NW-1/4 NE-1/4	--	2000' SW	Domestic
George Hesse	9	SE-1/4 SW-1/4	90	5500' S	Domestic
Ross Foster	9	NE-1/4 NE-1/4	155	2900' SE	Domestic
Mike Bidegary	0		50		Domestic
Awa M. Isbel	9	NE-1/4 NE-1/4	141	2900' SE	Domestic
Lakeview Mining Co.	9	NE-1/4 NE-1/4	800	2900' SE	Industrial
Jay Sounders	15	SE-1/4 SW-1/4	50	11500' SE	Irrigation

Table D.2.21 Local wells in the vicinity of the Lakeview processing site, Township 39 south, Range 20 east (Concluded)

Well owner	Section	Location	Well depth (in feet)	Distance from site	Use of well
Larry Alexander	16	SE-1/4 NE-1/4	110	9200' SE	Domestic
G. Workman	16	NW-1/4 NE-1/4	123	8800' S	Domestic
L.C. Morelleao	16	SE-1/4 NW-1/4	30	8000' S	Domestic
Jay Wickie (3 Wells)	16	NE-1/4 NW-1/4	All 81	6500' S	Domestic
Monty Stewart	16	NE-1/4 NW-1/4	132	6500' S	Domestic
Cecil Collier	16	NW-1/4 NE-1/4	81	8800' S	Domestic
Shelter Resources	16	NW-1/4 NE-1/4	101	8800' S	Domestic
Shelter Resources	16	NW-1/4 NE-1/4	140	8800' S	Domestic
Shelter Resources	16	NW-1/4 NE-1/4	120	8800' S	Domestic
Shelter Resources	16	NW-1/4 NE-1/4	120	8800' S	Domestic
Shelter Resources	16	NW-1/4 NE-1/4	120	8800' S	Domestic
Glenn Turner	16	NE-1/4 NE-1/4	121	7000' SE	Domestic
Don Clifford	16		80		Domestic

[a]Denotes wells nearest downgradient from the Lakeview processing site.

Table D.2.22 Lakeview municipal well locations, Township 39 south, Range 20 east

Well number	Depth (ft)	Section	Quarter
1	2072	15	NE-1/4 NE-1/4
2	1820	15	NW-1/4 NE-1/4
4	390	15	NW-1/4 SW-1/4
5	2072	15	NE-1/4 NE-1/4
6	500	15	NW-1/4 NW-1/4
7	361	16	NW-1/4 NW-1/4
8	230	16	NE-1/4 SE-1/4
9	335	16	NW-1/4 NW-1/4
10	330	16	NW-1/4 NW-1/4
11	371	16	NW-1/4 NW-1/4
12	365	16	NE-1/4 NE-1/4
13	360	16	SW-1/4 NW-1/4

the area show three ranches within a three-mile radius of the site. A visit to each of the ranches for a water use survey has been initiated. There are at least two wells, a 100-foot domestic and a 500-foot irrigation well, located one to two miles north of the site. Complete information from the survey should be incorporated after each of the ranches has been visited.

D.2.5.3 Flynn Ranch alternate disposal site

No records of wells within a three-mile radius of the Flynn Ranch disposal site were obtained. The Flynn Reservoir is located 0.6 mile northeast from the site.

