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United States Department of Energy

Remedial Action Plan and Site Conceptual Design for Stabilization of the Inactive Uranium Mill Tailings Site at Salt Lake City, Utah

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Appendix B of the Cooperative Agreement No. DE-FC04-81AL16309

December, 1984

Uranium Mill Tailings Remedial Action Project UMTRAP

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URANIUM MILL TAILINGS REMEDIAL ACTION PROJECT OFFICE

ALBUQUERQUE OPERATIONS OFFICE

DEPARTMENT OF ENERGY

ALBUQUERQUE, NEW MEXICO 87108

REMEDIAL ACTION PLAN

AND

SITE CONCEPTUAL DESIGN FOR STABILIZATION

OF THE

INACTIVE URANIUM MILL TAILINGS SITE

AT

SALT LAKE CITY, UTAH

APPENDIX B

TO

COOPERATIVE AGREEMENT

NO. DE-FC04-81AL16309

U.S. Department of Energy
Agreement No. DE-FC04-81AL16309
Appendix B

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1.0 INTRODUCTION

1.1 PURPOSE

This Remedial Action Plan (RAP) has been developed to serve a twofold purpose. It presents the series of activities which are proposed by the Department of Energy (DOE) to effect long-term stabilization and control of radioactive materials at the inactive uranium processing site located in Salt Lake City, Utah. It also serves to document the concurrence of both the State of Utah and the 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) of 1978, expressly finding that uranium mill tailings located at inactive (and active) mill sites may pose a potential health hazard to the public. Title I to the UMTRCA identified sites to be designated for remedial action. On November 8, 1979, Salt Lake City was designated as one of 24 sites.

UMTRCA charged the Environmental Protection Agency (EPA) with the responsibility for promulgating remedial action standards for inactive mill 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 will select and execute a plan of remedial action that will satisfy the EPA standards and other applicable Federal and state laws. Under UMTRCA, the DOE and the State of Utah entered into a cooperative agreement effective January 30, 1981, for remedial action at the Salt Lake City site. A revision to this agreement became effective July 16, 1984. The funding of the allowable costs on the project is described fully in the cooperative agreement. In summary, the DOE will fund 90 percent and the State will fund 10 percent of allowable costs up to the amount equal to the mutually agreed upon costs for stabilization in place (SIP) of $42,000,000 in March, 1984 dollars. DOE will pay 75 percent and the State will pay 25 percent of the allowable costs which exceed the amount of the SIP cost estimate.

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 the long-term monitoring and maintenance of disposal sites will be for the purpose of ensuring compliance with the standards set 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 7.0 of this report.

1.3 SCOPE AND CONTENT

This document has been structured to provide a comprehensive understanding of the remedial action proposed for the Salt Lake City site. An extensive amount of work has been conducted by numerous people to gather data, evaluate data, prepare remedial action alternatives, and write documentation. The detailed supporting information cannot 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 Salt Lake City site with a description of the present site characteristics. Section 4.0 provides a definition of site-specific problems, a listing of remedial action alternatives which have been considered, and the action which is being proposed. Section 5.0 is the Site Conceptual Design for the proposed action. Section 6.0 states the need for ensuring health and safety protection for the surrounding community and the on-site workers. Section 7.0 presents a detailed listing of the responsibilities of the project participants. Section 8.0 describes the features of the long-term maintenance and surveillance plan. Section 9.0 documents the on-going activities to keep the public informed and participating in the project.

Attached as part of the RAP are appendices which describe in more detail various aspects of the remedial action.

Appendix A, Regulatory Compliance, describes in detail the permits necessary for the remedial action activities.

Appendix B, Calculations Summaries and Design Drawings, presents a summary of the rationale and calculations that support the conceptual design and the concept drawings.

1.4 COLLATERAL DOCUMENTS

The Processing Site Characterization Report (PSCR), the Disposal Site Characterization Report (DSCR), and the Environmental Impact Statement (EIS) describe the existing conditions at the site and the results of the remedial action. They include details that are not reported in the RAP.

The PSCR contains all of the data, including geotechnical, hydrological, radiological, meteorological and physical, necessary to describe the existing conditions at the Salt Lake City site. The DSCR contains data that describe the existing conditions at the South Clive site. The reports also contain data which characterize potential remedial action construction materials.

The EIS describes the proposed remedial action and alternatives and the environmental impacts of the proposed actions.

An additional supporting document is the Site Design Criteria. The UMTRA Project staff has prepared a project document (DOE/AL-049) which addresses the general guidance on the operating procedures, formats for

drawings, specifications, calculations, schedules and cost estimates, and minimum design constraints to be incorporated in the final design documents (DOE, 1984c).

This general guidance is to be used in conjunction with the SCD, as the basis or guideline for preparation of the final design documentation for the Uranium Mill Tailings Remedial Action (UMTRA) Project sites. It is further intended to provide sufficient criteria for the reader to understand the constraints, procedures, codes, and standards to be used during the design and performance of the remedial actions at the UMTRA Project sites. Specific design criteria and instructions are included in the Site Conceptual Design.

Copies of all of these documents as well as supporting data and calculations are on file in the UMTRA Project Office, U.S. Department of Energy, Albuquerque Operations Office, Albuquerque, New Mexico.

2.0 EPA STANDARDS

2.1 GENERAL

Pursuant to the requirements of UMTRCA, 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 ground-water quality.

In developing the standards, 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. EPA further concluded that the potential for contamination of ground water 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 dispersal 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 guidance provided by the legislative history of UMTRCA which stresses the importance of avoiding remedial actions which would be effective only for a short period of time and which 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. 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, EPA called for designs which rely primarily on passive controls.

The Standard is framed as a longevity requirement which recognizes the difficulty in predicting very long-term performance with a very high degree of confidence. In establishing the longevity requirement, EPA concluded that existing knowledge permits the design of control systems that have a good expectation of lasting at least 1000 years. Therefore, a de-

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.

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

sign objective of 1000 years was established to be satisfied whenever reasonably achievable, but in any case with a minimum performance period of 200 years.

The Standard recognizes the need for institutional controls such as custodial maintenance, monitoring, and contingency response measures. In its preamble to the standards, EPA calls for such controls to be provided as an essential backup to the primary passive controls.

2.3 RADON EMISSIONS CONTROL

EPA identified a reduction of radon emissions from tailings piles as the second objective in its standards for the control of tailings. In developing the standards, it considered several alternative approaches and selected an emission limitation as the primary form of the standard. In addition, it established a concentration limit as an alternative form of the standard for use in cases where the DOE determined that the alternative was appropriate.

In establishing the emission limitation for tailings piles, EPA [illegible] 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, EPA estimates that exposure to radon emissions will be reduced by more than 96 percent. The radon standard of 20 pCi/m^{2}sec on the disposal site or 0.5 pCi/l outside the disposal site will limit the increase in radon concentration attributable to a pile to a small increase above the background radon level near the disposal site. Both standards are design standards with compliance to be determined on the basis of predicted rather than measured emission rates and concentrations. 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, 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

EPA reviewed available water-quality data at inactive tailings sites and determined that there was little evidence of recent movement of contaminants into ground water. They also determined that any degradation of ground-water quality should be evaluated in the context of potential beneficial uses of the ground water as determined by background water quality and the available quantity of ground water.

Rather than establish specific numerical limitations for contaminant discharges or ground-water quality, 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 ground-water quality through one or more upgradient wells and to identify the present movement and extent of contaminant plumes associated with the tailings piles. They further call for judgements of the need for restoration or prevention, or both, to be guided by 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 to be 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 alternative water supplies, and the degree to which human exposure is likely to occur.

UMTRCA requires that the standards promulgated by EPA ". . .to the maximum extent practicable, be consistent with the requirements of the Solid Waste Disposal Act, as amended." In setting the standard, EPA determined that the statutory requirement for 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, July 26, 1982). Accordingly, EPA established the implementation procedures requiring case-by-case evaluations of potential contamination at sites. Decisions regarding monitoring or remedial actions will be guided by relevant considerations in the hazardous waste management systems.

2.5 CLEANUP OF LANDS AND BUILDINGS

The EPA evaluated the risk associated with the dispersal of tailings off the site and concluded that the principal risk to man was the exposure to radon daughter products inside buildings. 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 WL (working level). For open lands, the purpose of removing the contamination that might arise from new construction on contaminated land. The 5 pCi/g and 15 pCi/g Ra-226 concentration limits for 15 cm 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 exceeding 0.03 WL. In cases where levels are between 0.02 and 0.03 WL, the Federal government may use measures such as sealants, filtration devices, or ventilation devices to provide reasonable assurance of reductions to below 0.02 WL.

3.0 SITE CHARACTERIZATION

Site Characterization describes the Salt Lake City site and the proposed disposal site at Clive, Utah, as they exist today. Emphasis is given to the three major concerns of stability, radiation, and ground water. The data to support the characterization may be found in the Processing Site Characterization Report (PSCR) (DOE, 1984a) and the Disposal Site Characterization Report (DSCR) (DSCR, 1984).

3.1 HISTORY

In 1951, Vitro Chemical acquired a plant originally built in the Salt Lake City Valley during World War II for the production of alumina from alunite. Later, Vitro converted the plant to process uranium ore. The ore was received by rail or truck from many small mines and prospects throughout the West. The Salt Lake City site location is shown in Figure 3.1.

Uranium ore was processed by acid leach from May 1951, to January 1964. The mill then was converted to produce vanadium from Idaho Ferrophos (resulting from elemental phosphorous production). Vanadium production ceased in July 1968.

From May 1951 to January 1964, the plant processed 1.9 million dry tons of ore. An additional 1 million dry tons of contaminated material exists on the site for a total of 2.9 million tons, or 2.45 million cubic yards.

Plant demolition began in 1968 and was completed in 1970. The 450-foot stack was demolished in December 1980, and the only structures remaining are a water tower and a railroad spur to the mill area. Various building foundations and concrete supports were left in place at the mill site.

In 1972, 78 acres of the property were purchased by David K. Richards and D. Eugene Moench, and a 60-acre tract leased by Vitro from Zions Security Corporation was acquired by the Salt Lake County Suburban Sanitary District. The entire 128-acre site as well as the Salt Lake City Suburban Sanitary District (40 acres) are now owned by Central Valley Water Reclamation Facility (CVWRF) Board, as shown in Figure 3.2. This figure also shows the designated boundaries of the inactive uranium mill tailings site.

3.2 PHYSICAL DESCRIPTION

Surface features of the Salt Lake City site

The Salt Lake City site (Figures 3.1 and 3.2) encompasses an area of about 128 acres and is located 4 miles south-southwest of the center of Salt Lake City, at the northeast corner of the street intersection of 3300 South Street and 900 West Street. The abandoned uranium processing site is actually located in the City of South Salt Lake. Because the original plant operator was Vitro Chemical Company, the site is often referred to

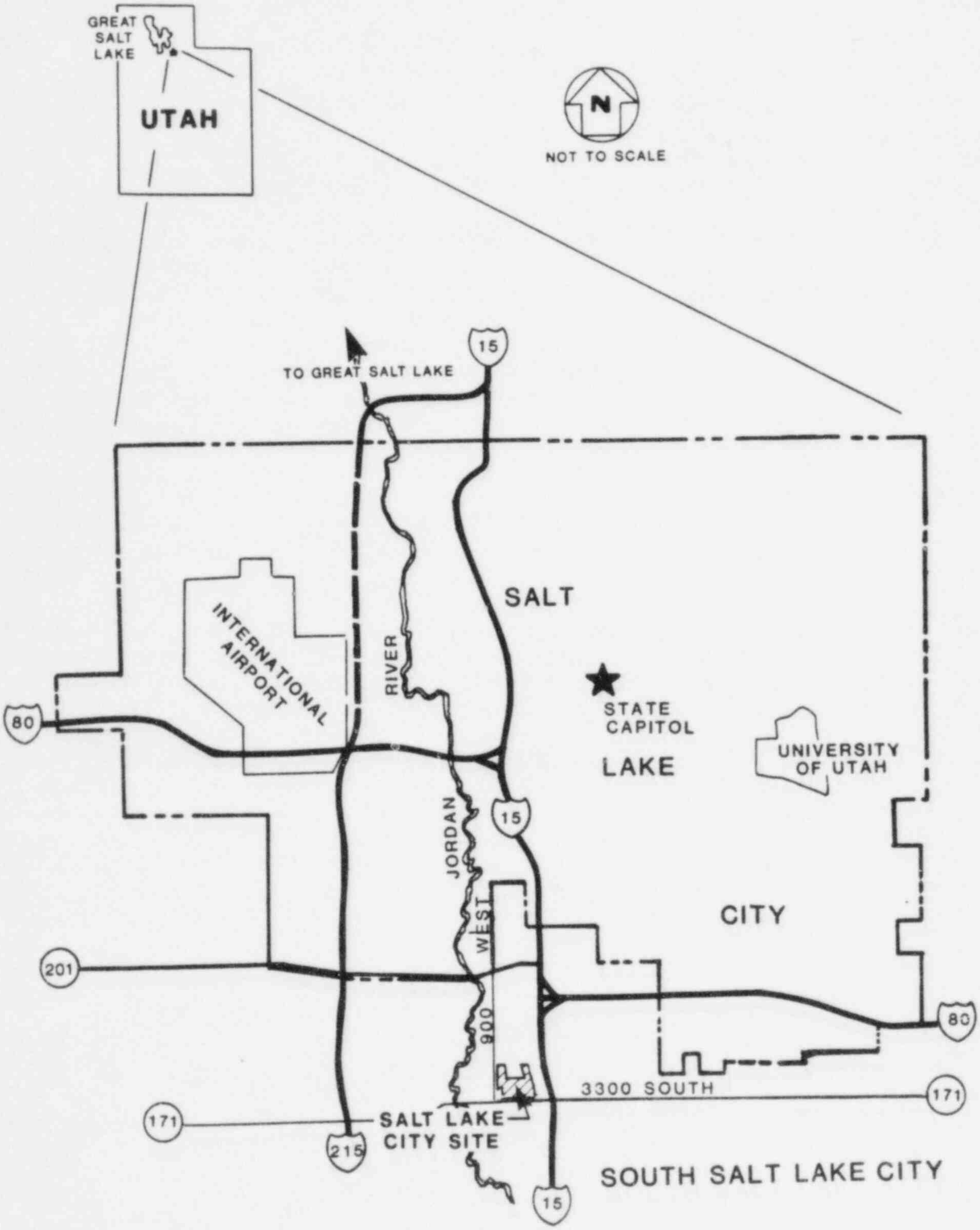

FIGURE 3.1
LOCATION MAP OF THE SALT LAKE CITY SITE
SOUTH SALT LAKE CITY, UTAH

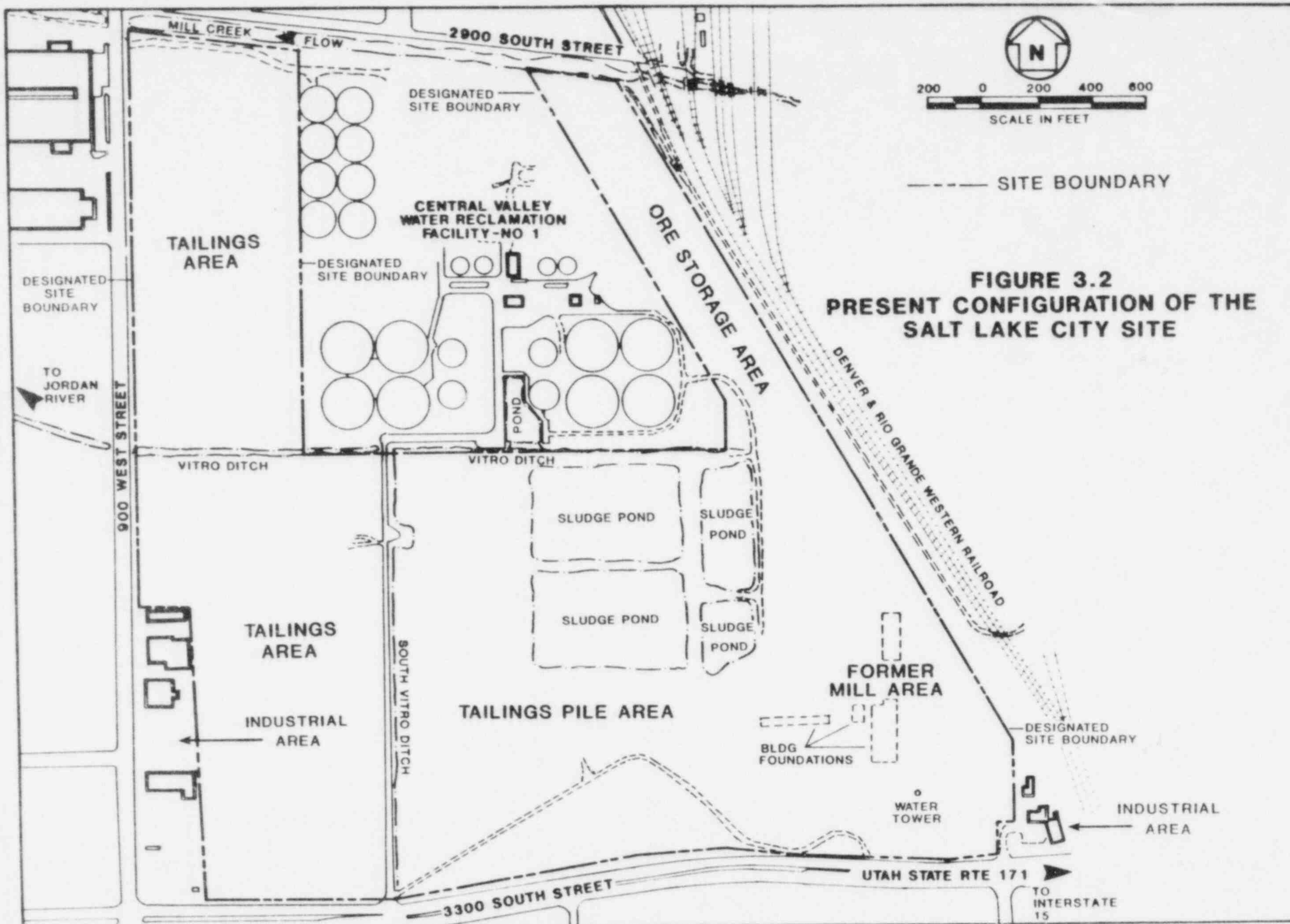

FIGURE 3.2
PRESENT CONFIGURATION OF THE SALT LAKE CITY SITE

as the Vitro site rather than the Salt Lake City site. The Central Valley Water Reclamation Facility (CVWRF) sewage treatment plant is located on adjacent property north of the central portion of the site. The entire site is presently owned by the CVWRF Board.