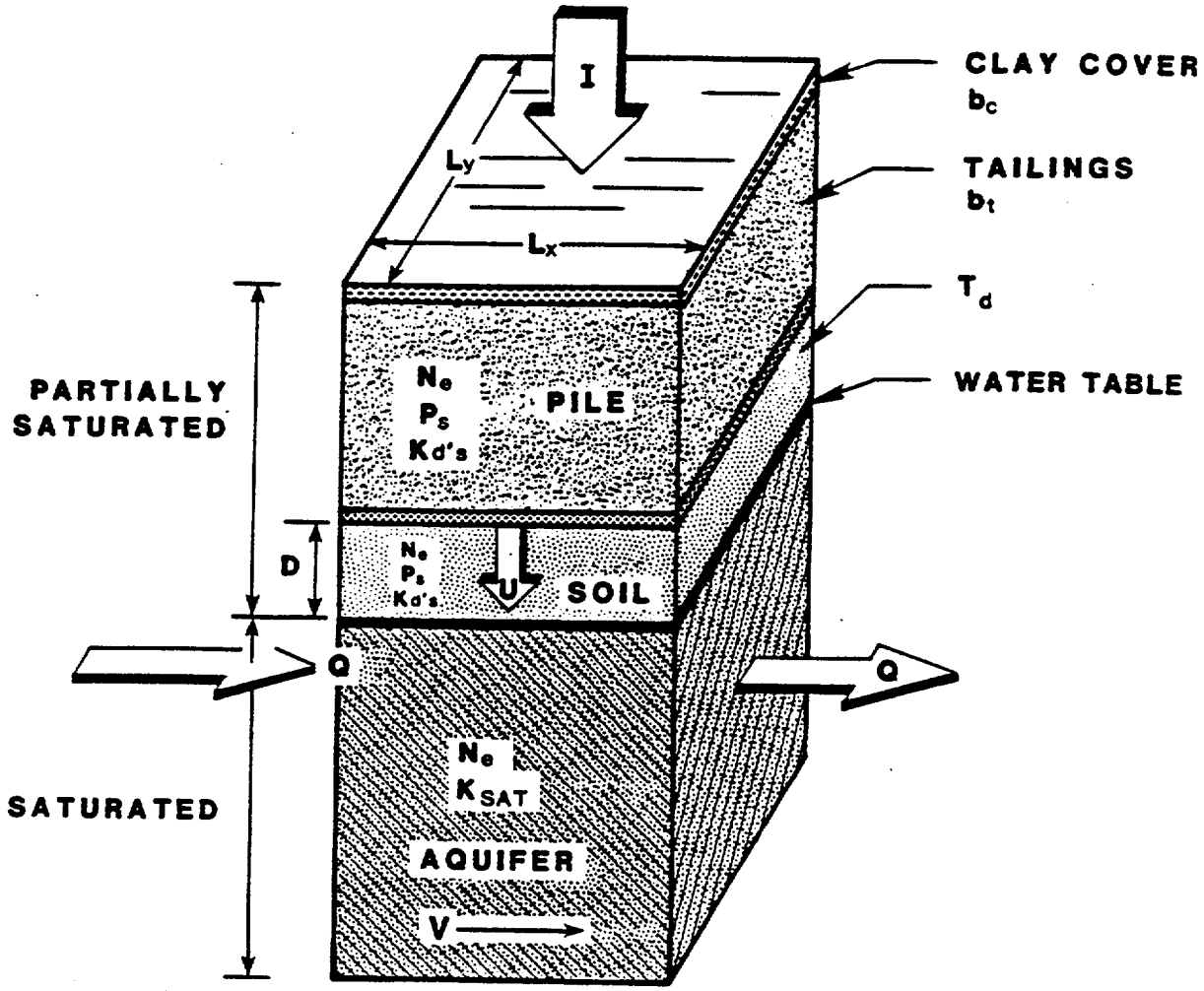
D.2.6 HYDROLOGIC MODELING

D.2.6.1 Purpose

The purpose of ground-water modeling is to evaluate present and projected characteristics of the ground-water flow regime upon stabilization of tailings at either of the alternate disposal sites. Ground-water modeling begins with a conceptual understanding of the physical system. The previous sections on geology, hydrogeology, ground-water hydraulics, and ground-water quality, as well as the engineering design criteria, are components of the site conceptual models for both of the alternate disposal sites. The next step in modeling is translating the physical conceptual model into mathematical terms. In general, this involves the ground-water flow equation and solute transport equations. These equations may be simplified, using site-specific assumptions to develop analytical solutions that are based upon model parameter definitions from available field data. An analytical modeling approach should be used at each of the alternate sites to evaluate present and projected flow patterns and rate of transport of radionuclides and other dissolved constituents in the hydrologic system. Because the tailings should be removed from the processing site and because the affected site ground water is not impacting domestic supplies, modeling would not be performed for the processing site.

D.2.6.2 Conceptual model - Collins Ranch

Hydrologic, geotechnical, geochemical, and engineering design information was combined in developing a simplified model to estimate migration rates and concentration of contaminants moving from the stabilized tailings pile. Figure D.2.29 is a schematic diagram illustrating the principal components of the solute generation ground-water flow model. In this idealized model, an infiltration rate, I, was estimated from the annual precipitation. The stabilized tailings pile and underlying soil above the potentiometric surface form a single homoge-



I	INFILTRATION CAPACITY (ft/yr)
L_x, L_y	DIMENSIONS OF STABILIZED PILE (ft)
b_c	THICKNESS OF CLAY COVER (ft)
b_t	AVERAGE THICKNESS OF PILE (ft)
U	LEACHOUT RATE (ft/yr); CONTAMINANT SOURCE TERM
$K_{d's}$	DISTRIBUTION COEFFICIENTS DEFINED FOR TRACER CONSTITUENTS
N_e	EFFECTIVE POROSITY
P_s	BULK DENSITY OF TAILINGS AND SOIL MATERIALS (g/cm^3)
K_{SAT}	HYDRAULIC CONDUCTIVITY (ft/yr)
V	GROUND WATER VELOCITY (ft/yr)
Q	VOLUMETRIC GROUNDWATER FLOW BENEATH THE SITE (ft^3/yr)
T_d	DELAY TIME (yr) FOR FLUID MOVEMENT FROM THE PILE TO THE WATER TABLE
D	DEPTH FROM TAILINGS/SOIL INTERFACE TO WATER TABLE

FIGURE D.2.29
SCHEMATIC DIAGRAM OF IDEALIZED MODEL FOR ESTIMATING RATE OF TRANSPORT OF DISSOLVED CONSTITUENTS FROM THE TAILINGS INTO THE GROUND WATER SYSTEM

neous stratum, and the leaching and migration mechanisms can be characterized by a single retardation factor, K_d, for each constituent. The K_d, distribution coefficient, is a lumped parameter that quantifies the ability of a porous medium to remove an ion from solution. It incorporates the mechanisms of ion exchange, adsorption, and chemical reactions which are the principal rate controlling mechanisms by which constituents are transferred from a solid substrate to water percolating through the substrate.

The infiltrating water will transport the solubilized species downward from the pile through the partially saturated (vadose) zone to the aquifer. The displacement rate of the soluble contaminant front from the tailings pile to the potentiometric surface is the "leachout rate", U. The model leads to the prediction that there should be no contamination of the ground water for a delay time $T_d = D/U$ where D is the distance from the bottom of the pile to the water table. Following the release into the ground water at the water table surface, the constituents would be diluted by mixing and transported with the ground water.

Solutes are transported by the mechanisms of advection, dispersion, and diffusion. The model assumes advective transport whereby solutes move through the subsurface at the same rate of flow and same direction as the ground water. The diffusion component can be discounted based upon the calculated ground-water velocity. Although dispersion may spread and dilute the contaminant front, it is not considered in the simplified model due to the complex stratigraphy beneath the site. Hydrogeochemical reactions between the fluid and saturated solid substrate materials which are additional retardation mechanisms of contaminant species are not considered, providing a conservative estimate of solute concentrations within the saturated zone.