The site is bounded on the north by the CVWRF and the channel of Mill Creek, on the east by the Denver and Rio Grande Western Railroad, on the south by 3300 South Street, and on the west by 900 West Street. A 5.4-acre industrial area occupies a 225-foot wide strip adjacent to the west edge of the south half of the site facing 900 West Street. Another industrial facility is situated adjacent to the southeast corner of the site. The nearest residences to the Vitro site are about 300 feet away from its southwestern corner, across 3300 South Street.

The site can be roughly divided into four areas: the former mill and ore storage area, and three former tailings storage areas labeled "northwest," "southwest," and "southeast" on Figure 3.2. The southwest and southeast tailings areas are separated by the South Vitro Ditch, which is part of a storm-sewer system that gathers surface water from areas south of the site. The northwest and southwest tailings areas are separated by the Vitro Ditch, which carries treated water from the CVWRF and groundwater discharge from low areas. The eastern portion of the Vitro site was used for the ore processing mill, ore storage, and transportation facilities. The buildings were removed, but various foundations and concrete supports were left in place or were buried at the site. This portion of the site remains at approximately natural ground surface level.

The tailings pile, which includes milled tailings soil and rubble cover, and natural soil starter dikes, is composed primarily of sand tailings (SP,SM) and slime tailings (ML,CL). The stratigraphy of the pile is relatively complex and the zoning from sands to slimes is gradational, depending on the history and methods of tailings deposition. Large portions of the piles have been covered with construction rubble and soils in order to reduce windblown tailings.

The northwest tailings consist mainly of medium to fine sands. The southwest and southeast piles contain mostly fine sands with varying properties of slimes. The site average tailings moisture content is 20 percent with the contaminated soil beneath the site averaging 23 percent (MSRD, 1982). In-situ densities are on the order of 1 to 4 g/cm^3. The site contains an average of 0.014 percent uranium and 560 pCi/g of radium-226.

The samples collected during drilling operations were classified according to the Unified Soils Classification System (USCS) and selected samples were subjected to laboratory testing in order to obtain material properties and physical characteristics necessary for use in design considerations. These tests included moisture content, dry density, gradation, Atterberg Limits, specific gravity, permeability, triaxial compression, and consolidation. Pertinent material properties are summarized in Appendix B, Section 2.0.

Since 1970, after milling operations at the Vitro site were terminated, the surface of the site has been altered considerably in several

places. In the northwest tailings area, approximately 13 acres are covered with sludge from the CVWRF sewage treatment plant. The northern half of the southwest tailings area contains an excavation approximately 10 feet deep and 600 feet long in the east-west direction. Excavated material on the order of 20 feet in height lies to the north and to the south of the excavation. Small amounts of debris and concrete rubble are scattered across the southwest and southeast tailings areas.

At present, off-site property cleanup projects are bringing contaminated material onto the southeast tailings and stockpiling it in a fenced low-lying area. Some of the imported material is concrete rubble, but most of it is sandy tailings that were originally taken from the site for use as fill. A recently-constructed system of unlined sludge ponds in the north portion of the southeast tailings area is currently accumulating sewage sludge from the CVWRF plant.

Subsurface features for the Salt Lake City site

Subsurface soil conditions at the Vitro site were evaluated through the drilling, logging, and sampling of a total of 86 exploratory test borings. Additional borings have been drilled on or near the site for projects not related to long-term tailings disposal. The borings were advanced into the tailings pile and the underlying soils. None of the borings extended into the underlying bedrock which has previously been estimated to exist at a depth in excess of 2200 feet below the site. In addition 5 relatively shallow test pits were excavated in the tailings pile in order to obtain large quantity disturbed samples.

Both disturbed and relatively undisturbed soil samples of the tailings and underlying natural soils were obtained at intervals in each boring. Sampling included Shelby tube and standard penetration tests. Details of boring locations, some of the boring logs, field procedures and sampling techniques are presented in other documents (DOE, 1984b; CSU, 1982).

The field investigations in the vicinity of the Vitro site indicate that the natural soils underlying the area consist of interlayered silt, silty-clay to clayey silt, and sands. The soils were deposited in a lacustrine environment and exhibit random and lenticular patterns of interlayering with no predominant material type of classification being correlated among the individual borings. These unconsolidated materials are thick- to thin-bedded and are known to contain a few beds of silt and fine sand (FBDU, 1981). The sands are lenticular and contain varying amounts of silt and clay. The clays provide a natural clay liner for the existing tailings. The individual zones of both granular and fine-grained soils encountered in the borings vary in thickness from 5 to 50 feet. The soil sequence extends to the full depth penetrated by the borings, 130 feet.

The silt and silty clay-clayey silt soils generally exhibit medium to high moisture contents, low to medium densities, and relatively low permeabilities that range from approximately 3×10^{-5} to 3×10^{-3} feet per day. The granular soils underlying the area contain various amounts of

silt, clay, and occasional gravel. When these granular soils contain a low percentage of silt and clay, they are generally dense to very dense and have considerably higher permeabilities that range from 1.4 to 27 feet per day.

It has been determined that approximately the upper two feet of the natural soils beneath and immediately surrounding the tailings pile have been contaminated due to the uranium milling process.

Surface features of the South Clive site

The proposed disposal site near Clive, Tooele County, Utah, is located approximately 85 highway miles west of the Salt Lake City Vitro site and consists of the 1-square-mile area designated as Section 32, Township 1 South, Range 11 West. The northern boundary of the site area is approximately 1 mile south of Clive which is a railroad siding for the Union Pacific System. The railroad right-of-way servicing this siding extends from the Salt Lake City area westward toward Nevada. Highway access to the site is provided by U.S. Interstate 80 which passes approximately 2.5 miles to the north of the site. A dirt trail intersects the highway north of Clive, extends in a southerly direction, and runs along the site's western boundary (Figure 3.3).

The site is owned by the State of Utah and leased for grazing. The area is rarely used and the nearest inhabitants are 15 to 20 miles away from the site. The existing roads in the area are used by recreational vehicles and for access to a military firing range south of the site. Approximately 70 acres of the section will be used for the proposed disposal area.

Subsurface features of the South Clive site

Subsurface conditions at the South Clive site were evaluated through the drilling, logging, and sampling of eleven exploration borings. In addition, 6 test pits were excavated at the site in order to evaluate the soils for cover suitability. The near surface generally consisted of light brown to tan, sandy to clayey silt and silty clay. These soils were classified as either medium stiff or very stiff and were noted to sometimes contain a small pinhole structure and bedding layers that ranged from approximately 0.06 to 1.0 inch in thickness. The thickness of surficial soil varied from 3.0 to 12.0 feet across the site.

The underlying material is an interlayered lacustrian deposit ranging from relatively clean fine- and medium-grained sands to silty clays. This interlayered soil sequence appears to be random and no definite pattern or predominate material type could be correlated among individual borings. In general, the soils are layered but varied in thickness from about 0.1 inch in stringers to 4 feet. The cohesive materials encountered were generally classified as stiff to very stiff while the cohesionless materials were generally medium dense to dense. This interlayered sequence extends to depths ranging from 45 to greater than 51 feet below the existing grade.

FIGURE 3.3
SOUTH CLIVE VICINITY MAP

Beneath the interlayered sequence the predominant material becomes a grayish-brown to brown, silty sand with a consistency classification ranging from medium dense to very dense. This deeper material extended to depths in excess of 250.8 feet and contained minor variations in silt or clay content and occasional zones where thin stringers of finer-grained materials were present. At a depth of 75 feet, zones were noted that contained coarse sand and gravel. At a depth of approximately 128 feet, the material was classified as very dense and remained consistent to the depth penetrated by the borings. More detailed characterizations of the site subsurface conditions are contained in Appendix B.

In order to determine the mechanical and engineering behavior properties of the foundation soils a series of laboratory tests were conducted on both disturbed and relatively undisturbed soil samples. These tests consisted of moisture content, dry density, gradation, Atterberg Limits, specific gravity, moisture-density relationships, consolidation, triaxial compression, direct shear and permeability.

3.3 STABILITY

Vitro site

The tailings are located next to Mill Creek, Vitro Ditch, and South Vitro ditch. Portions of the tailings have been covered with construction rubble or sewage sludge. The existing piles are as high as 17 feet above the natural grade and have sideslopes of greater than one to one, therefore, the material can be eroded by the wind or water. Analytical data from sediment samples and off-site soil samples support this hypothesis. The site is fenced; however, access to the tailings is not prevented because of the access to the sewage treatment plant.

The front of the Wasatch Range is apparently a still-active normal fault. Motion on it or its tributary faults could produce seismic accelerations of as much as 0.2 g (DOE, 1984b) at the Vitro site. The subsurface soils and the tailings are near saturation levels and would be subject to liquefaction and slope failure if a major seismic event occurred.

South Clive site

The site is 2.5 miles south of I-80 and remote from any permanent population. Some people enter the area to tend sheep, to reach the military ranges, or for recreational driving. The area has no surface water bodies, however, runoff from the surrounding mountain ranges crosses the area. The large open valley is also subject to high winds.

The nearby mountain ranges and seismogenic sources indicate potential faults in the area. Motion could produce seismic accelerations of as much as 0.37 g (DOE, 1984b). The subsurface soils at the South Clive site will not be susceptible to liquefaction.

3.4 RADIATION

Vitro site

Several studies to determine ambient-air radon concentrations near the Vitro site have been undertaken (FBDU, 1981; ORNL, 1977; Schearer and Sills, 1969; Monsanto, 1982). The only long-term measurements are those done by Monsanto using Passive Environmental Radon Monitors (PERMs). Forty sampling locations in the vicinity of the Vitro site were used to define the average ambient radon concentrations. These averaged about 3 pCi/l at the edge of the site and decreased to background concentrations (roughly 0.2 pCi/l) at distances of 1 to 2 miles from the site.

Gamma radiation levels have been measured and found to decrease rapidly with distance from the tailings pile. On the pile itself, gamma radiation levels range from 100 to 1200 microR/hr. At 0.1 mile from the edge of the pile, the gamma radiation level has fallen to 45 microR/hr, and at 0.5 miles from the pile the gamma radiation level has reached background for Salt Lake City--about 12 microR/hr (FBDU, 1976 and 1981). The range of typical background values is 9 to 17 microR/hr (FBDU, 1976).

Background concentrations of radionuclides in soils have been measured in and around Salt Lake City by a number of investigators (ORNL, 1977). Results are generally comparable and are typified by the ORNL results, which indicate the following values (Geometric mean plus or minus geometric standards deviation): Ra-226, 1.5 $\pm$ 1.2 picocuries per gram, and U-238, 2.0 $\pm$ 3.6 picocuries per gram. In addition, soil samples were collected by ORNL (1977) from 58 locations within about 400 to 1000 meters of the (south) sediment pile and analyzed for radioactivity. Samples were collected at the surface and at one-foot depth and were analyzed for Ra-226. Concentrations in surface samples ranged from background levels (about 1 pCi/g) away from the pile to over 100 pCi/g of Ra-226 near the pile. Samples obtained from the one-foot depth ranged from background to 460 pCi/g of Ra-226.

Sediment samples from the Jordan River, Mill Creek, and the Vitro Ditch were collected and analyzed for U-238, Th-230, Ra-226, and Pb-210 (ORNL, 1977). Results showed no contamination in Jordan River sediments, and slightly elevated levels (roughly twice estimated background) in Mill Creek sediments. The Vitro Ditch sediments, however, were shown to contain relatively elevated concentrations of all three radionuclides. Ra-226 concentrations range from 60 to 120 pCi/g, while Th-230 concentrations ranged up to 284 pCi/g which was higher than any other reported radionuclide. Although no samples were collected from South Vitro Ditch it can be assumed to have contamination similar to the Vitro Ditch.

Because of the nature of tailings, they are easily moved by the wind. Contamination appearing to be due to wind erosion of the piles has been identified up to 0.25 miles from the site. A statistically designed soil sampling protocol defined the extent of the contamination level (BFEC, 1983). The depth of the windblown contamination does not exceed 6 inches below the surface.

South Clive site

Radiation levels currently existing at the South Clive site have been determined from monitoring programs conducted by Dames and Moore and Argonne National Laboratory (ANL) (DOE, 1984b; ANL, 1983). Using the track etch method, ANL measured ambient air concentrations of Rn222 at the three locations surrounding Clive. All of the values obtained for the Clive area were below 1 pCi/l.

A general survey of terrestrial and cosmic gamma radiation levels was also conducted by ANL in the area surrounding Clive. These radiation levels are comparable with the gamma radiation levels measured beyond 0.5 miles from the Vitro site. The measurements were performed quarterly using thermoluminescent dosimeters (TLDs). The average exposure rates for Clive-South, Clive-Southeast, and Clive-North were 16.2, 14.1, and 11.6 microR/hr, respectively.

Surface-soil samples (to a depth of 5 centimeters) were collected at 300-meter intervals in each of eight compass directions out to a distance of 1500 meters from the center of the South Clive site. All of the samples were analyzed for Ra-226. Samples collected 1500 meters from the center were also analyzed for Th-230, U-238, and Pb-210. The surface-soil concentrations of Ra-226 ranged from 0.9 to 1.2 picocuries per gram dry weight (pCi/g); those of U-238 ranged from 0.7 to 1.0 pCi/g; those of Th-230 ranged from 1.2 to 1.6 pCi/g; and those of Pb-210 ranged from 1.1 to 2.3 pCi/g. These concentrations agree with the approximately 1 pCi/g average for surface soils of the contiguous United States (LASL, 1978).

3.5 GROUND WATER

Vitro site

The ground-water regime of the Jordan River Valley is generally characterized by two aquifer systems, a near-surface unconfined system and a deeper confined system. Near the site, both aquifers flow toward the west-northwest or the Great Salt Lake. The stratigraphy of the Valley consists of several hundred feet of unconsolidated to poorly consolidated alluvium. The two aquifers are separated by interbedded layers of low-permeability clays and silts. Wells at depths of 70 to several hundred feet below the ground surface reach water under artesian pressure.

The background water quality or chemistry of the two aquifer systems is substantially different. The upper unconfined aquifer water is characterized by a brackish quality with a high total dissolved solids range from 310 to 4250 mg/l, but generally 2000 mg/l or greater. This water has very limited use for domestic or agricultural purposes. The confined aquifer water generally has dissolved solids values of about 300 mg/l. The confined aquifer is a principal supply of domestic, agricultural, and industrial water in the Jordan River Valley. The relatively good water quality of the artesian aquifer is maintained by the upward vertical hydraulic gradient between the two aquifers which prevents downward migration of the naturally occurring brackish unconfined aquifer.

In order to determine the baseline ground-water conditions existing under and near the Vitro site, a series of 37 wells and 12 well points were completed in the upper aquifer and 13 wells were completed in the confined aquifer. In addition, two wells were installed in order to isolate the confining layer between the unconfined and confining systems. A series of field testing and water quality sampling programs of ground and surface water sources were conducted from 1978 through 1983. Details of the hydrology in the Vitro area along with testing procedures used and the results of data collected are summarized in the EIS (DOE, 1984b).

A contaminant plume exists in the unconfined aquifer downgradient of the Vitro site. The plume consists of elevated levels of total dissolved solids, sulfate and uranium. Further details on the plume are presented in Appendix B, Section 13.0.

South Clive site

The water table at the South Clive site ranges from about 25 to 35 feet below the ground surface, with saturated conditions extending to at least 230 feet deep. The hydraulic gradient is about 2.8 feet per mile, sloping gradually to the north-northeast. Measured fluctuations in ground-water elevations over time are generally less than 1 foot.

Studies of the hydrology of nearby areas indicate that there is minimal potential for significant ground-water recharge on the site. The low annual precipitation and fine-grained lake deposits below about 4600 feet tend to limit infiltration to the underlying ground water. Recharge may be concentrated on the more permeable alluvial fan deposits, and averages only 6 to 10 percent of the total precipitation on the drainage basin. It is believed that ground water from the alluvial fan deposits recharges the valley fill deposits. The South Clive site is on the periphery of the northern Great Salt Lake Desert hydrologic province, where it is reported that precipitation contributes little, if any, recharge to the shallow system (DOE, 1984b).

Information about ground-water conditions at the site is based on 13 observation wells in the vicinity of the site (DOE, 1984b). The wells extended to between 43 to 251 feet below the ground surface. Four additional wells were constructed for use during pump tests. Field testing and ground-water quality sampling programs performed on these wells indicate that concentrations of total dissolved solids range between about 20,000 mg/l to 50,000 mg/l. The water can be classified as unfit for all but limited industrial uses without extensive treatment, but could be used for dust control during disposal of tailings.

Significant concentrations of radionuclides are reported for analyses of water samples at the South Clive site. Dissolved uranium ranged from 2.7 to 35.9 pCi/l (0.004 to 0.053 mg/l). Reported concentrations of radon daughters were mostly reported on a "total" basis rather than a "dissolved" basis, but one analysis reported 6.8 $\pm$ 1.6 pCi/l of Pb-210 on a dissolved basis. Ra-226 was not reported on a dissolved basis. Other than the 17 monitoring wells installed for the UMTRA project, there are no existing ground-water wells on or near the South Clive site (DOE, 1984b).

4.0 PROBLEM DESCRIPTION

4.1 GENERAL

The Vitro site presently poses three major problems which must be corrected in order to meet the intent of PL95-604.

- The tailings are not secure from dispersion by natural and human forces.
- The site contains approximately 2.45 million cubic yards of tailings, contaminated rubble, and soil, and emits an estimated 560 pCi/m^2sec of radon which is in excess of the EPA standard of 20 pCi/m^2sec.
- The ground water beneath and downgradient of the tailings has elevated levels of specific contaminants attributable to the uranium milling operations.

Each of these problems are further discussed below.

4.2 LONG-TERM STABILITY

The tailings and contaminated rubble are not secure from physical removal off the site under present conditions. Although the site is fenced, portions of the fence along the access road to the sewage treatment plant are not secure. The site area is large and cannot be patrolled to prevent human access. Over one-hundred vicinity properties exist in the area which is evidence of the past removal of the material. The contaminated material at or near the surface is susceptible to natural erosive forces and transport because of the pile height and steep slopes. As maintained, the piles are located adjacent to Vitro Ditch, Mill Creek, and South Vitro Ditch. Data indicate the tailings have eroded into the waterways and have blown to surrounding properties. The sewage treatment plant is presently undergoing a major expansion. Their expansion from 40 acres to 100 acres is onto the tailings areas. The construction activities release the tailings to the air and nearby waterways.

4.3 RADIATION

Radon emissions from the tailings exceed the EPA standard of 20 pCi/m^2sec by nearly 30 times and the measured average concentration at the site boundary exceeds the alternative EPA standard of 0.5 pCi/l. Workers at the CVWRF treatment plant, the industrial complex on 900 West Street, as well as nearby residents are subjected to radon levels slightly higher than background. The radiation standards for buildings and open lands are exceeded in approximately 100 vicinity properties and 55 acres of windblown tailings around the site.

4.4 WATER QUALITY

The ground-water table lies close to the Vitro tailings-foundation soils interface and rises into the lower portion of the tailings during periods of high water. Contaminants associated with the tailings have moved into the shallow water table which flows toward the Jordan River. The City of South Salt Lake has plans to increase their withdrawal from the lower aquifer in the area of the Vitro site. The decrease of the artesian pressure could create a condition where the upper aquifer water is drawn into the lower aquifer.

The contaminant plume will exist after the tailings have been relocated to South Clive. The plume will move toward the Jordan River at a velocity of between 0.3 to 1.6 feet per day, so that the tail of the plume would reach the river between 4 to 24 years. The contaminants will have no effect on the river because of the great dilution. A cost-benefit study was performed and the results indicated that aquifer restoration would not be economical (Appendix B, Section 13.0).

4.5 ALTERNATIVES CONSIDERED

4.5.1 Remedial action concept

The process for the selection of the South Clive disposal site included the consideration of several other remedial action concepts including stabilization in place (SIP); relocation to other alternate sites including North Clive, Delle, and Knolls; and reprocessing the tailings for mineral recovery as an integral activity of the stabilization. Detailed discussions of the alternatives are incorporated into the Environmental Impact Statement (EIS) prepared for this project. The stabilization-in-place design alternatives that were considered included liner and no-liner options, several alternate configurations such as an embankment on both sides of the Vitro Ditch or on both sides of the CVWRF access road, and alternate geometrical shapes for a single embankment. Consideration was given to maintaining the 42" sewer line in-place, minimizing the land area to be used and accommodating the expansion plans for the CVWRF. Because of the unique circumstances at the Vitro site, the preferred alternative is to relocate the contaminated material to the South Clive site (DOE, 1984b). The unique circumstances included the population density near the Vitro site, the conflict with space for the treatment plant and commercial development, the risk of seismic events, and the ground-water regime.

Among the alternate disposal sites, the South Clive site was selected because of its remoteness, availability, geological suitability, distance away from and above the Great Salt Lake (20 miles and 25 feet above the present elevation) and proximity to the railroad and I-80.

Another aspect of the project which was addressed in order to comply with PL95-604 is the economic and technical feasibility of

reprocessing the tailings for the recovery of residual uranium and vanadium. Mountain States Research and Development (MSRD) was contracted in 1981 to perform an economic evaluation of reprocessing the Salt Lake City tailings. They conducted a drilling and sampling program to determine the amount of recoverable uranium, vanadium, and molybdenum. Laboratory leaching tests were conducted on the samples to estimate extractability and the process to be applied. The evaluation compared the recoverable value of the metals versus the capital and operating costs for processing, excavating, transporting, and final disposal. The results of the study indicated that reprocessing is not economical at present day or foreseeable future prices for the metals (MSRD, 1982).

4.5.2 Design concepts

Upon selection of the preferred alternative, relocation to the South Clive site, extensive engineering evaluations were involved in the development of this conceptual design. Major areas of alternative evaluation were in transportation and handling, configuration, dewatering, and ground-water protection.

Below grade disposal at South Clive was evaluated and determined to be unfeasible due to: 1) the objective of maintaining at least 15 feet between the water table and the tailings; and 2) the excessive amounts of spoil that would result since only 7 or 8 feet of excavation would be needed to provide sufficient material for the radon barrier. Additionally, alternate configurations were evaluated ranging from a pile designed to have the minimum surface area, which was rejected due to height (over 100 feet) and difficulty of construction, to a square pile. The final configuration as presented in Section 5.0 represents a selection that is designed for efficient construction while achieving partial below grade disposal.

Transportation alternatives that were considered for moving the tailings from the Vitro site to the South Clive site include trains, truck, slurry pipelines (water and CO_2) and conveyors. Conveyors were quickly rejected for the total move due to high capital and operating costs and concern about dust control but were considered further for either loading and unloading and spreading the tailings. Slurry pipelines were rejected due to the potential tailings dewatering problems (water), lack of data about slurrying tailings (CO_2), capital cost, and right-of-way concerns. Trains and trucks were both evaluated in detail as is discussed in Section 5.0.

Loading and unloading alternatives evaluated included mobile conveyors, fixed conveyors, roto-dumpers and others. The final selection was based upon cost, capacity, and environmental impacts. Additionally, both wellpoints and intercept trenches were considered for dewatering the Vitro site. Intercept trenches were selected based upon previous successful application in the area.

Alternatives for ground-water protection were considered at both the Vitro and South Clive sites. At South Clive, the need for a liner was evaluated based on the quality of the ground-water and the projected infiltration. The resulting requirements at South Clive will be an engineered base which will be scarified and compacted. More detailed discussions are presented in Section 5.0 and Section 10.0 of Appendix B. At Vitro, an extensive evaluation of aquifer restoration was carried out including an evaluation of alternate methods such as interception trenches, and drawdown and recharge wells. The detailed analysis, which is summarized in Appendix B, Section 13.0, indicat that natural purging would be less expensive than any availabl restoration method and that active measures would not be econom ly viable.

5.0 SITE CONCEPTUAL DESIGN

5.1 INTRODUCTION

This section provides the maps, drawings, and other information necessary to understand the proposed concept design for relocation of Salt Lake City, Utah tailings to a disposal site at Clive, Utah. The Site Conceptual Design is intended to provide sufficient detail for the reader to evaluate the feasibility and effectiveness of the basic design concepts which have been proposed. These concepts will provide a basis for the schedule and cost estimate to be used in obtaining concurrences and funding at Federal and state levels.

The Site Conceptual Design (SCD) demonstrates a concept that meets the requirements of PL95-604. Although the final design may vary to a limited extent from the present concept, the basic concept presented in this document represents the proposed completed remedial action. Some elements of the design have not been fully developed and are intended for completion during the detailed design.

5.2 SUMMARY OF PROPOSED REMEDIAL ACTION

The proposed remedial action calls for 2.45 million cubic yards of tailings and contaminated material to be transported for ultimate disposal at the South Clive site. Train and truck modes are the two transportation alternatives which are discussed in detail in the EIS (DOE, 1984b). The SCD is based on the train transportation mode because the design features are more complex. If the truck option were selected, the construction items related to the train system could be dropped. The cost estimate is discussed later in this section; however, the preliminary costs are approximately equal for the two transportation modes. The transportation mode will be proposed by the bidder when the bids are submitted. The approval of the transportation mode will be given upon plan submittal by the contractor.

The tailings and other contaminated materials will be placed in an embankment constructed largely above grade. Materials for the radon barrier will be excavated from the embankment area, the contaminated material placed and compacted, and an earthen cover placed to control the release of radon and to inhibit water infiltration. The embankment will then be capped with rock to counter the erosional effects of wind and water, to impede inadvertent disturbance by man or animal, and to minimize plant root intrusion. The plot plan for the South Clive area is shown in Figure 5.1.

For the transport by train option, tailings will be transported by 54-car unit trains, unloaded using a roto-dumper, and stockpiled by a radial stacker. The tailings will be removed from the stockpiles created by the radial stacker with dozers and scrapers, transported to the excavation, spread, and compacted. For the transport by truck option, trucks will drive directly from the Vitro site into the excavation and spread their load for compaction.

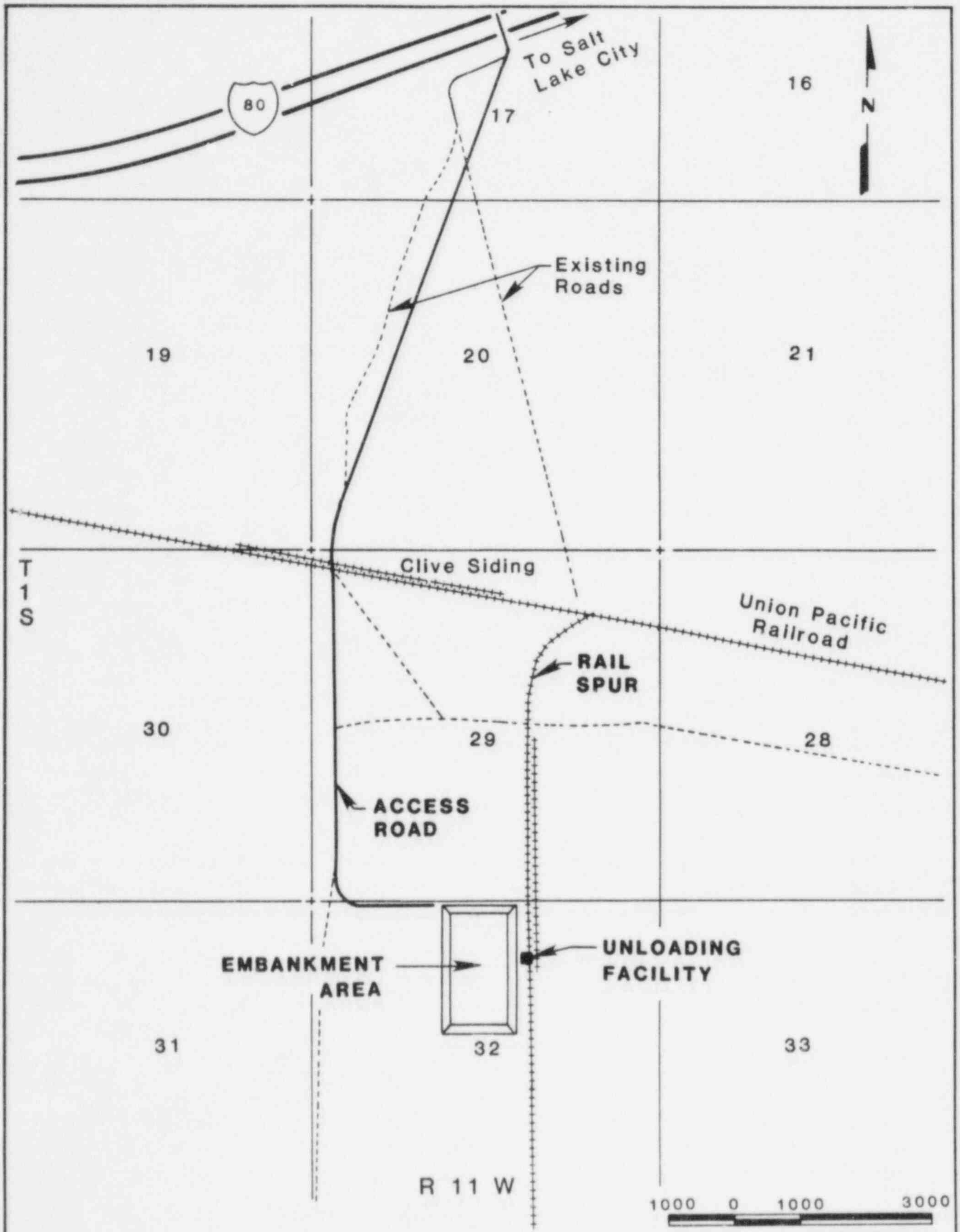

FIGURE 5.1
PLOT PLAN FOR SOUTH CLIVE

All excavated areas at the Vitro site will be backfilled to the natural ground level, as appropriate, and graded to promote drainage. Backfill and restoration material will be purchased from a source approximately 10 miles west of the Vitro site. The site will be released for uses restricted only by the local zoning ordinances. Figure 5.2 is a presentation of the final condition of the Vitro site. The proposed remedial action design is discussed in detail in the following sections.

5.3 DESIGN OBJECTIVES

The principal objective of this remedial action concept is to design control measures which meet EPA standards. These standards include specific limitations on the release of radon, along with limitations on the release of radiation from radium and radon daughter products. There is also the requirement for long-term stabilization, designed with controls effective for up to 1000 years but for at least 200 years. Applicable requirements of the State of Utah Department of Health and other agencies will be adhered to during construction. These requirements are included in Appendix A.

The purpose of remedial action and the formation of standards for this effort is the protection of the local environment. The public must be protected both during and after remedial action from unsafe levels of radiation. The quality of adjacent surface water and ground water must not be adversely affected by discharges from the site. The remedial action must provide assurance of long-term stabilization of the site through erosion control and flood protection. Inconveniences and increased hazards to the local public must be minimized by considering working schedules and construction vehicle routes. The sites will be fenced during construction and the South Clive site will be permanently fenced after construction to prevent inadvertent public access and will have custodial maintenance and surveillance to assure continued long-term compliance with EPA standards.

The following major design objectives have been established:

- o Relocate the contaminated material to the South Clive site which is in a less populated and more environmentally stable location.
- o Reduce the average radon flux from the tailings to levels less than 20 picocuries per square meter per second (annual average).
- o Design controls to be effective for up to 1000 years with minimum maintenance.
- o Prevent inadvertent human intrusion.
- o Ensure that existing or anticipated beneficial uses of ground and surface water are not adversely affected by the stabilized tailings.
- o Reduce contaminant levels at and around the Vitro site to levels which do not exceed 5 picocuries of Ra-226 per gram above back-

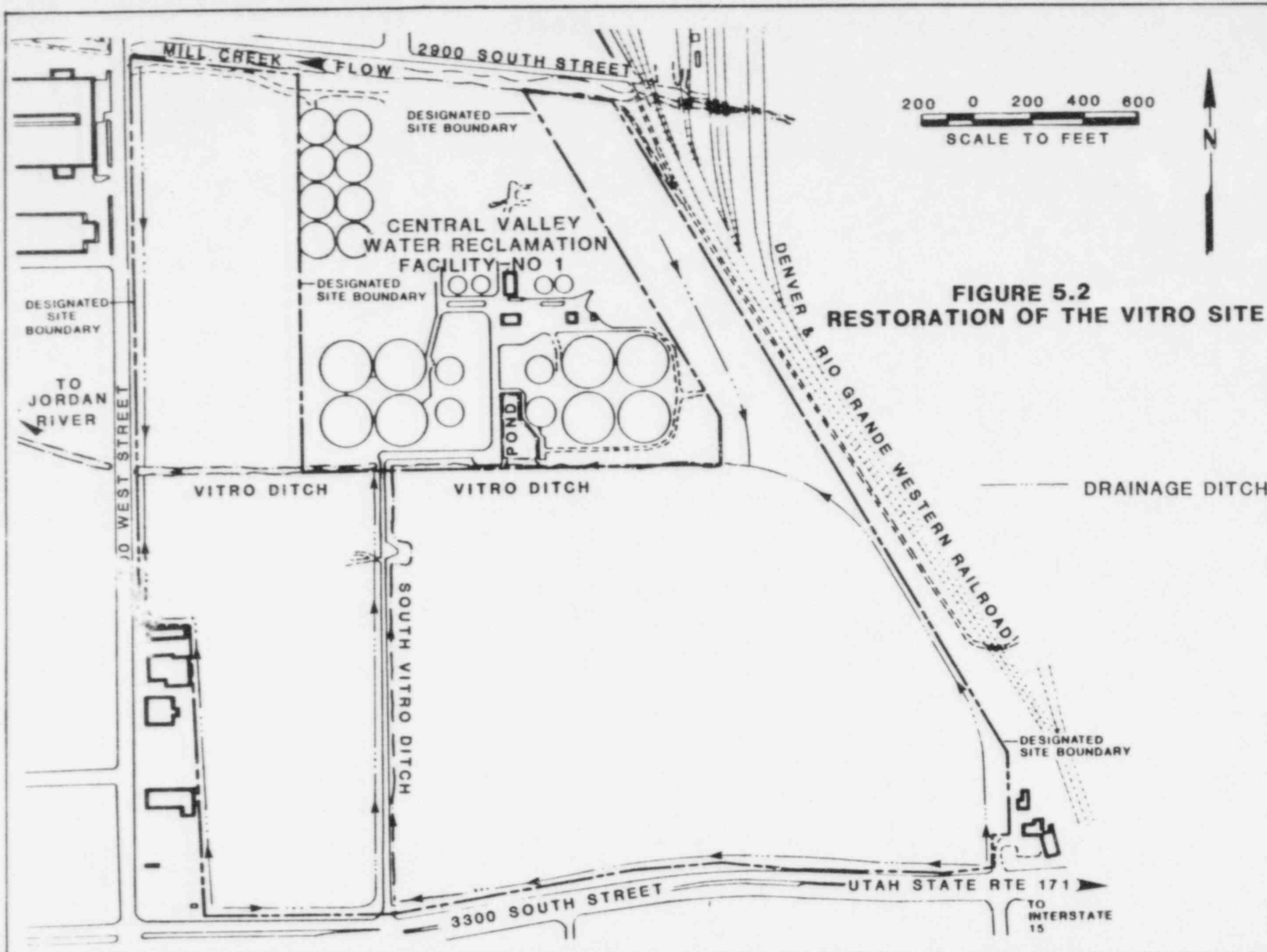

FIGURE 5.2
RESTORATION OF THE VITRO SITE

ground in the top 15 centimeters (cm) of soil and do not exceed 15 picocuries per gram in any 15-cm layer below that depth.

- o Protect against releases of contaminants from the site during construction.
- o Provide runoff and sediment control.
- o Minimize areas disturbed during construction and minimize exposure to contaminated materials.
- o Release the entire Vitro site for unrestricted use by private and public entities.

5.4 DESIGN FEATURES

The remedial action will stabilize the uranium mill tailings and contaminated material at the South Clive site in a manner which complies with EPA standards. The conceptual design establishes the starting point for remedial action. Detailed engineering design plans and construction specifications will be subsequently prepared to provide the basis for final cost estimates and for the award and execution of construction contracts. The permanent and temporary construction design features, respectively, including the rationale for the results of the design are discussed in this section. The calculations summaries, Appendix B, provide detailed support for the design rationale.

The principal feature of the design concept is the movement of contaminated materials approximately 85 miles from the Vitro site in South Salt Lake and consolidation of the tailings and contaminated soils into a contoured embankment at South Clive. The transportation mode will not be selected until the construction bid packages are opened; therefore, the major construction activities for the proposed action are listed separately below for the train and truck transportation modes.