D.2.6.3 Methods and calculations - Collins Ranch

The following analytical methods and calculations were used to characterize the potentially affected hydrogeologic environment and the potential for contaminant migration in the ground water at the Collins Ranch alternate disposal site:

- Computation of values of effective porosity.
- Calculation of the bounding maximum value for infiltration through the pile.
- Computation of distribution coefficients (K_d's) for selected mobile species and potentially hazardous species using geochemical data from the tailings site.
- Computation of the bulk densities of underlying soils from geotechnical laboratory data on site soils samples.

- o Calculation of the delay time for selected constituents to migrate from the lower boundary of the pile to the water table.

- o Calculation of the leachout rate or migration rate of the contaminant front.

- o Calculation of ground-water flow volumes and velocities using Darcy's Law.

- o Computation of the dilution factor in contaminants moving into the saturated zone.

Each of these factors was then analyzed by the following methods:

a. Computation of values of net porosity and estimates of effective porosity from tailings pile, evaporation ponds, and soil sample laboratory test results.

Initial void ratios were measured for six solid samples subject to consolidation tests. Net porosities can be directly derived from the bulk void ratio by the following formula:

$$n = e/(1 + e)$$

where

$$n = \text{net porosity}$$

$$e = \text{void ratio} = \frac{\text{volume of voids}}{\text{volume of solids}}$$

Computed values of net porosity are shown in Table D.2.23 for representative tailings and soil materials at the Collins Ranch site.

Using a weighted average based upon calculated volumes of tailings material and evaporation pond material to be excavated, the homogenized net porosity of the stabilized pile would be:

$$\frac{(239{,}000 \text{ cy})\ (0.551) + (191{,}000 \text{ cy})\ (0.724)}{(430{,}000 \text{ cy})} = 0.628$$

Based upon two test pit soil samples from the Collins Ranch site, net porosities are between 0.435 and 0.617. Davis and DeWiest (1966) lists net porosities for selected nonindurated sediments. Porosities of the stabilized pile materials are extremely high, near those reported for montmorillonite clays (0.66). It is likely that mill processing of the siliceous host rock altered the silicate minerals, chiefly

Table D.2.23 Void ratios and corresponding net porosities for tailings material and soil samples at Collins Ranch

Sample identification	Sample location	Sample depth internal (ft)	Void ratio	Net (total) porosity
Pond #3	Raffinate pond	--	2.619	0.724
5A	Tailings pile	--	1.302	0.566
7A	Tailings pile	--	1.162	0.537
10A	Tailings pile	--	1.014	0.503
505	Test pit (Collins Ranch site)	4.0 - 8.0	1.610	0.617
507	Test pit (Collins Ranch site)	3.5 - 6.0	0.77	0.435

feldspars, to produce montmorillonite, accounting for the high measured void ratios. The net porosities listed for silts and fine sands are between 0.47 and 0.51 (Davis and DeWiest, 1966), and include the range for soils tested from the Collins Ranch site.

Representative values of effective porosity listed by Todd (1980) for loess (a mixture of sediments most descriptive of the site) are about one-third the value of total porosity. Using this proportion for both types of tailings and soils, the bounding effective porosities, n_e, of the pile materials and sediments are:

$$n_e = (1/3) \times n$$

$$n_e \text{ tailings} = 1/3\ (0.50) \text{ to } 1/3\ (0.72)$$
$$= 0.17 \text{ to } 0.24$$

$$n_e \text{ soils} = 1/3\ (0.44) \text{ to } 1/3\ (0.62)$$
$$= 0.15 \text{ to } 0.21$$

b. Calculation of the bounding maximum value of infiltration.

A maximum value of infiltration can be estimated by assuming a substantial proportion of the annual precipitation of 16.0 in/yr infiltrates into the soils at the site, and provides the driving mechanism for leaching of contaminants into the ground-water system.

The mean annual pan evaporation in the Lakeview area is 63 inches per year (PSCR, 1985). Therefore, the PET (potential evapotranspiration) to precipitation ratio is 4.4. A ratio greater than four indicates an arid climate. Also, an arid climate is indicated by the "pre-fire" ground cover, consisting of sagebrush and bunch grasses. Infiltration capacity over the site area varies both in time and space, but assuming similar vegetation and soil types over the proposed site, a single value may be applied over a year time frame by estimating a percentage of annual precipitation.

A maximum value for infiltration can be estimated as 10 percent of the annual precipitation or:

$$16.0 \text{ in/yr} \times (0.10) = 1.6 \text{ in/yr} = 0.133 \text{ ft/yr}$$

This is a maximum bounding estimate of infiltration due to high evaporation combined with low annual precipitation and the design feature of a one-foot cover layer of clay. Recent field experiments (Lewis, 1985) to investigate the behavior of infil-

trated precipitation into sandy tailings with seven percent clay content showed about 15 percent of the average precipitation (16 in/yr) moved downward. Under similar climatic conditions, a design feature of a one-foot compacted clay cover should conservatively reduce infiltration to about 10 percent of average precipitation.

c. Computation of distribution coefficients, K_d's, for selected mobile species and potentially hazardous species, using geochemical data from the tailings pile and sampled ground water.

The distribution coefficient is a lumped parameter that determines the partitioning of constituents between the solid particles and infiltrating fluid as seepage migrates through the pile and soils toward the ground water. The distribution coefficient ignores the dissolution and diffusion and represents only ion-exchange and adsorption, the more rapid release mechanisms, representing an upper bound to the leaching of contaminants. The distribution coefficient for a species, may be defined as (Williams, 1982):

$$K_d(x) = \frac{\left(\begin{matrix}\text{milligrams of } x \\ \text{in solid phase}\end{matrix}\right) / \left(\begin{matrix}\text{grams of} \\ \text{solid}\end{matrix}\right)}{\left(\begin{matrix}\text{milligrams of } x \\ \text{in liquid phase}\end{matrix}\right) / \left(\begin{matrix}\text{milliliters} \\ \text{of liquid}\end{matrix}\right)}$$

The parameter has the units of (ml/g) or can be expressed as a dimensionless ratio. Values range from zero for mobile ions moving through a medium with no charged surfaces, to several hundred-thousand for cations moving through a media with high clay content.

The concept of the distribution coefficient is a method of quantifying solid-liquid phase geochemical interactions, processes that are dynamic, extremely complex, and not well understood. When applying the concept to a model system, chemical equilibrium between the tailings and subsoils and the percolating water must be assumed. Upon excavation, homogenization, and compaction of the tailings, subsoils, and evaporation pond subsoils, the original chemical equilibrium will be disturbed and a new set of chemical conditions (pH, Eh, compaction waters, governing chemical reactions) and physical conditions (porosity, bulk density, moisture content, grain size distribution) will ultimately govern the distribution of contaminant species.

Assessing the geochemical data obtained from tailings and evaporation ponds solid and extract analyses gives some field evidence and quantification of the established distribution of contaminants between the soils-tailings and the ground water. Due to the similarity between subsoils at the processing site and soils at the Collins Ranch site, the simplifying assumption is made that the chemical equilibrium at the processing site will also be established upon disposal at the Collins Ranch alternate disposal site. With time, the disturbed tailings-soil geochemical interface noted in processing site core samples will be established at the alternate site.

For a field estimation of a partition coefficient, the concentration of a species, x (mg/g), from water extracts of tailings core samples can be divided by the concentration of the species, x (mg/ml), in suction water samples obtained from the tailings pile. GECR analyzed water extracts from three tailings core samples and BFEC analyzed suction water samples from the tailings and the evaporation ponds. Until suction water chemical analyses are available, shallow ground-water samples from the tailings pile and evaporation ponds will represent the partitioning of species, x in the liquid phase. The geochemical data and derived partition coefficients are listed in Table D.2.24. Migration of four target species are evaluated in these calculations: uranium (U), arsenic (As), manganese (Mn), and sulfate (SO_4). Uranium and arsenic are known to be contained in the tailings residue and pose the most critical health hazard if leached into the ground-water system. Manganese appears sporadically in concentrations above Federal secondary drinking water standards in ground water sampled around the processing site. Manganese also appears to continue to increase in concentration with depth below the tailings-soil interface, noted in GECR tailings core analyses. Sulfate is a conservative species and thus can be considered to travel with ground water, marking the advance of the seepage front from the processing site. Average partition coefficients from the data are as follows:

$$K_d(U) = 5{,}627,\ K_d(As) = 707,\ K_d(Mn) = 12.24,$$

$$K_d\ (SO_4) = 2.61.$$

A more representative liquid phase concentration would be represented by water-quality data from tailings or evaporation pond suction water samples unaffected by dilution from ground water. As suction water chemical data become available, adjustments in the estimated K_d values will be made. It is expected that suction water will be more concentrated,

Table D.2.24 Partition coefficients derived from processing site geochemical data

Sample ID	Sample type	Chemical species	Solid phase concentration: Core extract data (GECR) (water extract) (mg/l)	Liquid phase concentration: Ground-water chemistry data (Bendix) (mg/ml)	Solid phase concentration / Liquid phase concentration: Derived partition coefficient K_d (ml/g) (cm^3g)
701	Tailings	U	.02	4.5×10^{-6}[a]	4.44×10^3
705	Tailings	U	.02	4.5×10^{-6}[a]	4.44×10^3
707	Tailings	U	.036	4.5×10^{-10}[a]	8.0×10^3
707	Tailings	AS	.070	7.0×10^{-5}[b]	1.00×10^3
705	Tailings	AS	.029	7.0×10^{-5}[b]	4.14×10^2
705	Tailings	Mn	.250	1.39×10^{-2}[c]	18.0
707	Tailings	Mn	.090	1.39×10^{-2}[c]	6.47
705	Tailings	SO_4	17.0	7.30[d]	2.33
705	Tailings	SO_4	21.0	7.30[d]	2.88

[a]Uranium reported as <1 pCi U-234 and <1 pCi U-238 in all ground-water samples. Liquid concentration was calculated by converting 1 pCi U-234 and 1 pCi U-238 to ppm and combining the values for a conservative estimate of liquid phase concentration.

[b]Reported as the highest concentration observed in ground-water samples (.07 mg/l) in wells 513, 521, and 529 in the evaporation pond source area.

[c]Reported as highest observed concentration in evaporation pond well #513.

[d]Reported as the highest observed concentration in evaporation well #529.

shifting the reported values lower, increasing the calculated mobility of the constituents.

d. Bulk density of soils from geotechnical laboratory data on Collins Ranch soil samples.

Bulk specific gravity is reported for seven soil samples obtained from test pits at the Collins Ranch alternate site. Bulk specific gravity of the soil, G_m, is the ratio of the unit weight of soil to that of water, or:

$$G_m = P_s/P_w$$

where

G_m = bulk specific gravity

P_s = bulk density of soils

P_w = density of water

Because P_w is approximately equal to one, $P_s = G_m$. Table D.2.25 lists bulk density of soil samples along with soil type classifications. Higher bulk density values indicate a larger clay content in soils.

e. Calculation of the delay time for selected constituents to migrate from the lower boundary of the pile to the water table.