Train Transportation

- o Preparation of both sites, and construction of waste-water sedimentation basins to protect against release of contaminants. Security fencing would be installed at the Vitro site.
- o Construction of drainage control measures to direct generated waste-water and storm-water runoff to the waste-water sedimentation basins during construction activities.
- o Installation of measures to control erosion and sediment transport from disturbed areas during construction.
- o Installation and operation of a waste-water treatment facility at the Vitro site to protect against inadvertent contaminant release during construction.
- o Protection of surface and subsurface utilities at the Vitro site during construction.

- o Construction of a railroad loadout spur on the Vitro site.
- o Construction of a railroad spur and offloading facility at the South Clive site.
- o Upgrading of the existing frontage road from the Aragonite exit of I-80 to the Clive overpass and construction of an improved access road from the I-80 overpass to the disposal site.
- o Demolition and disposal of structures and rubble from the Vitro site.
- o Excavation and loading of tailings and other contaminated material into train cars.
- o Institution of measures to limit the release of contaminated materials during transportation.
- o Excavation and construction of the embankment at the South Clive site.
- o Relocation of the tailings from the offloading facility to the embankment.
- o Construction of the cover system over the tailings to inhibit water infiltration and radon exhalation.
- o Emplacement of erosion protection on the embankment.
- o Installation of a permanent fence around the disposal site.
- o Demolition and disposal of railroad spurs at both sites.
- o Restoration of the excavated areas at the Vitro site with backfill and vegetation.

Truck Transportation

- o Preparation of both sites, and construction of waste-water sedimentation basins to protect against release of contaminants. Security fencing would be installed at the Vitro site.
- o Construction of drainage control measures to direct generated waste-water and storm-water runoff to the sedimentation basins during construction activities.
- o Installation of measures to control erosion and sedimentation from disturbed areas during construction.
- o Installation and operation of a waste-water treatment facility at the Vitro site to protect against inadvertent contaminant release during construction.

- Protection of surface and subsurface utilities at the Vitro site during construction.

- Upgrading of the existing frontage road from the Aragonite exit of I-80 to the Clive overpass and construction of an access road from the I-80 overpass to the disposal site.

- Demolition and disposal of structures and rubble.

- Excavation and loading of tailings and other contaminated material into trucks.

- Institution of measures to limit the release of contaminated materials during transportation.

- Excavation and construction of the embankment at the South Clive site.

- Construction of the final cover system over the tailings to inhibit water infiltration and radon exhalation.

- Emplacement of erosion protection on the embankment.

- Installation of a permanent fence around the disposal site.

- Restoration of the excavated areas at the Vitro site with backfill and vegetation.

5.5 PERMANENT DESIGN FEATURES

5.5.1 Layout

The completed South Clive site embankment will be surrounded by drainage ditches and an access road, situated on the edge of the Great Salt Lake Desert (Figure 3.3) and covering approximately 60 acres. The completed site will be approximately 65 miles in a straight-line distance due west of Salt Lake City. The northern boundary of the site area is approximately 1 mile south of the Clive railroad siding of the Union Pacific System and approximately 2.5 miles to the south of U.S. Interstate 80.

5.5.2 Decontamination and restoration

Material excavated from the Vitro site, the windblown areas, adjacent ditches, and vicinity properties will be combined in the embankment at the South Clive site. The contaminated rubble remaining in the mill area will also be added to the embankment. The contaminated materials to be consolidated in the embankment are discussed in greater detail in Appendix B, Section 1.0, Earthwork Volumes, and Section 3.0, Limits of Contamination.

Areas of excavation at the Vitro site will be restored with uncontaminated fill, as required, to meet the natural grade plus

additional material to establish a slope for proper drainage around the site. The sediment from Mill Creek and the Vitro ditches will be sampled to determine if the contamination has been removed.

5.5.3 Embankment construction

Approximately 2,450,000 cubic yards of tailings and other contaminated materials will be relocated to the South Clive embankment which is designed to provide long-term stability as well as maximize radon control.

The relocated tailings will be placed in lifts and compacted. Because the tailings will be mixed during excavation and again during the unloading, spreading, and compacting at the South Clive site, the pockets of slimes in the existing tailings will be eliminated. Further, any saturated tailings will be dewatered during excavation and will tend to dry out to a lower moisture content during handling. Consequently, differential and total settlement will not affect the long-term integrity of the embankment.

Organic materials such as wood, sewage sludge, demolition debris and grubbed vegetation from the Vitro site will be evenly distributed throughout the lower lifts of tailings placement, and represent less than 5 percent of the total volume of the lift. Rubble pieces will be placed in the lower portions of the embankment and surrounded with compacted tailings. The specifications for this activity will be written to stress the proper procedures to ensure the material is placed to avoid concentration in any area and to ensure good compaction of soil material around the rubble. Details concerning embankment construction concepts including site preparation and compaction criteria are presented in the Site Design Criteria and Appendix B.

Limiting the embankment slopes to 1 vertical to 5 horizontal will provide the embankment with a factor of safety greater than 3.0 against slope failure and will reduce the potential effects of erosion. A typical section of the embankment is presented in Figure 5.3 (see Appendix B, Section 11.0, Slope Stability and Liquefaction Potential, and Section 6.0, Erosion Protection Design.)

5.5.4 Cover construction

The radon exhalation rate from the embankment will be reduced to EPA standards by a compacted soil cover. This cover or radon barrier will be protected by a 2-foot layer of rock which is designed to protect the soil cover for a 1000-year design period and thus prevent exposure of contaminated materials.

A compacted silty clay layer, approximately 7 feet thick, will serve as a radon barrier. The compaction of the silty clay will produce a soil barrier that retains moisture and retards ra-

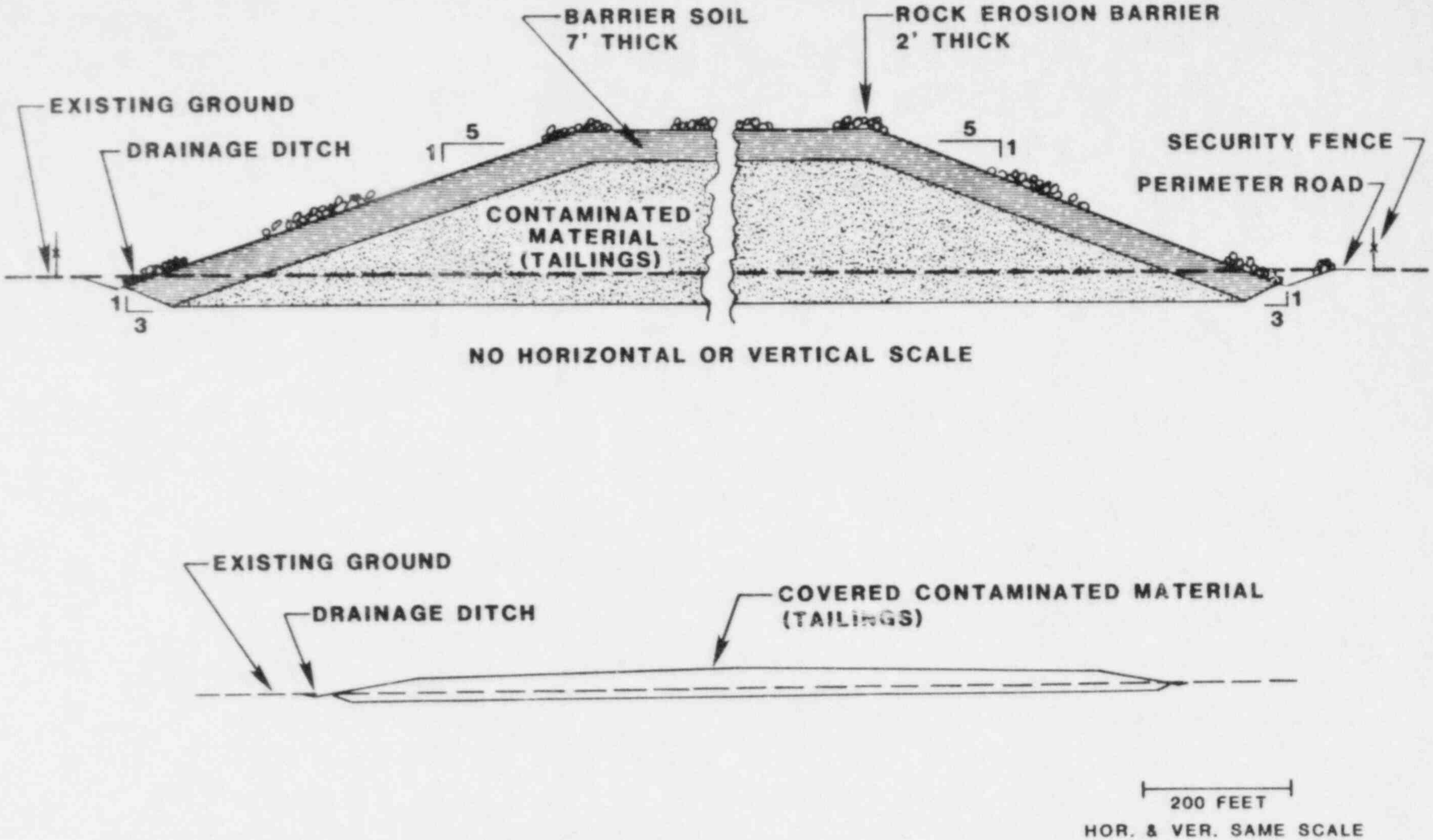

FIGURE 5.3

TYPICAL SECTION OF THE EMBANKMENT SOUTH CLIVE SITE

don gas diffusion. The rock cover will reduce the potential for drying of the compacted silty clay. Compaction techniques and radon retardation properties of the cover materials are discussed in more detail in Appendix B, Section 1.0, Earthwork Volumes, and Section 4.0, Radon Barrier Thickness.

The rock layer is designed to resist erosion and gully formation during any rainstorms that can logically be expected to occur in the next 1000 years. It protects the silty clay radon barrier and prevents it from being eroded away. The rock layer 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 most severe combination of meteorological conditions that are reasonably possible in a region. For the Clive area, the one-hour PMP is 6 inches (Hansen et al., 1977). A rainfall intensity of 30 inches per hour for a period of five minutes was used for design of the rock erosion barrier (NRC, 1983). A minimum of a 2-foot-thick layer of at least 1.5-inch mean diameter rock on the 2 percent top slopes, and a 2-foot-thick layer of at least 4.5-inch mean diameter rock on the 20 percent side slopes will protect the embankment from the results of a PMP (See Appendix B, Section 6.0, Erosion Protection). The rock layer will also protect the embankment from wind erosion.

Plant root intrusion and burrowing animals will be discouraged by the rock cover.

5.5.5 Site drainage

The drainage of the South Clive embankment area, along with general site grading, will ensure long-term tailings stability. Drainage ditches around the base of the embankment will intercept runoff from the embankment and direct the flow into the natural drainage patterns west of the site. The ditches will have triangular cross sections with side slopes of 1 vertical to 5 horizontal. The ditches will have gentle slopes and depths great enough to carry the runoff from the 100-year, 1-hour storm event. Rock erosion protection in the ditches will prevent damage to the embankment cover and contaminant exposure. To prevent the formation of gullies that could head cut into the embankment, outer slopes of the access road adjacent to the embankment will be covered with rock erosion protection. (See Appendix B, Section 5.0, Site Drainage, and Section 6.0, Erosion Protection Design.)

5.5.6 Ground-water protection

The existing ground water at the South Clive site is of extremely poor quality. The total dissolved solids in 13 samples range from 20,000 mg/l to 50,000 mg/l. The final embankment cover system will be much less permeable than the present ground due to compaction during construction. This, coupled with low average annual precipitation of 5 inches, will result in insignificant rates to no infiltration into the tailings, and thus no driving

force for leachate migration. In the unlikely event that leachates were to reach the water table, calculations in Appendix B, Section 10.0, show that they would not affect a water supply in less than 1000 years.

Additionally, the bottom of the tailings embankment will be at least 15 feet above the water table which will reduce the potential for leaching of soluble contaminants and subsequent migration via either ground-water intrusion or capillary action. The clay fraction of the underlying soils will tend to absorb by cation exchange many of the contaminants that do leach. The underlying soil layer will be scarified and compacted in place.

5.5.7 Flood protection

Flooding at the South Clive site could result from precipitation on the Cedar Mountains east of the site. There are no bodies of water in the area. The Probable Maximum Flood (PMF) peak flow past the embankment resulting from a 6-hour PMP of 9.7 inches over the 46-square-mile drainage area was calculated to be 83,000 cfs as shown in Section 12.0 of Appendix B. The peak flood depths of the PMF were calculated to be approximately 5.5 feet adjacent to the embankment. The peak velocity of the overland flow will be approximately 3 feet per second and the peak velocity at the toe of the embankment slope will be approximately 10 feet per second.

Riprap design methods as summarized in Appendix B, Section 12.0, were then used to determine that the 2-foot-thick pit run rock layer with a 4.5-inch mean diameter in the ditches adjacent to the embankment, in conjunction with the erosion protection layer on the embankment (as discussed in Section 5.5.4), will provide protection from the flood waters of the PMF.

5.5.8 Site access

After remedial action is complete, permanent fencing with signs will be placed around the entire site. The access gate will be located at the northwest corner. A 20-foot-wide road will circle the embankment, inside the fence, allowing access to all of the embankment for custodial inspection purposes.

5.6 CONSTRUCTION FEATURES

5.6.1 Layout

Construction activities will be performed in an area that includes the site and adjacent areas as shown on Drawings .0003 and .0004 in Appendix B.

At the Vitro site, the construction staging area will be on the east side of 900 West Street just south of the interceptor easement. An equipment decontamination pad will be located adja-

cent to the staging area. Drainage ditches will surround the tailings piles and discharge to four waste-water retention basins constructed on the site as shown in Drawing .0005. A construction fence will enclose the staging area and the areas to be excavated on the site.

At the South Clive site, the staging area will be located next to the northeast corner of the embankment for the railroad option but it will be shifted to the northwest corner for the truck option. The decontamination pad will be adjacent to the staging area. Construction fences will enclose the entire embankment area and staging area.

5.6.2 Site access

Equipment will be decontaminated prior to leaving the Vitro site and the embankment area at South Clive. The construction fences will provide control of traffic entering and leaving the site and prevent unauthorized traffic from entering the area.

5.6.3 Staging area facilities

During construction operations, temporary facilities will be required for construction workers along with supervisory, engineering, administrative, security, and radiation monitoring personnel. The facilities will consist of office space, showers and change facilities for all personnel working on the site, and include provisions for laundering contaminated clothing. Portable construction toilets will be provided for on-site workers. On-site equipment will be stored in the staging areas.

5.6.4 Utilities

Since the Vitro site will be decontaminated and released for unrestricted use, the existing 42-inch sewer line and all other surface and underground utilities will be protected in place during construction or temporarily removed and replaced in kind. All affected utility companies must be contacted before work begins to discuss the activities and avoid project delays. All known existing utilities are located and identified in Figure 5.4.

Potable water for personnel needs is available from an 8-inch water line that runs along 900 West Street. This water supply is adequate to supply showers, laundry, vehicle wash, and drinking water. Water from the site dewatering and the waste-water retention basins will be used for dust suppression in contaminated areas and supplemented from the existing supply line as needed.

No electricity, gas, or other utilities are available at the South Clive disposal site. Electricity will be supplied by portable generators. Telephone service will be by radio telephone.

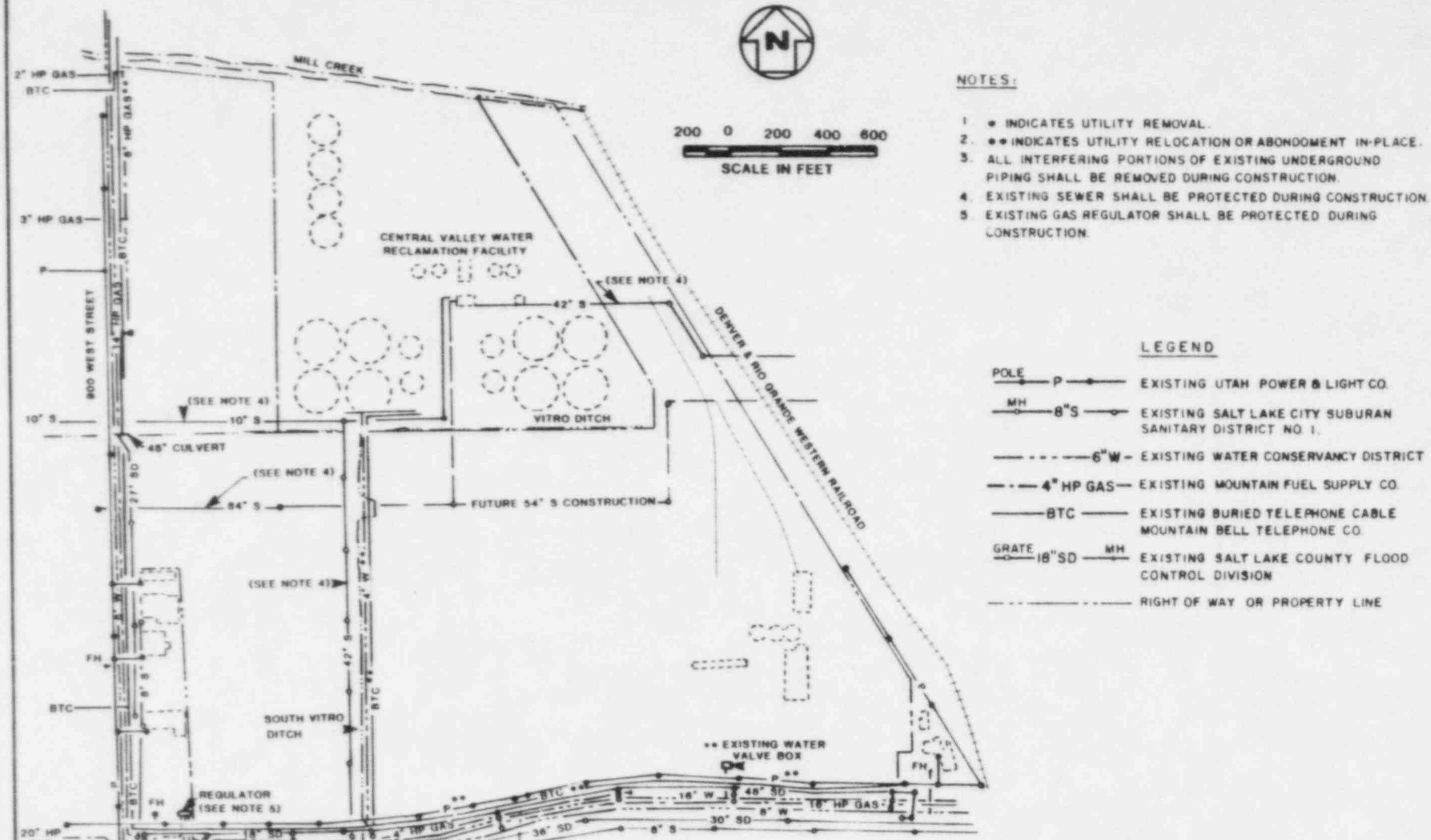

FIGURE 5.4
EXISTING UTILITY LOCATION PLAN FOR THE SALT LAKE CITY SITE

There is no developed water supply at the disposal site. Brackish water, adequate for equipment decontamination, compaction, and dust control on the site will be developed from an onsite well. A holding pond will be constructed for storage of developed water. Potable water will be hauled from the nearest source.