The delay time for a selected constituent to travel from the stabilized pile to an area of release into the aquifer at the water table can be expressed (DOE, 1983):

$$T_d = \frac{D\ (n_e + P_s\ K_d)}{I}$$

where

T_d = delay time (yrs)

D = the distance from the encapsulated material to the water table (ft)

n_e = effective porosity

P_s = average bulk density of the subsurface soil (g/cm^3)

K_d = the distribution coefficient, the ratio of the amount of a given species sorbed on the solid to that in solution (cm^3/g)

Table D.2.25 Bulk density values for soil samples from Collins Ranch alternate site

Test pit location	Bulk density P_s	Soil class
509	2.17	GC-clayey gravel
512	2.32	GC-clayey gravel
513	2.04	ML-clayey silts
514	2.32	GP-GM gravels and silty gravels
517	2.45	SM-silty sands
518	2.51	SM-silty sands
519	2.12	GM-silty gravels
P_s; Geometric average bulk density	2.27	

I = infiltration rate (ft/yr)

(1) D = 20 feet; based upon present ground-water level measurements and the site conceptual design. Water levels will be monitored through at least June, 1985, to indicate seasonal fluctuations. Incorporation of a capillary break layer into the site design plan will be considered if a significant rise in ground-water elevations is observed in spring and early summer.

(2) n_e = 0.17 (average of part a. calculations)

P_s = 2.2 (part d. calculations)

If suction water samples show concentrations ten times greater than ground water, a range of K_d's can be expressed:

K_d (U) = 5,627 to 562 K_d (AS) = 707 to 71
K_d (Mn) = 12.2 to 1.2

$K_d(SO_4)$ = 0.0; sulfate reassigned a value of 0 for most conservative estimate of seepage migration (part c. calculations).

(5) I = 0.117 ft/yr (part b. calculations)

Using these parameter values, the delay times for species migration from the stabilized pile into the ground water are as follows:

$$T_d(U) = \frac{20 \text{ ft } (0.17 + 2.2 \text{ g/cm}^3 \times 5.63 \times 10^3 \text{ cm}^3/\text{g})}{(0.117 \text{ ft/yr})}$$

$$= 2.12 \times 10^6 \text{ yrs to } 2.12 \times 10^5 \text{ yrs}$$

$$T_d(AS) = \frac{20 \text{ ft } (0.17 + 2.2 \text{ g/cm}^3 \times 707 \text{ cm}^3/\text{g})}{(0.117 \text{ ft/yr})}$$

$$= 2.66 \times 10^5 \text{ yrs to } 2.66 \times 10^4 \text{ yrs}$$

$$T_d(Mn) = \frac{20 \text{ ft } (0.17 + 2.2 \text{ g/cm}^3 \times 12.2 \text{ cm}^3/\text{g})}{(0.117 \text{ ft/yr})}$$

$$= 2.58 \times 10^2 \text{ yrs to } 29 \text{ yrs}$$

$$T_d(SO_4) = \frac{20 \text{ ft } (0.17 + 2.2 \text{ g/cm}^3 \times 0 \text{ cm}^3/\text{g})}{(0.117 \text{ ft/yr})} = 29 \text{ yrs}$$

Calculations show that the key hydrological parameters for estimating migration rates through the unsaturated zone are the infiltration rate, I, and the distribution coefficient, K_d. K_d's were decreased by 10 to give ranges in delay times. Although the estimated infiltration rate is high for the site and design conditions, the water of compaction and residual soil moisture creates an additional fluid component supplanting the actual infiltration. As stated previously, the above distribution coefficients are expected to be higher than "real" values, due to a dilution effect in observed concentrations in ground-water samples, thus they were decreased by a factor of ten.

Reported laboratory data on distribution coefficients are conspicuously lacking in the literature. Distribution coefficients reported for radionuclides range from 11 to 23,000; in the pH range from 4 to 9 (DOE, 1983). Values of K_d for specific sites will vary depending upon the soil properties, chemical content, and Eh and pH of the water.

f. Computation of the leachout rate or migration rate of the contaminant front.

The infiltrating water transports species downward through the unsaturated zone according to the equation:

$$U = I / \; n_e + P_s \, K_d$$

where

U = the leachout rate of the contaminant front (ft/yr)

n_e = effective porosity

I = the infiltration rate (ft/yr)

P_s = bulk density of the soils (g/cm^3)

K_d = partition coefficient (cm^3/g)

Using sulfate as the conservative tracer species ($K_d = 0$), the leachout rate becomes:

$$U = \frac{(0.177 \text{ ft/yr})}{(0.15) + (2.2 \times 0)} \text{ to } \frac{(0.117 \text{ ft/yr})}{(0.24) + (2.2 \times 0)}$$

$$= 0.78 \text{ ft/yr to } 0.49 \text{ ft/yr}$$

According to this model, the range of values for contaminant-front migration is limited by the infiltration rate which becomes a Darcy velocity at unit gradient when divided by the range of effective porosities. The model, accommodated by a conservatively large estimate of infiltration, predicts that the vertical movement of a unit of infiltrating water through the stabilized pile to the saturated zone will occur in approximately 25 to 40 years.

g. Calculation of ground-water flow volumes and velocities using Darcy's Law.