5.6.5 Drainage, erosion control, and waste-water retention basin

During remedial action, all drainage from both the Vitro and South Clive sites will be effectively blocked from reaching any waterways. Areas disturbed by construction activities will be graded so that runoff will drain to waste-water retention basins. Drainage ditches will be lined with erosion resistant materials. In addition, the ditches will be designed and maintained to carry the runoff from the 10-year 1-hour storm event for the area tributary to the channel. Runoff from land outside of affected areas will be diverted away from the site. Diversions will be designed and maintained to prevent run-on to unreclaimed areas from the 10-year 1-hour storm event (See Appendix B, Section 5.0, Site Drainage).

The waste-water retention basins will receive waters resulting from:

- o Decontamination activities including equipment washing, truck, or train washdown.
- o Runoff from contaminated materials.
- o Laundry waste from washing protective clothing.
- o Shower and wash basin waste water.
- o Dewatering at the Vitro site.

The retention basins at both the Vitro and South Clive sites are designed to retain the runoff from a 10-year 24-hour storm as well as the excess wash water from the decontamination operations. The equipment, truck, and rail washdown facilities will have separate holding basins or tanks from which the wash water will be recirculated. Excess wash water will be pumped to the waste-water retention basins for treatment. Additionally, the basins have sufficient capacity to hold all sediment inflow over the life of the project. The emergency outlets from the basins at both sites are designed to safely discharge the 25-year storm peak runoff while maintaining at least 1 foot of freeboard in the basins.

At Vitro, there will be four basins, as shown in Drawing .0004, Appendix B, with a total capacity of 11 acre-feet. At South Clive, there will be one basin with a volume of 4.0 acre-feet, as shown in Drawing .0005, Appendix B. Section 7.0 of Appendix B provides more design details for these basins.

5.6.6 Waste-water treatment

Waste water will be generated from the following sources:

- o Ground water collected from excavation dewatering.
- o Storm-water runoff.
- o Decontamination water from equipment washdown.
- o Laundry waste from washing protective clothing.
- o Shower and wash basin waste water.

Waste water from these sources will flow to the waste-water retention basin which will provide primary settling, and flow and contaminant equalization. Some of this flow will be utilized for road and pile wetdown for dust and radon control on contaminated areas. The remainder must be treated to acceptable limits and discharged to Vitro Ditch. Assumed NPDES discharge limitations are as follows:

Total radium - 10 pCi/l
Gross alpha - 30 pCi/l
Suspended solids - 20 mg/l

The principal dry-weather flow at the site will be the ground water from the excavation. This flow may be as high as 300 gpm. An additional treatment capacity of 200 gpm will adequately treat any storm-water runoff within a reasonable period of time. The flow from other sources will be insignificant, totaling only a few thousand gallons per day; therefore, the total treatment capacity will be 500 gpm.

Unit processes which have been selected for treatment of the settled and equalized flow include:

- o Multi-media filtration for removal of suspended solids.
- o Uranium- and radium-selective ion exchange for control of radium and gross alpha.

Suspended solids which are captured by the filter and later backwashed will be piped to a seepage basin or placed in an excavation for solids containment. Solutions from resin regeneration and the ultimate spent resins will be buried at the South Clive site for contaminant containment. Neutralizing chemicals (e.g., NaOH or H_2SO_4) and flocculent aids (e.g., polymer) may be mixed with the sedimentation basin inflow, if necessary, for pH and solids control.

The performance specifications for the treatment unit will be detailed by the State of Utah for construction by an experienced manufacturer. The system will include automatic controls for minimal operator attention and be weather proof, requiring no enclosure. After completion of the remedial action, the treatment system will be decontaminated and salvaged or buried at the South Clive site.

5.6.7 Dewatering

Ground water at the Vitro site is near the surface and at times rises into the tailings. To facilitate handling, the tailings will require dewatering.

If needed, dewatering will be accomplished in layers by plowing or trenching to let the material drain, pumping or draining the water into the waste-water retention basins, excavating the dewatered material until a new level is reached which is too wet for handling, and repeating the process. Other options such as well points could be utilized if proved to be more cost-effective.

5.6.8 Equipment decontamination pad

Decontamination pads with holding ponds or underground tanks and recirculating pumps will be provided to wash contaminated equipment, trucks, or trains at both the Vitro and South Clive sites, thereby preventing contaminated materials from being carried out of the areas.

5.6.9 Dust control

Dust generated by excavation, earth movement, vehicle use, temporary materials stockpiling, and similar activities will be controlled and minimized by the use of a water-based surfactant sprayed from trucks or hoses. Special care will be taken to control dust created during demolition and the temporary stockpiling or mixing of contaminated materials.

The sources for dust suppression water at the Vitro site will be recycled water from the waste-water retention basins, for use on contaminated areas or potable water for use on clean areas.

At Clive, water for dust suppression will be pumped from the retention basin for use in the embankment or the ground water, for use on clean areas.

The schedules for spraying the roads and pile areas will vary daily and will be determined on an hour-by-hour basis. The frequency of spraying will increase as combinations of low soil moisture and high wind speed conditions are encountered. Extreme conditions may require the reduction or stoppage of work.

To prevent windblown contamination during transport, railcars or trucks would be covered with a tarpaulin or canopy, or with a spray latex seal. The trucks would be 35-ton capacity trucks and trailers fitted with door seals to prevent leakage.

5.6.10 Railroad construction

Transport of the tailings and other contaminated material to the South Clive site by railroad requires the construction of approximately 3800 feet of railroad spur on the Vitro site. The spur will originate at an existing spur at the Roper rail yard, follow the existing railbed to the mill site, turn about 120° and angle through the site (Drawing .0004, Appendix B).

To prepare for the railroad bed, tailings and any contaminated subbase will be removed from the railroad route and stockpiled. Since it is proposed to load the cars directly with a front-end loader, the railroad route through the tailings will be excavated to a width sufficient for the railroad plus a working area for loading from both sides of the train.

A second spur approximately 9200 feet long will be constructed from a point just east of the existing Clive siding, and run south across the desert to the disposal site. Subbase will be excavated from along the right-of-way, and the surface will be scarified and recompacted. At the site, a roto-dumper will be installed and about 3400 feet of runaround track laid to allow unit trains to be switched out.

There is one area requiring special design consideration for the Salt Lake City remedial action. If the railroad option is selected, then it will be necessary to develop the design in accordance with railroad construction specifications. Compliance with the requirements of the American Railroad Engineers Association (AREA), Denver and Rio Grande Western Railroad (D&RGW), and the Union Pacific Railroad (UPRR) specifications is essential. This is an additional criteria to those outlined in the Project Site Design Criteria Report (DOE/AL-049) (DOE, 1984c).

5.6.11 Borrow area

A local borrow area for approximately 1,040,000 cubic yards of restoration material has been identified within about 10 miles of the Vitro site. It is located along 5400 South in the southwest Salt Lake County area and is privately owned. An existing borrow area about 5 road miles north of the South Clive site will be used to provide approximately 202,000 cubic yards of rock erosion barrier. The radon barrier soil will be obtained from the embankment excavation area.

5.6.12 Construction sequence

The following construction sequence is proposed for the remedial action.

Initially, a site security system will be set up at both the Vitro and South Clive sites and coordinated with staging and vehicle decontamination areas. This will provide control of traffic entering and leaving the site, and prevent unauthorized traffic from entering the area.

The next major item of site preparation will consist of construction of the waste-water retention basins. Materials excavated from the basin area at Vitro will be stockpiled for later transportation to South Clive. The materials excavated from the basin area at South Clive, however, will be stockpiled for later use as cover. Site preparation also includes construction of drainage and erosion control measures, preliminary site dewatering, and installation of the waste-water treatment facility at the Vitro site.

While the site preparation activities are underway, the access road from I-80 and the railroad spur from the Union Pacific mainline can be constructed. These will be followed by construction of the railroad spur at Vitro and the off-loading facilities at the South Clive site.

Next, the disposal site will be partially excavated and the embankment constructed. Excavation and transport of the tailings and rubble will then begin using either rail or truck transportation. In the train option, tailings would be transported with one train per day. Two trains of 54, 100-ton capacity cars would be required. One would be loaded at the Vitro site daily while the other is being unloaded at the South Clive site. The loaded train would be covered, decontaminated, and hauled to the South Clive site in the evening. The locomotive engines would leave the loaded train at the South Clive site and return to the Vitro site with the unloaded train by morning.

Fifty of the railroad cars (per unit train) would be rotary-coupled gondola cars which would be water and sand tight. Large pieces of rubble or other contaminated material which cannot be handled by the offloading system at the South Clive site would be transported in four side-dump railcars fitted with door seals to prevent release of contaminated materials.

In the truck option, tailings and other contaminated materials would be hauled to the South Clive site by truck. The concept is based on hauling 5400 tons per day. Seventy-seven, 35-ton capacity trucks would be required. The trucks would make two round trips per day. They would be loaded, covered, and decontaminated at the Vitro site in the morning, driven to the South Clive site, unloaded and decontaminated, and returned to the Vitro site in the afternoon for a second load. Each round trip would take 4.5 to 5 hours.

Rubble will be dumped and pushed into the disposal site, and tailings will be off-loaded and stockpiled for transport and spreading by scrapers.

The embankment will be constructed in stages. Initially a portion of the total embankment area will be excavated and the material saved for future cover. The contaminated materials will be placed in this first part of the disposal area. This area will then be covered with the soil excavated from the next part of the site. The cover materials will be placed in lifts and compacted to the design thickness of 7 feet. The final stages of remedial action will involve overall site drainage grading; placement of rock cover over the embankment and in the drainage ditches; removal of the railroad spur; restoration and revegetation of disturbed areas at both sites; and construction of an access road and security fence around the embankment.

Demobilization will consist of the removal of the remaining waste-water retention basins and drainage ditches. The water will be treated and discharged while the bottom sludges and dikes will be transported to South Clive for burial. All decontamination areas will be removed and the equipment cleaned for salvage. The staging areas will be destroyed with the contaminated items either cleaned or buried. All contractor equipment must be decontaminated and inspected for project release.

5.7 DESIGN INSTRUCTIONS

This site conceptual design and the Project Site Design Criteria have been developed for use as a guide for the detailed design task. In no instance are they to be interpreted as precluding good engineering judgement and professionally-accepted procedures.

The conceptual design and these criteria were developed using the information available at the date of issue. The data and information available as of this date do not necessarily represent all of the data required for the Vitro and South Clive detailed designs. The design engineer is expected to examine the data provided relative to both sites and bring any questions to the attention of the UMTRA Project Office in a timely manner prior to the start of design.

The State will prepare specific design specifications for the items discussed in Section 5.5 and performance specifications for the items discussed in Section 5.6.

5.8 BASIS FOR EXCAVATION

A Radiological Support Plan (RSP) defines the monitoring surveys which will be required at the site during excavation of contaminated materials. A final survey will certify that applicable radiation standards are met following completion of construction. The State of Utah will prepare this plan and have the responsibility for implementing the program. The following subsections describe the purpose of the RSP.

5.8.1 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 standard. 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 documented.

5.8.2 Certification

During the remedial action operations, the State of Utah will make available to appropriate Federal agencies data related to the cleanup. In addition, samples may be split for analysis 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.

After remedial action, the DOE will certify that remedial action has been completed according to the plan and final design, and that the site meets applicable standards.

5.9 PROPOSED FINAL CONDITION

The completed embankment will be partially below grade, extending approximately 1100 feet by 2200 feet. The tailings will extend from approximately 9 feet below grade to approximately 26 feet above grade. Material excavated for partial below grade disposal will be used to construct the 7-foot-thick silty clay cover. The embankment will have maximum side slopes of 20 percent and 2 percent top slopes. The top and sides will be covered with a 2-foot-thick layer of pit run rock for erosion protection. The final covered embankment will be 35 feet above the surrounding terrain.

The rock erosion barrier will tie into an unpaved access road which will loop the bottom of the embankment. A security fence with warning signs will enclose the embankment and roadway. Permanent monuments will be established designating the embankment as Federal property. Drainage channels adjacent to the embankment will provide drainage and divert surface drainage around and away from the embankment.

The railroad spur and unloading facilities will be decontaminated and removed, or disposed of on the site, and the R.O.W. restored to its original condition. The unpaved access road from I-80 to the site will remain.

The excavated areas at the Vitro site will be restored with clean soil to the original approximate ground level, contoured for surface drainage, and revegetated. Final contours and the site drainage plan are shown in Drawing .0005 in Appendix B. The Vitro site will be available for uses permitted by local zoning ordinances.

Aquifer restoration of the relic plume downgradient of the Vitro site was assessed (DOE, 1984b). The assumptions and calculations are summarized in Appendix B, Section 13.0. The restoration does not seem warranted given the high cost-benefit ratio and the absence of ground-water use in the maximum area of the plume.

5.10 SCHEDULE

Remedial action at the Salt Lake City site is scheduled to begin in January, 1985. Figure 5.4 is a graphical representation of the detailed Salt Lake City Remedial Action Schedule.

The Environmental Impact Statement, Record of Decision, and State and NRC concurrence with this document are the remaining key items which affect this schedule and must occur as planned for the timely initiation of construction. It is estimated that construction activities will require approximately 36 months and will be completed in late 1987. Maintenance and surveillance will continue after construction.

The vicinity property remedial actions are scheduled to be completed in 1987; however, if there is a delay, space will be left in the embankment for the remaining contaminated material. As the remedial action construction nears completion, the site closure plan and vicinity property cleanup schedules can be coordinated.

5.11 COST ESTIMATE

A preliminary cost estimate has been prepared, based upon the conceptual design described in this Remedial Action Plan. The conceptual design was based on rail transportation because of the complexity. Both rail and truck costs are presented here with total processing site costs in Tables 5.1 and 5.2, and detailed remedial action costs in Tables 5.3 and 5.4. The vicinity property remedial action costs are in addition to the processing site costs.

The State of Utah continues to differ with the cost estimates shown in this plan. The State's concurrence in this plan in no way reflects their concurrence with the actual numbers shown in the cost estimate tables. The matter of allowable costs has been discussed in detail in the cooperative agreement. For the purpose of calculating the DOE/State shared costs, it was mutually agreed to estimate the stabilization in place cost at $42,000,000 in March, 1984 dollars. The costs shown in this plan are estimates prepared by DOE for relocating the uranium mill tailings and stabilizing them at Clive, Utah.

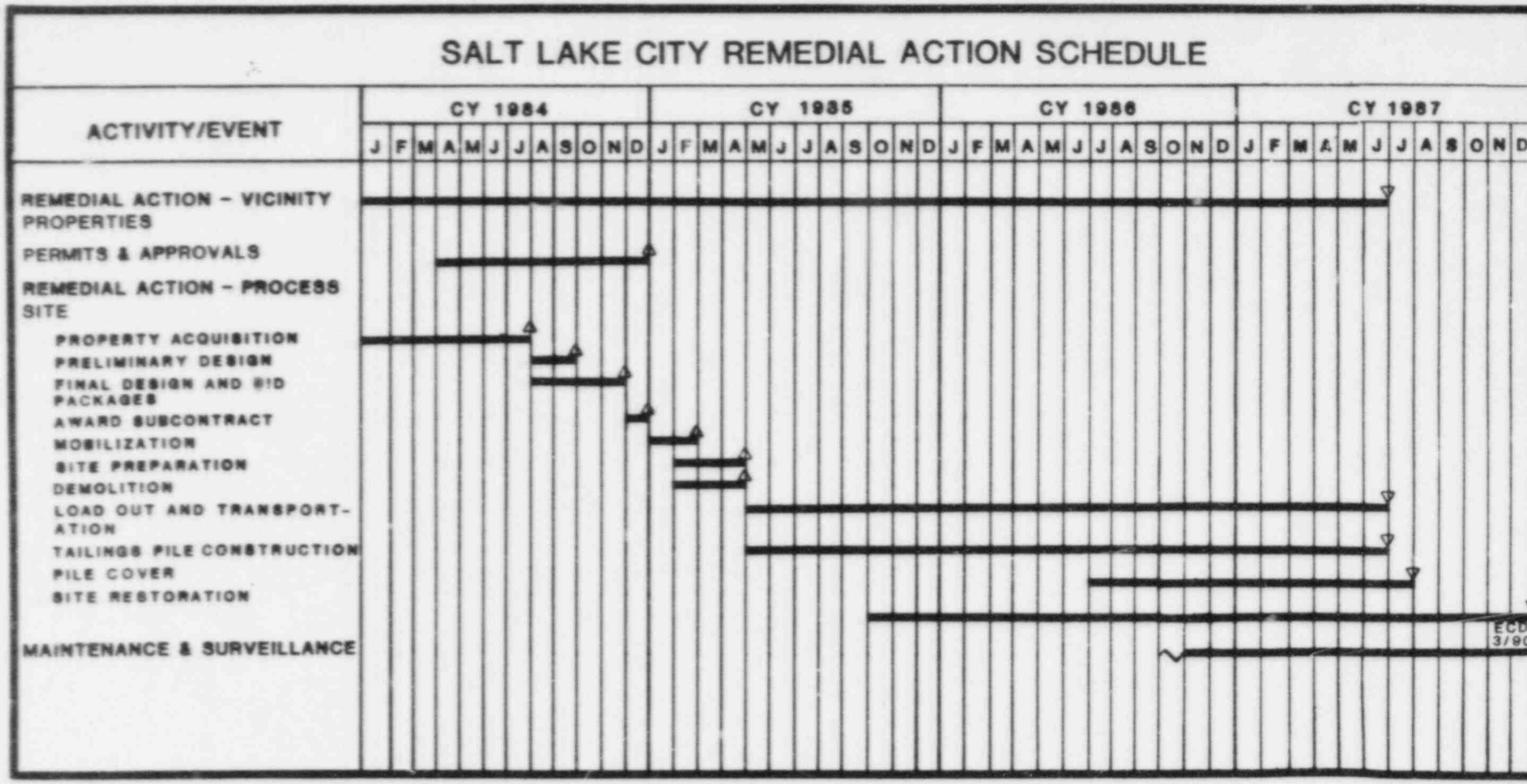

FIGURE 5.5 REMEDIAL ACTION SCHEDULE SALT LAKE CITY

Table 5.1 Site cost estimate summary (1984 - $000) - train transportation

Item		Costs
Site Acquisition		
Mineral value	0	
Land value	80	
TOTAL SITE ACQUISITION		$ 80
Remedial Action (RA)		
Work at Salt Lake City		
Site preparation	2,520	
Decontamination	330	
Site relocation	33,400	
Site restoration	5,270	
Supervisory & field services	3,980	
		45,500
Work at Clive		
Site preparation	2,820	
Cover	1,630	
Erosion protection	1,430	
Decontamination	330	
Site relocation	6,460	
Fencing	90	
Supervisory & field services	3,020	
		15,780
TOTAL REMEDIAL ACTION		61,280
Engineering/construction management		
Engineering (ENG)	1,260	
Construction management (CM)	1,560	
TOTAL ENGINEERING/CONSTRUCTION MANAGEMENT		2,820
MAINTENANCE AND SURVEILLANCE		100
TOTAL SITE COST ESTIMATE		$ 64,280

Table 5.2 Site cost estimate summary (1984 - $000) - truck transportation

Item		Costs
Site Acquisition		
Mineral value	0	
Land value	80	
TOTAL SITE ACQUISITION		$ 80
Remedial Action (RA)		
Work at Salt Lake City		
Site preparation	1,490	
Decontamination	120	
Site relocation	41,300	
Site restoration	5,270	
Supervisory & field services	4,320	
		52,500
Work at Clive		
Site preparation	3,510	
Cover	1,630	
Erosion protection	1,430	
Decontamination	120	
Site relocation	2,680	
Fencing	90	
Supervisory & field services	3,220	
		12,680
TOTAL REMEDIAL ACTION		65,180
Engineering/construction management		
Engineering (ENG)	1,260	
Construction management (CM)	1,560	
TOTAL ENGINEERING/CONSTRUCTION MANAGEMENT		2,820
MAINTENANCE AND SURVEILLANCE		100
TOTAL SITE COST ESTIMATE		$ 68,180

Table 5.3 Cost estimate - detailed, train transportation

Item	Cost ($000)
WORK AT SALT LAKE CITY	
SITE PREPARATION	
1. Mobilization (lump sum)	$ 60
2. Staging area (lump sum) o Laydown and parking facilities	20
3. Utility protection o Concrete protection pads over utilities	20
4. Clearing and grubbing (lump sum)	10
5. Dewatering o Temporary ditches, gravel liners o Sump pumps and lines o Retention ponds o Permanent ditches	140
6. Waste-water treatment facility	860
7. Demolition o Stack, concrete foundations o Telephone and power lines (relocate) o Water and gas lines (relocate)	380
8. Temporary railroad spur o Construct base, install new and used track, maintenance and salvage	1,030
Total site preparation	$ 2,520
DECONTAMINATION (lump sum)	330
1. Equipment and truck washdown facility	
2. Train washdown facility	

Table 5.3 Cost estimate - detailed, train transportation (Continued)

Item	Cost ($000)
SITE RELOCATION	
1. Excavate and load contamination material (2,450,000 cy)	$ 8,810
2. Transportation: cars, maintenance, hauling, covers	24,590
SITE RESTORATION	
1. Fill material (825,000 cy) o Purchase, haul, spread, and compact	5,270
Select fill material (120,000 cy) o Purchase, haul, spread, and compact	
2. Seeding (128 Acres)	
SUPERVISORY AND FIELD SERVICES	
1. Field staff o Project manager o Project engineer o Construction engineer o Safety engineer o Schedules/cost engineer o Secretary	1,190
2. Field services o Additional labor o Security o Survey crew o Quality control	1,090
3. Field health services o Health physics manager o Access control technician o Laboratory services o Equipment and miscellaneous	1,140

Table 5.3 Cost estimate - detailed, train transportation (Continued)

Item	Cost ($000)
SUPERVISORY AND FIELD SERVICES (Cont'd)	
4. Temporary facilities	$ 560
o Field office	
o Field office expenses	
o Change and shower unit	
o Temporary utilities	
o Temporary sanitary facilities	
o Insurance	
o Consumable supplies	
o Laundry and operation	
o Mobile equipment	
o Fencing, barricades, signs, and miscellaneous	
Supervisory and field services total:	3,980
WORK AT CLIVE	
SITE PREPARATION	
1. Mobilization (lump sum)	60
2. Staging area (lump sum)	20
o Laydown and parking facilities	
3. Roads	1,070
o Construct and maintain temporary roads	
o Construct permanent roads	
4. Dewatering	190
o Temporary ditches, gravel liners	
o Retention ponds	
o Permanent ditches	
5. Water well	120
6. Temporary railroad spur	1,360
Total site preparation:	$ 2,820

Table 5.3 Cost estimate - detailed, train transportation (Continued)

Item	Cost ($000)
RADON COVER	$ 1,630
1. Compacted on-site soils (740,000 cy) o Excavate, spread, and compact	
EROSION COVER	1,430
1. Pit run rock (190,000 cy) o Excavate, haul, spread	
DECONTAMINATION (lump sum)	330
1. Equipment and truck washdown facility	
2. Train washdown facility	
SITE RELOCATION	
1. Haul tailings from radial stacker; (2,450,000 cy) spread and compact	4,290
2. Off-loading facility	2,170
FENCING (7,500 LF)	90
SUPERVISORY AND FIELD SERVICES	
1. Field staff o Construction engineer	260
2. Field services o Additional labor o Security o Survey crew o Quality control	1,260

Table 5.3 Cost estimate - detailed, train transportation (Concluded)

Item	Cost ($000)
SUPERVISORY AND FIELD SERVICES (Cont'd)	
3. Field health services	$ 810
o Health physics manager	
o Access control technician	
o Laboratory services	
o Equipment and miscellaneous	
4. Temporary facilities	690
o Field office	
o Field office expenses	
o Change and shower unit	
o Temporary utilities	
o Temporary sanitary facilities	
o Insurance	
o Consumable supplies	
o Laundry and operation	
o Mobile equipment	
o Fencing, barricades, signs, and miscellaneous	
Supervisory and field services total:	3,020
TOTAL REMEDIAL ACTION PRELIMINARY COST ESTIMATE	$ 61,280

Table 5.4 Cost estimate - detailed, truck transportation

Item	Cost ($000)
WORK AT SALT LAKE CITY	
SITE PREPARATION	
1. Mobilization (lump sum)	60
2. Staging area (lump sum) o Laydown and parking facilities	20
3. Utility protection o Concrete protection pads over utilities	20
4. Clearing and grubbing (lump sum)	10
5. Dewatering o Temporary ditches, gravel liners o Sump pumps and lines o Retention ponds o Permanent ditches	140
6. Waste-water treatment facility	860
7. Demolition o Stack, concrete foundations o Telephone and power lines (relocate) o Water and gas lines (relocate)	380
Total site preparation	$ 1,490
DECONTAMINATION (lump sum)	120
1. Equipment and truck washdown facility	
SITE RELOCATION	
1. Excavate and load contamination material (2,450,000 cy)	4,510
2. Transportation: trucks, maintenance, hauling, covers	36,790

Table 5.4 Cost estimate - detailed, truck transportation (Continued)

Item	Cost ($000)
SITE RESTORATION	
1. Fill material (825,000 cy)	$ 5,270
o Purchase, haul, spread, and compact	
Select fill material (120,000 cy)	
o Purchase, haul, spread, and compact	
2. Seeding (128 Acres)	
SUPERVISORY AND FIELD SERVICES	
1. Field staff	1,190
o Project manager	
o Project engineer	
o Construction engineer	
o Safety engineer	
o Schedules/cost engineer	
o Secretary	
2. Field services	1,090
o Additional labor	
o Security	
o Survey crew	
o Quality control	
3. Field health services	1,500
o Health physics manager	
o Access control technician	
o Truck monitor	
o Laboratory services	
o Equipment and miscellaneous	
4. Temporary facilities	540
o Field office	
o Field office expenses	
o Change and shower unit	
o Temporary utilities	
o Temporary sanitary facilities	
o Insurance	
o Consumable supplies	

Table 5.4 Cost estimate - detailed, truck transportation (Continued)

Item	Cost ($000)
SUPERVISORY AND FIELD SERVICES (Cont'd)	
4. Temporary facilities (concluded) o Laundry and operation o Mobile equipment o Fencing, barricades, signs, and miscellaneous	
Supervisory and field services total:	$ 4,320
<u>WORK AT CLIVE</u>	
SITE PREPARATION	
1. Mobilization (lump sum)	60
2. Staging area (lump sum) o Laydown and parking facilities	20
3. Roads o Construct and maintain temporary roads o Construct permanent roads	3,120
4. Water well	120
5. Dewatering	190
Total site preparation:	$ 3,510
RADON COVER	1,630
1. Compacted on-site soils (740,000 cy) o Excavate, spread, and compact	
EROSION COVER	1,430
1. Pit run rock o Excavate, haul, spread	
DECONTAMINATION (lump sum)	120
1. Equipment and truck washdown facility	

Table 5.4 Cost estimate - detailed, truck transportation (Concluded)

Item	Cost ($000)
SITE RELOCATION	
1. Spread and compact tailings in the embankment area (2,450,000 cy)	$ 2,680
FENCING (7,500 LF)	90
SUPERVISORY AND FIELD SERVICES	
1. Field staff o Construction engineer	260
2. Field services o Additional labor o Security o Survey crew o Quality control	1,260
3. Field health services o Health physics manager o Access control technician o Truck monitor o Laboratory services o Equipment and miscellaneous	1,010
4. Temporary facilities o Field office o Field office expenses o Change and shower unit o Temporary utilities o Temporary sanitary facilities o Insurance o Consumable supplies o Laundry and operation o Mobile equipment o Fencing, barricades, signs, and miscellaneous	690
Supervisory and field services total:	3,220
TOTAL REMEDIAL ACTION PRELIMINARY COST ESTIMATE	$ 65,180

6.0 ENVIRONMENTAL HEALTH AND SAFETY

The UMTRA health and safety policy is that the DOE and its contractors will 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 and its contractors will 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).

The State of Utah will have the principal responsibility for implementing a health and safety program. The program should include an on-site professional radiation health staff responsible for implementing monitoring, sampling, training, and reporting procedures. A section of the plan must address the procedures to handle a spill of the material during transportation. The surrounding community and the on-site workers must be protected to prevent accidents and radiation exposure. The State will prepare an Environmental Health and Safety Plan which meets the requirements of the UMTRA Project Health and Safety Plan, DOE/AL-6, June 1983, and its revisions.

7.0 RESPONSIBILITIES OF PROJECT PARTICIPANTS

7.1 INTRODUCTION

The following defines the various responsibilities of the Department of Energy (DOE) UMTRA Project Office, the Nuclear Regulatory Commission (NRC), and the State of Utah during detailed design, remedial action, and through the initiation of custodial maintenance and surveillance. Responsibilities are divided into major categories to be performed by the parties. The DOE will be assisted by its Technical Assistance Contractor (TAC), the Jacobs-Weston Team. In general, the TAC will assist the DOE in the preparation of concept designs and remedial action plans and will provide quality assurance, audits, and recommendations for final certification.

The State of Utah will be responsible for engineering design and remedial actions for the processing site and the CVWRF vicinity property. Their responsibilities will be administered and coordinated by the Utah Department of Health.

Major areas of responsibility for future actions by the DOE, the State of Utah, and the NRC are summarized as follows:

1. <u>DOE (including TAC)</u>:

   Prepare RAP.
   Provide available data for State use in preparing the detail design.
   Provide funds.
   Review and comment on the final design.
   Review and comment on environmental health and safety plan, radiological support plan, quality assurance plan, and public participation and information plan.
   Audit remedial action construction.
   Prepare licensing plan and submit license application.
   Prepare maintenance and surveillance plan.
   Receive license.
   Conduct maintenance and surveillance.
   Certify remedial action and prepare certification report.

2. <u>State of Utah</u>:

   Concur in RAP.
   Manage and coordinate remedial action.
   Obtain permits and approvals.
   Prepare detailed designs and specifications.
   Prepare and implement environmental health and safety plan.
   Prepare and implement radiological support plan.
   Prepare and implement quality assurance plan.
   Prepare and implement public participation and information plan.
   Conduct remedial action.
   Prepare completion report.
   Transfer site to DOE on completion and certification of remedial action.
   Provide funds.

3. NRC:

Review and concur in RAP.
Review and concur in the environmental health and safety plan, radiological support plan, and quality assurance plan.
Review and comment on the public participation and information plan.
Review of detail design packages.
Review and concur in maintenance and surveillance plan.
Audit remedial action construction.
Review and concur in final certification report.
Issue license for long-term monitoring and maintenance of the disposal site.

7.2 DETAILED RESPONSIBILITIES

Detailed responsibilities of project participants in the areas of permitting, licensing, land acquisition, detailed design, construction, health and safety, public information, radiological support, quality assurance, and custodial maintenance and surveillance are defined in the following text.

7.2.1 Regulatory compliance

Requirements for regulatory compliance, previously identified by Federal and State agencies (Agencies), will be incorporated into the final design specifications, as needed, by the State.

The State will submit permit applications, and supporting details to the Agencies for permit issuance.

During the remedial action, the DOE and NRC may audit construction activities for compliance with provisions in the permits and approvals. (Permitting Agencies may independently audit relevant activities consistent with normal practice.)

Upon completion of the permitted action, the State will conduct a final review and will prepare a close-out report for submittal to the respective Agencies. Permits will then be terminated.

7.2.2 Licensing

As part of the licensing task and prior to completion of the remedial action, the DOE will prepare a license application including a site maintenance and surveillance plan. The application will be submitted to the NRC for review and concurrence. Revisions resulting from this review will be incorporated into the final application which will be submitted after the DOE and NRC have certified that remedial action is complete.

Any final revisions required will be added and the license will be issued by the NRC to the DOE (or responsible designated Federal agency).

7.2.3 Land acquisition

The State shall assure that DOE, NRC, and EPA have a right to inspect the disposal site at any time from the time the State acquires the site until the time the State transfers title to the U.S. Government. The State will acquire the interests of permittees, lessees, and sublessees of, or other individuals with property interests in the disposal site. Upon completion of the remedial action, legal title to the residual radioactive materials will be conveyed to the Federal Government.

7.2.4 Detailed design

The State will prepare preliminary and final engineering drawings, specifications, and bid packages. Once finalized and submitted to DOE for review and comment, the bid packages will be issued to prospective bidders pursuant to State regulations and construction subcontractors will be selected. Any major changes from the RAP must be reviewed and concurred in by DOE and NRC. The NRC will review the design.

7.2.5 Construction

The State will prepare guideline documents to comply with health and safety, security, quality assurance, public information, and other regulatory requirements.

The State will acquire the necessary permits and approvals from the appropriate agencies and will perform remedial action pursuant to the detail design.

Construction activity audits may be performed by the DOE and NRC. Revisions to the remedial action resulting from site audits will be incorporated into the record drawings and the remedial action plan by the State as necessary after the DOE and NRC have concurred in the changes.

Upon completion of the remedial action, the site will be certified by the DOE.

7.2.6 Health and safety

The State will prepare an environmental health and safety plan to be consistent with relevant Federal and State standards/regulations. The DOE and NRC will review and comment on the plan. As part of the implementation procedures, the State will institute construction and radiation safety procedures (for workers and public) and environmental monitoring, and will develop response procedures for severe weather and medical emergencies.

Construction subcontractors will comply with all state procedures and file required safety reports with the State that record the results of monitoring, accidents, and illnesses. Records will be maintained by the State following remedial action construction.

Employee and public complaints will be investigated by the State.

7.2.7 Public information

The State will prepare a public participation and information plan for review and comment by the DOE and NRC. The State will establish a local site manager who will provide information to the public and local media.

Prior to and during construction, the State will conduct public information meetings to inform the interested public of key aspects and current progress of the remedial action. The DOE and NRC will assist the State in conducting the meetings upon request by the State.

Concurrent with the public meetings, the State will provide status and progress reports for other agencies (e.g., DOE, NRC).

7.2.8 Radiological support

The State will prepare and implement a radiological support plan to assure tailings excavation/removal is conducted to meet EPA standards. The DOE and NRC will review and comment on the plan.

After remedial action, the State will prepare a completion report, conduct a final certification survey, and provide a recommendation to DOE for site certification. The DOE will certify and prepare a certification report. The NRC will review and concur in the final certification report.

7.2.9 Quality assurance

The State will prepare a quality assurance plan for design and remedial action. The DOE and NRC will review and comment on the plan. The DOE and NRC may audit the construction activities at such times and for such activities as they deem appropriate.

7.2.10 Maintenance and surveillance

The DOE will prepare and submit to NRC the site Maintenance and Surveillance Plan. The NRC will review and concur with the plan, and the DOE (or responsible Federal agency designated) will assure that the plan is implemented.

8.0 MAINTENANCE AND SURVEILLANCE

8.1 INTRODUCTION

The objectives of the custodial maintenance and surveillance program are to assure that, upon completion of remedial action, the stabilized embankment remains undisturbed and that the tailings continue to be nonhazardous to the public and the local environment.

The custodial maintenance and 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.

8.2 SURVEILLANCE

8.2.1 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 EPA standards. Inspections will consist of two phases: Phase I, a systematic walk-over designed to qualitatively evaluate the condition of the disposal site; and Phase II, 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 will be conducted on a specific schedule, such as annually, by a team of qualified professionals. The inspection team will review record drawings, engineering details, aerial photographs, and supporting documentation. A site walk-over will 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 evaluation may 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.

8.2.2 Aerial photography

Aerial photography 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 photography may also be conducted 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.