Volumetric flow under the tailings can be calculated by using Darcy's Law (Davis and DeWiest, 1966).

$$Q = KA \frac{(h_1 - h_2)}{dl}$$

where

Q = flow rate (ft^3/day)

K = hydraulic conductivity (ft/day)

A = cross-sectional area beneath site through which ground water flows

h_1 = hydraulic head immediately upgradient of the proposed tailings site (ft above msl)

h_2 = hydraulic head measured from the farthest downgradient well beneath the tailings site along the same flow line as h_1 (ft above msl)

dl = distance between points where h_1 and h_2 are measured

For the Collins Ranch alternate disposal site, flow rate can be calculated using the following values:

(1) to K = 0.64ft/day

$$K = (1.3 \times 0.84 \times 0.56 \times 1.5 \times 0.12)^{1/5}$$

= 0.64 ft/day from five-slug test results

(2) A cross-sectional area is calculated by multiplying the saturated thickness of water-bearing zone, b, times the cross-sectional width of the zone for which the discharge is being calculated, m.

The saturated thickness, b, is assumed to be 25 feet. This value represents the saturated thickness which could reasonably be influenced by seepage from the stabilized pile in the near-field zone of contaminant migration beneath the stabilized pile. This is based upon a description of the sediments at Collins Ranch and the estimated depth of contamination at the processing site. At the processing site, seepage as determined from TDS and sulfate concentrations is limited to the 25-foot zone in the immediate source areas of the tailings pile and evaporation ponds.

At Collins Ranch the sampled sediments are finer than at the processing site and downward vertical movement in the near-field zone is expected to be less than at the processing site. Twenty-five feet represents a conservative estimate of the vertical zone of contaminant influence in the near field.

The cross-sectional width perpendicular to the movement of ground water beneath the proposed disposal site is 1,000 feet, measured at the widest transect across the proposed excavation (DOE, 1985). Therefore the area through which ground water flows is:

$$A = 25 \text{ ft} \times 1{,}000 \text{ ft}$$
$$= 25{,}000 \text{ ft}^2$$

(3) Taking the potentiometric contours 4870 feet and 4855 feet as representative of the upgradient and downgradient bounding contours for the proposed site (Figure D.2.14).

$h_1 = 4870$ feet
$h_2 = 4855$ feet

(4) The distance between the potentiometric contours 4870 feet and 4855 feet is (2.4 inches) (400 ft/in) = 960 feet (Figure D.2.14); thus dl = 960 ft.

The discharge can now be calculated.

$$Q = (0.64 \text{ ft/day})\ (25{,}000 \text{ ft}^2)\ \frac{(4870 - 4855) \text{ ft}}{960 \text{ ft}}$$

$$= 250 \text{ ft}^3/\text{day}$$

The average flow velocity V, through the saturated sediments beneath the Collins Ranch site can be calculated using the discharge through area A

and the effective porosity n_e of the site soils calculated in A as 0.15 to 0.24.

$$V = Q/n_eA$$

$$= \frac{(250\ ft^3/day)}{(25{,}000\ ft^2)\ (0.24)} \text{ to } \frac{(250\ ft^3/day)}{(25{,}000\ ft^2)\ (0.15)}$$

$$= 0.04\ ft/day \text{ to } 0.06\ ft/day$$

$$= 14.6\ ft/yr \text{ to } 21.5\ ft/yr$$

h. Computation of the dilution factor for contaminants moving into the saturated zone.

When the contaminant front reaches the ground water, dilution occurs as the seepage mixes with the ground water. The dilution factor is expressed by the equation:

$$D = U/V$$

where

D = the dilution factor for contaminants moving into the saturated zone

U = the "leachout rate" (part f. calculations)

V = the ground-water velocity (part g. calculations)

(1) V = 15 ft/yr to 21.0 ft/yr

(2) U = 0.49 ft/yr to 0.78 ft/yr

$$D = \frac{0.49\ ft/yr}{21.5\ ft/yr} \text{ to } \frac{0.78\ ft/yr}{15.0\ ft/yr}$$

$$= 2.3 \times 10^{-2} \text{ to } 5.2 \times 10^{-2}$$

According to the model time seepage rates, the total concentration of dissolved species in the contaminant front will be reduced by a factor of between 20 and 45 upon mixing with the ground water, assuming no additional mass of the species in the ground water.

In addition to linear dilution of the contaminant front, dispersive, diffusive, and chemical reaction mechanisms act to reduce the concentration of constituents during solute transport. Chemical mixing models such as PHREEQE can be used to simulate resultant chemical equilibrium concentrations upon mixing of the seepage fluid with ground-water fluid in various proportions and under a specified pH and Eh.

D.2.6.4 Conclusions - Collins Ranch

The analytical methods and calculations used are based upon a very simplified prototype system. The parameter values chosen can be considered conservative. Conclusions about the potential for contaminant migration at the Collins Ranch alternate site are as follows:

- The ground-water flow velocity under the site is 15 to 21.5 ft/yr. The leachout rate or vertical seepage front velocity is 0.49 to 78 ft/yr based upon a high infiltration rate. A resultant dilution factor for volumetric mixing between percolation and ground-water flow is about 0.02 to 0.05.

- With a conservative infiltration rate, leachate would travel through the pile (average thickness of 45 feet) and underlying soil (minimum thickness of 20 feet) in 80 to 130 years.

- Delay in the movement of contaminant species is characterized by the distribution coefficients of selected species. Considering only the time delay for movement from the base of the pile through 20 feet of soil to the ground water, uranium and arsenic require on the order of 10^4 to 10^6 years. Manganese requires 30 to 250 years and sulfate, which is conservative, requires 29 years. These values (except sulfate) may become shorter upon revision of the distribution coefficients.

- The inundation at the base of the pile by site ground water is not considered as a leaching mechanism in this model. Ground-water elevations and the preliminary site conceptual design indicate that this event is very unlikely. However, seasonal fluctuations in water levels will be monitored through at least June, 1985, to account for spring snowmelt recharge from the Fremont Mountains, and resultant rises in ground water beneath the site.

D.2.6.5 Conceptual model - Flynn Ranch

No ground water was encountered to a depth of 150 feet at the Flynn Ranch alternate disposal site. A conceptual model of fluid migration through the pile and contaminant transport includes a consideration of movement in the vadose zone.

A preliminary engineering design shows a 1200-foot by 600-foot pile with an average thickness of 30 feet, including a one-foot clay cover, constructed on top of the basaltic bedrock. Hydraulic properties of the bedrock were measured by three packer tests. Two tests at intervals from seven to 14 feet and 38 to 43 feet in two different coreholes produced hy-

draulic conductivities of 0.13 ft/day and 0.82 ft/day, respectively. Another test in the interval from seven to 14 feet produced "no take" readings. Results are in accordance with the hydraulic properties of basalt flows where the base or deeply weathered surfaces of flows are more than four orders of magnitude more permeable than unaltered portions of flows (Freeze and Cherry, 1979).

Any seepage front from beneath the pile would move into the unsaturated permeable weathered zones and unhealed fractures. Unsaturated hydraulic conductivities which are a function of moisture content and negative pressure head would be considerably lower than the saturated hydraulic conductivities of 0.13 ft/day and 0.82 ft/day. No moisture or capillary (negative) pressure data are available for the Flynn Ranch site to quantify the unsaturated hydraulic conductivity.

The absence of shallow ground water may indicate there is little local recharge combined with no extensive shallow nearly impermeable zones to create perched saturated conditions. Due to the arid climate, the infiltration rate from snowmelt and precipitation is expected to be low. Other potential sources of recharge to the bedrock are two ephemeral intermittent drainages that run north and northwest of the site. Both branches intersect and join Mapes Creek which drains into Flynn Reservoir northeast of the site. All drainages were dry and both branches appear only to flow in response to major precipitation events. There are two large springs with yields of 30 to 40 gpm located about two miles south and southeast from the site, and several springs occurring within four miles east and west of the site.

The sporadic occurrence of ground water in the area indicates that structural barriers, tilting, and faulting of the basaltic bedrock control ground-water movement. More extensive drilling along with careful lithologic and structural interpretation are required to draw conclusions on ground-water movement beneath the site.

Due to the depth to ground water immediately below the site and the lack of a large infiltration component to transport solutes from the pile, the site is well isolated from the hydrologic system. In a projected "worst case" scenario, tailings seepage would move from the base of the pile, possibly through a small layer of saprolith or mantle of weathered bedrock, into permeable zones of the basalt. The lithologic log of the 150-foot borehole, LKV03-511, shows moderately to highly fractured basalts with some voids up to three feet. The packer test results showed high contrasts in fluid pressures in selected intervals showing an anisotropic media whereby the hydraulic conductivity, K, takes on different values depending on the direction of flow under a unit hydraulic gradient.

Movement of fluid through unsaturated voids would be slowed by trapped air which eventually becomes dissolved in

the fluid before migration of the fluid in response to the hydraulic gradient and the effective or unsaturated hydraulic conductivity. The 150-foot corehole lithology and packer tests indicate that travel paths for contaminant migration are likely not principally downward, increasing the length of flow path before reaching a saturated system. Due to expected slow migration rates and long tortuous travel paths, diffusive transport along with the advective dispersive transport processes would act to further attenuate the movement of contaminant species.

In conclusion, any movement of seepage from the Flynn Ranch disposal site would require long travel times before interception with ground water. From collected data, the site appears to be a hydrologically isolated system.

D.2.7 IMPACT ANALYSES

The two basic approaches to mitigation include ground-water protection and aquifer restoration. Protection involves technologies that will preclude the spread of existing contamination within an aquifer and or reduce the potential for future contamination. Restoration requires physical removal and treatment of contaminated ground water and reinjection of the treated water. Aquifer restoration may be used after stabilization and containment methods have been implemented.

Aquifer protection measures at the Lakeview site involve removal of the contaminated material from the processing site area to a disposal site where natural site attributes and engineering design factors will reduce the potential for future contaminant migration to ground water. Aquifer restoration measures for extant contamination in shallow ground water at the processing site are discussed at the end of Section D.2.7.1.

D.2.7.1 Stabilization at the Collins Ranch site

Impacts to the ground-water regime at both the processing site and the Collins Ranch site are from the construction-excavation activities and from a projection of the long-term effects.

Mitigation of contamination measures are built into the remedial action construction sequence. These include installation of a waste-water treatment facility to treat dewatering ground water from excavation and construction of drainage and erosion control measures to prevent infiltration of contaminated water. Excavation of tailings materials would extend to depths of four to seven feet and excavation of evaporation pond subsoils would extend to depths of three to four feet. Some dewatering of the shallowest unconfined zone is anticipated, and contaminated water from these source areas would be treated, used for compaction and dust control, or evaporated. Consolidation and excavation of contaminated material could generate an increase in the source term for contaminant migration for a short duration until all materials are removed.

Relocation of Hammersley Creek to the south of the processing site is not expected to impact ground water. Plans involve excavation of a three-foot trench and emplacement of a clay liner and riprap for erosion protection. Any changes to the local ground-water recharge patterns due to excavation and relocation would be minimal due to the intermittent nature of the drainage channel.

Water used during remedial actions would be obtained from existing deep wells (400 to 500 feet) on the site. Compared to consumption during milling activities, water consumption during the remedial actions would have negligible impact upon the confined aquifer.