8.2.3 Reporting

Summary surveillance and monitoring reports that evaluate the results of these activities and recommend needed custodial maintenance (i.e., corrective actions), along with future surveillance and monitoring, will be prepared. Reports and supporting documentation will be placed on file with DOE, NRC, and the State.

8.3 CUSTODIAL MAINTENANCE

The need for custodial maintenance (i.e., corrective action) can only be determined following site inspection and monitoring. However, it is anticipated that custodial maintenance will consist primarily of the following:

- o Limited soil/rock replacement due to unanticipated erosion, human or animal intrusion, or cover disturbance -- these activities are expected to be required infrequently.
- o Control of deep rooted plants by infrequent application of herbicides or physical removal as required.
- o Mechanical repairs to security fence, gates and locks, and warning signs, when necessary.

8.4 CONTINGENCY PLANS

Procedures will be developed to inspect and perform custodial maintenance of the disposal site upon the occurrence of severe meteorological events (e.g., extreme rainfall), seismic events in excess of design parameters, or unusual human intrusion.

9.0 PUBLIC PARTICIPATION AND PUBLIC INFORMATION

9.1 INTRODUCTION

Section III of 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 participation and public information program to fully inform the interested public and use the feedback in the decision-making processes and remedial action activities relative to the UMTRCA-designated site in Salt Lake City, Utah. The following sections describe the actions the DOE and State will take to encourage the participation of an informed public in this project.

9.2 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 can begin, an EIS will be completed for the Salt Lake City site. Public participation is an important part of the preparation of the EIS and the participation requirements are detailed in the Council on Environmental Quality (CEQ) Regulations (effective July 1979) for implementing the provisions of NEPA, and in the DOE guidelines of 1980 for NEPA compliance.

In preparing the EIS, DOE has conducted and the State will continue to conduct 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 public is given the opportunity to express their concerns and identify what they believe to be significant issues.

The identified issues are documented in the EIS and incorporated into the decision-making process. The DOE accepts written comments for a 45-day period after publication of the draft EIS, and for a 30-day period after the final EIS. Interested parties were given the opportunity to comment on the draft EIS at an official comment-taking hearing in Salt Lake City and Tooele after the draft EIS was published.

In addition to meetings on the EIS, the State will hold public information meetings in Salt Lake and Tooele counties to describe the remedial action plan for the Vitro project and receive comments which may be used in the design for remedial action.

A Task Force comprised of local citizens, formed to serve as a major communication link in the decision-making process, will meet with the State to convey community response on project activities. The Task Force should continue to meet periodically throughout the duration of remedial action construction.

Frequent meetings and briefings will be held by the State to provide information and project status updates and solicit public participation in the project activities. State and local officials and interested citizens will be involved in frequent discussions regarding remedial action construction schedules, radiation monitoring reports, ground-water protection plans, and other project activities. These meetings will be advertised as to time and place.

9.3 PUBLIC INFORMATION

In order for public participation to be effective, the public must be informed concerning the remedial action project in Salt Lake City. Several methods of information dissemination have been 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 some 400 individuals, media representatives, and Federal, State, and local officials have been computerized for information dissemination purposes. Information is provided to interested persons in the Federal government, State administration, and private citizens.

A public pre-construction meeting will be conducted by the State. Principal topics of discussion will include the remedial action plan and construction methods and schedules.

An on-site representative will be designated by the State to respond to public inquiries during remedial action construction. This representative will provide information, and will meet frequently with the public throughout the construction period.

A variety of printed materials have been prepared concerning the UMTRA Project and the Salt Lake City site. These include project fact sheets, a site fact sheet, and the EIS document. As they are printed, these materials and other fact sheets and documents are sent to interested individuals and are available in Tooele, Salt Lake City, university, and county libraries.

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GLOSSARY

absorbed dose, radiological	The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. The unit of absorbed dose is the rad. One rad equals 100 ergs per gram.
alluvium	Sediment deposited by the operation of modern rivers.
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.
aquifer	A subsurface formation containing sufficiently saturated permeable material to yield usable quantities of water.
aquitard	A water-bearing zone that allows transmission of water at a very slow rate.
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.
background radiation	Levels of radiation, or concentration of radionuclides which are typical of an undisturbed area, or area not effected by residual radioactive material.
beta particle	Charged particle emitted from the nucleus of an atom, 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.
confined aquifer	An aquifer bounded above and below by relatively impermeable beds.
contamination	In this report, the presence of radioactive material in undesirable concentrations and in undesirable locations.
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.
DOE	Department of Energy.
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 discreet 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."
dose, external	The absorbed dose that is due to a radioactive source external to the individual as opposed to radiation emitted by inhaled or ingested sources.
dose, internal	The absorbed dose or dose commitment resulting from inhaled or ingested radioactivity.
DSCR	Disposal Site Characterization Report.
EIS	Environmental Impact Statement.
EPA	Environmental Protection Agency.
exposure	A measure of the ionization produced in air by x or gamma radiation. It is the sum of the electrical charges on all ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air, divided by the mass of the air in the volume element. The unit of exposure is the Roentgen (R).
flux, radon	The emission of radon gas from the earth or other material, usually measured in units of picocuries per square meter per second.
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	Short wave length electromagnetic radiation of nuclear origin with energies ranging from 10 KeV to 9 MeV.
gamma spectral analysis (gamma spectroscopy)	An analytical technique for identifying radionuclides based on their different gamma energy levels.
ground water	Water below the land surface, generally in a zone of saturation.
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	Rate of change of pressure head per unit of distance of flow at a given point.
half life	The time required for a radioactive substance to lose 50 percent of its activity by decay. Each radionuclide has a unique half-life.
in-situ	In the natural or original position.
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.
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.
maintenance, custodial	The repair of fencing, 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.
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 resulting in data for evaluation of the performance and characteristics of the disposal site.

MSRD — Mountain States Research and Development.

NEPA — National Environmental Policy Act

NRC — Nuclear Regulatory Commission.

OSHA — Occupational Safety and Health Act.

passive institutional controls — Those controls which require action by a governmental agency to 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 capacity of a rock or soil mass to transmit a fluid.

permissible dose — That dose of ionizing radiation that is considered acceptable by standards-setting bodies such as the EPA. Also, the dose of radiation that may be received by an individual within a specified period with the expectation of no substantially harmful result.

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 — An imaginary surface that everywhere coincides with the static level of the water in the aquifer.

promulgate — To make known by open declaration; proclaim.

proton — Elementary nuclear particle with a positive electric charge equal numerically to the charge of the electron and a mass of 1.007277 mass units. Also the nucleus of a hydrogen atom.

PSCR — Processing Site Characterization Report.

RAC — Remedial Action Contractor.

rad — A unit of measure for the absorbed dose of radiation. It is equivalent to 100 ergs per gram of material.

radioisotope — A radioactive isotope of an element with which it shares almost identical chemical properties.

radionuclide — A radioactive nuclide.

radium-226, Ra-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, Ra-222 — An inert gas continuously generated by the decay of Ra-226 in rock and soil with a half-life of 3.8 days generating a series of non-gaseous radioactive decay products.

radon-daughter product — One of several short-lived radioactive daughter products of radon-222. All are solids.

RAP — Remedial Action Plan.

RDC — Radon Daughter Concentration.

recharge — The process by which water is absorbed and is added to the zone of saturation.

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.

ROD — Record of Decision.

roentgen — The unit of exposure. One roentgen equals 2.58×10^{-4} coulombs per kilogram of air. 1 roentgen (R) 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 downward.

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.

standard Proctor — A test procedure to measure moisture-density relationship (ASTM D698).

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.
TAC	Technical Assistance Contractor.
tailings, uranium-mill	The waste material remaining after most of the uranium has been extracted from uranium ore.
TDS	Total dissolved solids.
thorium-230, Th-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	Uranium Mill Tailings Remedial Action.
UMTRCA	Uranium Mill Tailings Radiation Control Act.
unconfined aquifer	An aquifer that is not confined by impermeable beds. The upper water surface is called the water table.
uranium-238, U-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 Salt Lake City site that is determined by the DOE, in consultation with the NRC, to be contaminated with residual radioactive material derived from the Salt Lake City site, and which is determined by the DOE to require remedial action.
water table	The upper surface of a zone of saturation in an unconfined aquifer.
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)	Exposure to a worker resulting from inhalation of air with a concentration of 1 WL of radon daughters for 170 working hours. Continuous exposure of a member of the general public to 1 WL for one year results in approximately 53 WLM.

APPENDIX A

REGULATORY COMPLIANCE

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INTRODUCTION

Obtaining permits and other regulatory approvals for the remedial action is essential for the initiation of the project. This Regulatory Compliance Appendix is intended to identify and describe the permits, licenses and approvals that are likely to be required for the proposed action based upon the concept design. Other permits and approvals may be required for activities beyond the scope of the Remedial Action Plan or due to modification in the concept design.

Procedures for preparing permit applications and agency review processes are outlined for each permit. The principal technical and supervisory personnel at the regulatory agencies are listed as well. The State of Utah should consider this Regulatory Compliance Appendix to be an introduction to the permitting process, while details must be obtained from regulatory agencies.

A preliminary schedule for regulatory compliance activity (Figure A.1) is included for initial project planning purposes. The State of Utah should sequence the preparation and filing of permit applications so that approvals will be received in a timely manner without causing delay to construction activities.

FIGURE A.1 REGULATORY COMPLIANCE SCHEDULE SOUTH SALT LAKE - CLIVE

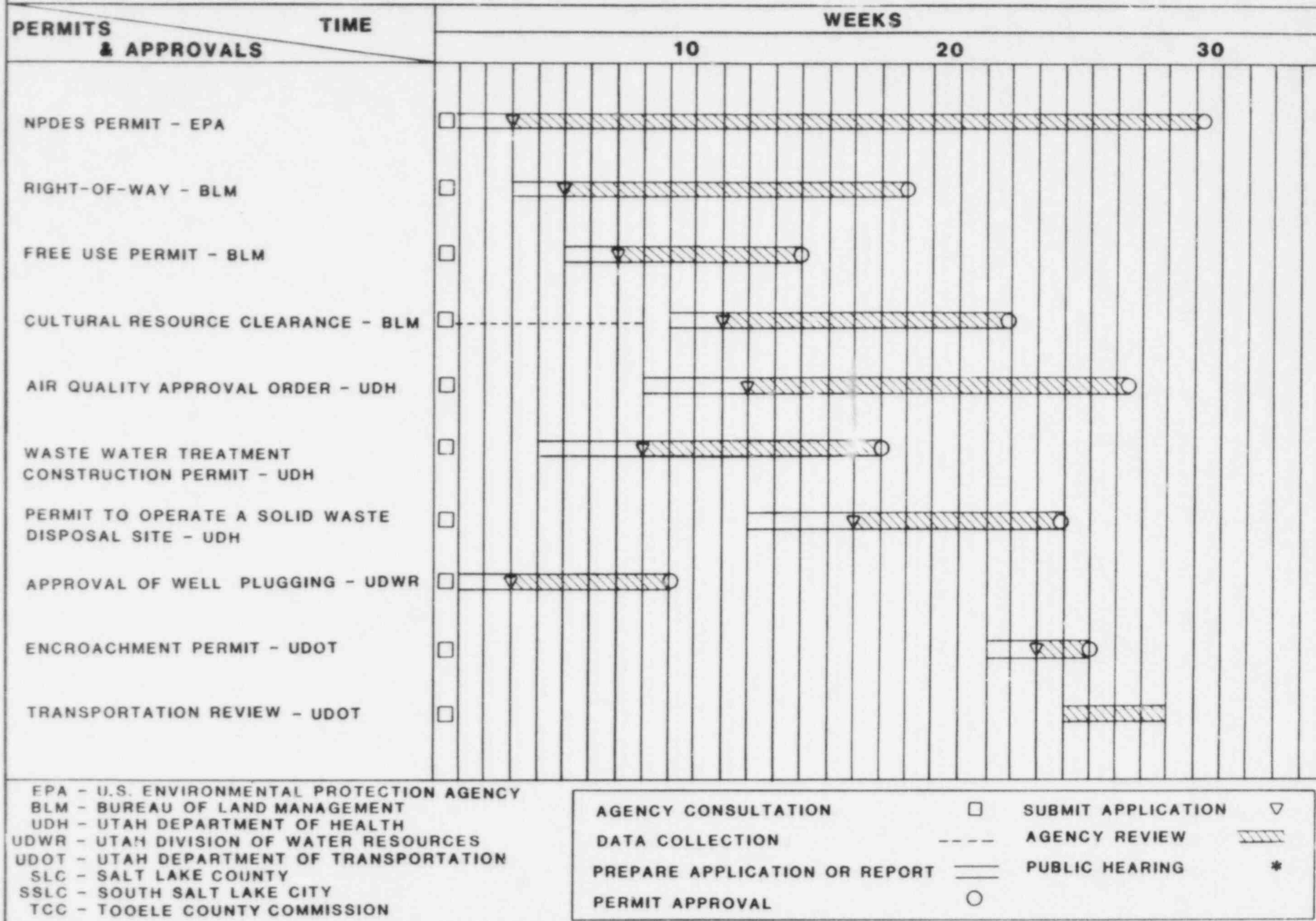
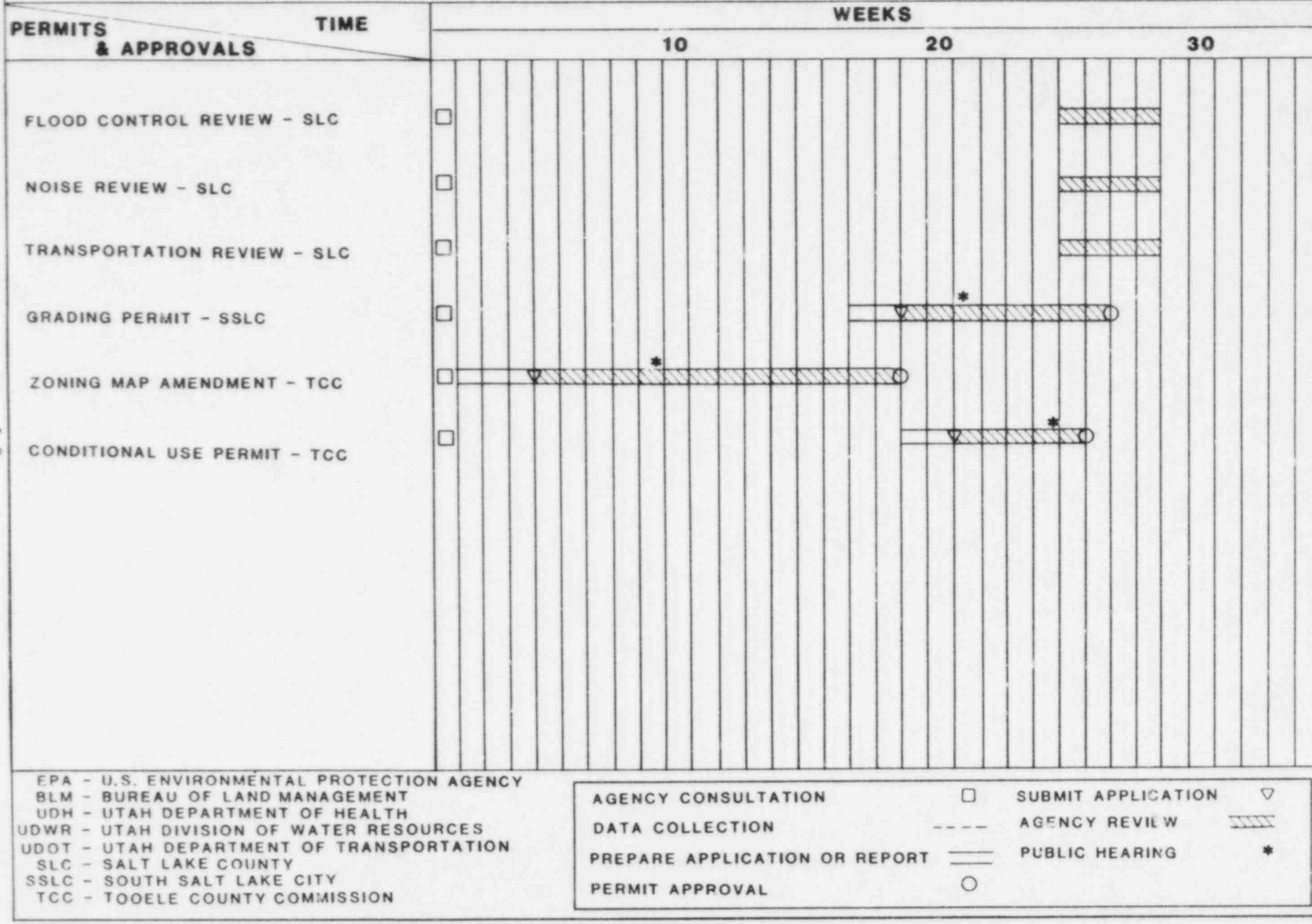


FIGURE A. 1 (CONT.) REGULATORY COMPLIANCE SCHEDULE SOUTH SALT LAKE - CLIVE



ACTIVITY: NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT

LEGAL CITATION: Sections 25-8-501 through 508 CRS 1978 in conformity with the Federal Water Pollution Control Act Amendments of 1972, the Clean Water Act of 1977, and regulations promulgated thereunder.

AGENCY/CONTACT: U.S. EPA
Region VIII
Compliance Branch
1860 Lincoln, Suite #900
Denver, CO 80203
ATTN: Patrick J. Godsil, Branch Chief (303) 837-4901
Rob Walline
Regional Mining Expert

PROCEDURE: The permit applies to all operations discharging to waters of the United States from a point source. Application is made by filing completed EPA Forms 1 and 2C. Information required on Form 1 includes:

(1) Name, mailing address and location of the facility.

(2) Facility contact.

(3) Standard industrial classification code for the facility.

(4) Name of facility operator and status (i.e., Federal, state).

(5) Existing Federal, state, or local permits.

(6) A map covering an area extending at least one mile beyond the facility property boundaries. The map should be based on a 7 1/2-minute USGS quadrangle map.

(7) A description of the nature of the business.

Form 2C requires the following information:

(1) Location, by latitude and longitude, and number designation of each effluent outfall.

(2) Name of receiving water for each outfall.

(3) A schematic flow diagram indicating sources of water, operations contributing waste water for the effluent water balance, and treatment processes for each waste stream.

(4) A list of each operation, average flow, and treatment related to each outfall.