During relocation of the tailings at the Collins Ranch site, the ground water should remain isolated from effects of construction activities. The disposal area would be graded into the western slope of Augur Hill to an average depth of 30 feet. Based upon current water-level information, ground water is at least 20 feet below the depth of excavation.

Projected impacts to the ground water after remedial action are based upon analytical calculations in Section D.2.6. Emplacement of the relatively impermeable earthen cover over the stabilized tailings would minimize water infiltration through the tailings and thereby minimize the leaching of contaminants into the underlying strata.

Analytical calculations for the Collins Ranch alternate disposal site predict travel times of 25 to 40 years for seepage migration, with additional attenuation time for contaminant species such as uranium and arsenic on the order of 10^3 to 10^6 years. Because the primary geochemical nature of the tailings and the substrate soils at Collins Ranch would be similar to the Lakeview processing site, it is expected that a similar geochemical equilibrium would be established and a similar chemistry plume would emanate from the stabilized pile. In this occurrence, radionuclides and most heavy metals would be attenuated at the developed pile-soil interface zone, and the mobile species such as sulfate, manganese, and sodium would mix with the existing low TDS ground water beneath the site.

A quicker mechanism for contaminant leaching and movement into the ground water would be by a seasonal rise in the ground-water levels, inundating the base of the tailings pile and mobilizing contaminants at the interface zone. The present minimum depth to ground water is 20 feet, and a 20-foot rise due to seasonal water level fluctuations is not in the realm of natural occurrences in an alluvial sediment sequence. Should a rise of 10 feet occur, the site design plan would incorporate a capillary break layer at the base of the pile to direct flow lines away from the stabilized pile.

At the Lakeview processing site, the resultant effect after remedial action would be removal of the source areas for future ground-water contamination. Existing contamination, including any additional contamination generated by the remedial action, would continue to migrate downgradient with absolute concentrations reflecting the effects of dilution and attenuation. The time required for this natural flushing action is not estimated due to the complex nature of the ground-water flow system. The flushing action could be accelerated by aquifer restoration.

Aquifer restoration

For affected ground water at UMTRA Project sites, the decision on whether to institute remedial action, what specific action to take, and to what levels an aquifer should be protected or restored is made on a case-by-case basis (USEPA, 1983). The decision must take into account several factors:

- Technical feasibility of improving the aquifer in its hydrogeologic setting.
- Cost of applicable restorative or protective programs.
- Present and future value of the aquifer as a water resource.
- Availability of alternate water supplies.
- The degree to which human exposure is likely to occur.

Remedial actions for affected aquifers can take the approaches of ground-water protection, ground-water restoration, or a combination of the two. At the Lakeview site the source areas of ground-water contamination are going to be physically removed. The existing plume shows no elevated concentrations of radionuclides or elevated concentrations of heavy metals except manganese greater than upgradient levels of the species in natural ground water. The occurrence of geothermal ground water within the Lakeview area, showing natural exceedence levels of arsenic, boron, and fluoride, makes the factor of improving the aquifer in its hydrogeologic setting a questionable criterion for restoration.

Well records show only three wells immediately downgradient from the processing site, and all but one were completed from depths of 220 to 320 feet. One well on file was reported to have been drilled less than 50 feet deep southeast of the tailings pile. This well was not observed during the field activities. Future value of the Lakeview area aquifer as a water resource rests upon the economic development of the area, as well as the suitability of the geothermal system for drinking water consumption and/or energy development. Based upon the present data, human exposure to the processing site contaminated ground water is minimal.

The removal of contaminated material from the processing site precludes the need for ground-water protection. The chemical composition of the existing plume relative to the natural geothermal water chemistry and the lack of water use from the shallow system downgradient of the site appears to negate the need for aquifer restoration. A final decision on the need for aquifer restoration will be made following the collection of additional ground-water data.

D.2.7.2 No action

Implementation of the no-action alternative would result in continued infiltration of water through the tailings pile and the associated leaching of contaminants from the tailings into the shallow ground water. Seasonal fluctuations of the unconfined water level into the base of the tailings pond or the evaporation pond subsoils would continue to contribute to the leaching of contaminants into the ground water. Contamination would continue to move downgradient and possibly vertically downward into more productive pumping zones.

Attenuation of radionuclides and trace metals would continue until a new set of geochemical conditions occurred or in some cases, a chemical equilibrium was reached. Leaching and attenuation would occur until the source areas were leached of all mobile contaminants. The time required for these natural geochemical-transport processes to be completed has not been estimated, but the time period would be considerably longer than that required if the source areas of contamination were not removed from the site.

D.2.7.3 Stabilization at the Flynn Ranch site

As discussed in Section D.2.6, ground water does not occur within at least 150 feet of the surface at the Flynn Ranch site. During relocation of the tailings to the Flynn Ranch site, water used for compaction and tailings pore water would migrate from the base of the excavation into more permeable zones along fractures or along the weathered zones of the basaltic bedrock.

After remedial action, seepage migration from the stabilized tailings would occur under unsaturated conditions. Migration rates through more than 150 feet of nonhomogeneous unsaturated bedrock would be extremely slow. Travel time should be sufficiently slow to allow the attenuation effects of matrix diffusion as well as dispersion to remove most soluble contaminant species. The disposal site can be considered essentially isolated from the ground-water system at the Flynn Ranch site.

Therefore impacts to the ground water at the Flynn Ranch site are estimated to be minimal or nonexistent.

Impacts at the Lakeview processing site from relocation of the tailings to the Flynn Ranch site would be the same as those discussed in Section D.2.7.1.

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