(5) Description of the variation and frequency of water flow.

(6) Explanation of any Federal, state or local implementation schedule for construction or improvement of waste-water treatment or other environmental programs.

(7) Influent and effluent characteristics:

- Pollutants present.
- Source of pollutants.
- Concentration of pollutants.
- Temperature of effluent.
- Flow of effluent.
- pH of effluent.

SPECIAL CONSIDERATIONS: Prohibitions of a discharge permit include, but are not limited to, the following:

(1) No discharge is allowed that will violate state, regional, or local land use plans unless all requirements and conditions of applicable Federal and state statutes and regulations are met or will be met according to a schedule of compliance. Similarly, no discharge is permitted that by itself or in combination with other pollutants will result in pollution of the receiving waters in excess of standards, unless the permit contains effluent limitations and a schedule of compliance with water-quality requirements.

(2) No discharge of any radiological, chemical, or biological warfare agent or high level radioactive waste is permitted. Limits of radiological wastes that may be discharged are determined by state water-quality standards.

(3) No discharge from a point source that is in conflict with an established water-quality management plan promulgated under Sections 201, 208, 209, and 303(e) of the Federal Water Pollution Control Act of 1972 and the Clean Water Act of 1977 is permitted unless the waste discharge permit contains limitations and a schedule of compliance approved by the Divisions.

Frequency of measuring, monitoring, and reporting is dependent on specific discharges.

Two permits may be needed, one for the South Salt Lake waste-water treatment facility and one for the South Clive waste-water treatment facility. If the South Clive waste-water treatment will be a zero-discharge evaporation pond, an NPDES permit may not be needed depending upon the storm reoccurrence interval used in selecting the pond capacity.

SCHEDULE: An applicant is to apply for a permit at least 180 days in advance of the date the discharge is to begin. In some cases, EPA may determine that a site visit or extra information is necessary. In such a case, the applicant has 60 days to reply.

ACTIVITY: CERTIFICATION OF NPDES PERMIT

LEGAL CITATION: Certification by the state pursuant to Clean Water Act, 1977, Section 402. Utah Waste-Water Disposal Regulations, Parts I and II.

AGENCY/CONTACT: Utah State Department of Health
Division of Environmental Health
Bureau of Water Pollution Control
P.O. Box 2500
Salt Lake City, UT 84110
ATTN: Steven McNeal (801) 533-6146

PROCEDURE: State of Utah certification must be obtained prior to obtaining a NPDES permit from EPA, Region VIII. State review of the NPDES permit application (Forms 1 and 2C) is coordinated by EPA.

SPECIAL CONSIDERATIONS: None.

SCHEDULE: At least 180 days (see NPDES Permit - EPA).

ACTIVITY: WASTE-WATER TREATMENT FACILITY CONSTRUCTION PERMIT

LEGAL CITATION: Utah Code Annotated 26-15-45 and 73-14-1 through 13. Waste-Water Disposal Regulation, Parts I through VII.

AGENCY/CONTACT: Utah State Department of Health
Division of Environmental Health
Bureau of Water Pollution Control
P.O. Box 2500
Salt Lake City, UT 84110
ATTN: Steven McNeal (801) 533-6146

PROCEDURE: The Construction Permit is required prior to construction of waste-water treatment works, or the discharge of waste water. Application is made by submitting complete construction plans and specifications in the form of an engineer's report which shall include:

(1) A brief description of the project.

(2) A description of the location and topography of the site.

(3) Volume and character of waste-water flow in various seasons.

(4) A brief description of the extent of existing and proposed sewers and sewage treatment facilities in the area.

(5) A description of the treatment plant site, including:

- Distances to residences and commercial development areas.

- Topography and layout of proposed facilities.

- Flood potential.

(6) Location of wells and surface waters within one-half mile. Results of soil borings to determine surface and subsurface characteristics of any proposed pond areas.

(7) A discussion of the facility design including reasons for the selection of the treatment process.

The Utah Water Pollution Control Committee considers the recommendation of the Bureau and approves or denies the Construction Permit application.

SPECIAL CONSIDERATIONS: The regulations are directed primarily at sewage treatment facilities; however, the regulations also apply to industrial waste-water treatment. Part II of the regulations contain "Standards of Quality for Waters of the State" and Part III contains specifications for "Sewers and Waste-water Treatment Works." Separate permits may be required for the South Salt Lake tailings site and the Clive site.

SCHEDULE: An approved permit is required prior to construction. A 30- to 60-day review time is needed for permit approval. No public notice is required.

ACTIVITY: RIGHT-OF-WAY OR TEMPORARY USE PERMIT

LEGAL CITATION: Federal Land Policy and Management Act (FLPMA) 43 U.S.C. 1701 et. seq., 43 CFR 2800.

AGENCY/CONTACT: Bureau of Land Management
Pony Express Resource Area Office
2370 South 2300 West
Salt Lake City, UT 84119
ATTN: A. Lowell Decker, Area Manager
Nancy Bloyer, Realty Specialist (801) 524-5348

PROCEDURE: A right-of-way or temporary use permit must be obtained prior to construction and use of haul roads and railroad spurs on Federal lands administered by the Bureau of Land Management (BLM). Application is made by filing a completed Standard Form 299 "Application for Transportation and Utility Systems and Facilities on Federal Lands" with the BLM Resource Area Office having jurisdiction over the Federal lands. The following information is required in the application:

(1) Name, address, and telephone number of applicant.

(2) Classification of applicant (e.g., individual, corporation, Federal agency).

(3) Description of the project.

- Type of facility.
- Related structures.
- Physical specifications (length, width, grading).
- Term of years needed.
- Volume or amount of materials to be transported.
- Duration and timing of construction.
- Temporary work areas needed for construction.

(4) Map(s) showing the location and layout of the project.

(5) State or local government approval.

(6) Application fee (not required if the applicant is a Federal agency).

(7) A statement of the applicant's technical and financial capability to construct, operate, maintain, and terminate the system for which authorization is being requested.

(8) A description of alternative routes and modes considered and why these alternatives were not selected.

(9) An explanation of why it is necessary to cross Federal lands.

(10) A list of authorizations and pending applications filed for similar projects which may provide information to BLM.

(11) A statement of need for the project.

(12) A description of the probable effects on the population of the area, including social and economic aspects and the rural lifestyles.

(13) A description of the likely environmental effects that the proposed project will cause.

(14) The names of departments/agencies where this application is being filed.

SPECIAL CONSIDERATIONS: BLM representatives have suggested that a right-of-way be issued for construction and use of a haul road to the Clive site. Rail spur construction and use should be authorized with a temporary use permit because the spur will be dismantled after the project is completed. Applications for both the right-of-way and temporary use permit can be combined using one application form.

Rights-of-way are granted for a maximum 30-year term with the option to renew for additional 30-year periods. Renewing the right-of-way would provide continued legal access to the site for maintenance and surveillance. The temporary use permit would be cancelled after the spur is removed.

Information from the project EIS concerning transportation, site-specific environmental impacts and mitigation should be attached to the application. BLM will use the information in preparing an EA related to the application. The location of the facilities can be drawn on USGS 7½-minute quadrangle topographic maps (scale 1" = 2000 feet).

When a government entity (e.g., DOE) is the applicant, a copy of the law, resolution, or order authorizing the project should be attached to the application.

SCHEDULE: BLM requires a minimum of two months to process an application after it has been received. Sensitive environmental issues or other controversial factors can prolong processing of the application by several months.

ACTIVITY: FREE USE PERMIT

LEGAL CITATION: Material Sales Act of 1947, P.L. 167 and Title 43 CFR 3620

AGENCY/CONTACT: Bureau of Land Management
Pony Express Resource Area Office
2370 South 2300 West
Salt Lake City, UT 84119
ATTN: A. Lowell Decker, Area Manager
Clair Quilter
Natural Resources Specialist (801) 524-5348

PROCEDURE: This permit authorizes government agencies to excavate and utilize common variety minerals for public works construction projects. Application is made by filing a completed Form 3500-6 with the Area Manager, including the following information:

(1) Name and address of the government entity sponsoring the project.
(2) Name, address, and telephone number of authorized officer.
(3) Type of mineral to be mined (e.g., clay subsoil, gravel).
(4) Amount of mineral needed.
(5) Legal description of location.
(6) Intended use of the minerals.

Bureau personnel evaluate the application, make a site inspection, and prepare a technical examination report. An environmental assessment is prepared for the borrow material excavation if the remedial action environmental assessment has not adequately covered the subject. The Bureau develops a list of mitigating measures to offset the potential adverse environmental impacts of the mineral extraction. The Bureau then notifies the applicant that the permit is approved pending approval of a mining plan (to be developed by the applicant) that incorporates the mitigation measures.

The applicant, when required by the authorized officer, shall prepare a mining plan that includes, but is not limited to:

(1) A map, sketch, or aerial photograph showing the area applied for, the area to be disturbed, existing and proposed access, and the names and locations of major topographic and known cultural features.

(2) A description of the proposed methods of operation and the periods during which the proposed activities will take place.

(3) A description of measures to be taken to prevent hazards to public health and safety and to prevent unnecessary and undue degradation.

The applicant, when required by the authorized officer, shall submit a reclamation plan that includes, but is not limited to:

(1) A statement of the proposed manner and time for completion of the reclamation of the areas disturbed by the permittee's operations.

(2) A map or sketch which delineates the location and area to be reclaimed.

SPECIAL CONSIDERATIONS: When other resources are present in the area to be mined, additional mitigation measures and extended application processing times should be expected. The locations of known cultural resources are plotted on Unit Resource Analysis map overlays at the Pony Express Area Office in Salt Lake City.

Avoiding sensitive areas would expedite approval of the permit. A cultural resource survey will be required if the area has not been surveyed previously.

The presence of mining claims on the borrow site creates additional internal reviews that can delay issuance of the permit.

SCHEDULE: Uncomplicated applications are processed in 30 to 45 days. Applications that affect a large acreage of land or are in an environmentally sensitive area could involve three to four months for processing.

ACTIVITY: CULTURAL RE OURCE CLEARANCE

LEGAL CITATION: Historic Pre ervation Act of 1966, 16 USC 470; Executive Order 11593; and 36 CFR 800

AGENCY/CONTACT: Bureau of Land Ma agement
Pony Express Resource Area Office
2370 South 2300 West
Salt Lake City, UT 84119
ATTN: A. Lowell Decker, Area Manager
Bob Neleigh, Area Archaeologist (801) 524-5348

State Historic Preservation Office
Utah State Historical Society
300 Rio Grande
Salt Lake City, Utah 84101
ATTN: Dr. Melvin T. Smith, State Historic Preservation Officer (801) 533-5755

PROCEDURE: All Federal agencies are required to inventory archaeological and historical resources affected by their undertakings and do whatever is possible with regard to protecting and, when necessary, recovering significant resources. Prior to initiating surface disturbing activities on BLM land, cultural resource clearance should be obtained with concurrence from BLM and the State Historic Preservation Officer (SHPO). The organization sponsoring the activity should contract with an approved archaeologist to conduct a site survey. If a survey of the area has been completed previously, a new survey may not be required. The survey report should be sent to the BLM and the SHPO.

SPECIAL CONSIDERATIONS: The discovery of archaeological sites during the course of Federally assisted, permitted, funded, or licensed construction or land alteration must be reported to the Interagency Archaeological Service (IAS) of the U.S. Department of the Interior. If a previously undiscovered site is revealed during the course of construction, the official in charge should halt construction and request an on-site assessment by the IAS. The IAS will respond within 48 hours with a professional assessment of the significance of the site. In consultation with agency officials, the IAS representative makes an on-site decision for (a) salvage, (b) burial, or (c) destruction of the site. The main office of IAS can be contacted at (202) 272-3750. For more information, see 36 CFR 66.

The archaeological survey of the South Clive disposal site revealed no archaeological sites. However the corridors to be used for the construction of a new rail spur or access roads have not been surveyed.

SCHEDULE: The SHPO review of archaeological reports involves one to six months. BLM reviews take two weeks to two months to complete.

ACTIVITY: AIR QUALITY APPROVAL ORDER

LEGAL CITATION: Utah Code Annotated 26-15-5 and 26-24-5, 1953 as amended. Utah Air Conservation Regulations (UACR) Part III, Section 3.1.

AGENCY/CONTACT: Utah State Department of Health
Division of Environmental Health
Bureau of Air Quality
P.O. Box 2500
Salt Lake City, UT 84103
ATTN: Brent Bradford, Director
Montie Keller, Engineer (801) 533-6108

PROCEDURE: A notice of intent to construct, modify, or relocate an installation is submitted to the Executive Secretary of the Utah Air Pollution Control Board. The notice of intent is based upon the following information:

(1) Description and nature of the process(es) and materials handling system(s) including a plot plan and process flow chart(s) with a narrative walk-through of the process(es).

(2) Quantities and types of raw materials used (including fuels) and production output of each process (normal and maximum pounds/yr). Include chemical composition, particle size distribution, formula, and moisture content of the materials.

(3) Chemical composition and physical characteristics of each effluent/ exhaust stream (e.g., particle size distribution, formula, moisture content, molecular weight).

(4) Effluent/exhaust loading before (if known or estimated) and after control equipment/procedure (e.g., grains/dscf, lbs/hr, ppm, grams/sec). Must address all pollutants including those from fuel combustion operations and from fugitive sources. Special emphasis must be given to TSP, SO_2, NO_x, CO, O_3, and HC (especially VOC).

(5) Operating schedule (hr/day/yr) for each individual pollution point/ area. In the absence of a schedule, the State will assume 365 days/ yr, 24 hr/day.

(6) Known or estimated construction/installation/modification schedule (start and end dates).

(7) Since best available control technology (BACT) is required on all sized sources througnout the State and for all types of air emissions, including fugitives, provide the rationale for the selection of type and efficiency of control equipment and/or operational procedures used to minimize emissions. For visible emissions, give expected/guaranteed opacities.

(8) Calculations of emissions (normal and maximum/hr or yr) showing emission factors used with rationale and technical justification (state reference). For vehicular emissions include combustion of fuels and haul/access/operational area fugitive dusts and vehicle miles traveled. For fugitive sources estimate the: height of source/height of pile, area of source and/or dimensions; for roadways give average moisture and silt content, length, type of surface, and location/orientation.

(9) Type of compliance stack/exhaust testing to be done by applicant to show compliance. List/discuss the test points/locations and test methods selected.

After reviewing the notice of intent, the Executive Secretary issues an approval order or disapproval order. An approval order authorizes the commencement of construction.

SPECIAL CONSIDERATIONS: Best available control technology (BACT) includes:

(1) Use, where possible, of water or chemicals for control of dust in the demolition of buildings or structures, construction operations, the grading of roads, or the clearing of land.

(2) Application of asphalt, oil, water, or suitable chemicals on dirt roads, material stockpiles, and other surfaces which can give rise to airborne dusts.

(3) Paving and maintenance of roadways.

(4) Prompt removal of earth or other material from paved streets onto which earth or other material has been transported by trucking or earthmoving equipment, erosion by water, or other means.

SCHEDULE: Approval orders are normally issued within 90 days of receipt of the notice of intent. The Bureau can grant itself a maximum of three 30-day extension periods if the review has not been completed within the initial 90 days. A copy of the notice of intent to approve or disapprove is sent to the applicant and to the directors of Federal, state, or local governing bodies that may be affected by the proposed air emissions. A copy of the notice of intent to approve or disapprove is also published in a local newspaper. If no substantive objections are received within 30 days, a final approval or disapproval order is issued.

ACTIVITY: PERMIT TO OPERATE A SOLID WASTE DISPOSAL SITE

LEGAL CITATION: Utah Code Annotated 26-14, 1953 as amended. Code of Solid Waste Disposal Regulations.

AGENCY/CONTACT: Utah Division of Environmental Health
Bureau of Solid and Hazardous Waste Management
P.O. Box 2500
Salt Lake City, UT 84110
Attn: Dr. Dale Parker, Director
Dennis Downs
Environmental Health Manager (801) 533-4145

PROCEDURE: Design plans and supporting information are to be submitted for review and approval to the Bureau. Plans are to include:

(1) A plat map or aerial photograph upon which is accurately shown the exact location of the proposed disposal site, current land use, zoning within 1/4 mile of the site, homes, industrial buildings, wells, water courses, surface drainage channels, rock outcroppings, roads and general topography.

(2) A report including the following details:

- Total area of the proposed site.

- Special provisions for handling special and/or hazardous wastes.

- Anticipated type, quantity and source of solid waste to be deposited in the site.

- Soil description to a depth of at least five feet below the proposed excavations, maximum ground-water elevations throughout the site, and a general description of geology of the area. Such data shall be obtained by soil borings, trenching, or other appropriate means.

- Availability, source, and characteristics of cover material.

- Type and availability of equipment for efficient excavating, earthmoving, spreading, compaction, and other needs.

- Provisions for fire control, which may include arrangements made with the nearest fire department to control any fires which may occur at the site.

- Evidence of year-round accessibility to the site, to include an all-weather road.

- Proposed fencing for control of access as well as prevention of scattering of waste material by wind.

- Evidence of land ownership or lease agreement.

- Final grading to provide effective surface drainage.

- Extent of average working face. This should be limited to the smallest area practical to confine the amount of exposed waste without interfering with effective operation procedures.

- Qualifications of personnel to be at the site to supervise activities during all hours of scheduled operation.

- Provisions for dust control at the site and along access roads.

SPECIAL CONSIDERATIONS: The Bureau of Solid and Hazardous Waste Management is primarily involved with the disposal of non-radioactive wastes.

(1) Certain bulky wastes, such as automobile bodies, furniture and appliances should be crushed and then pushed onto the working face near the bottom of the embankment or into a separate disposal area. Other bulky items, such as demolition and construction debris, tree trunks or stumps and large timbers, should be pushed onto the working face near the bottom of the embankment or into a separate disposal area.

(2) Plan approval will depend, in part, upon adequate isolation, avoidance of excessively irregular topography, ground-water elevations, extremely pervious soil formations, surface rock formations and outcroppings, and close proximity to natural drainage channels. At least five feet of separation between the bottom of disposal trenches and the highest ground-water elevation is desirable. Exceptions to this rule will be considered on individual merit but only where the site can be so modified as to demonstrably preclude any wetting of deposited waste by ground water.

SCHEDULE: Agency review time of 60 days.

ACTIVITY: APPROVAL TO REPAIR, CLEAN, DEEPEN, OR REPLACE AN EXISTING WELL

LEGAL CITATION: Utah Code Annotated, 73-3-1, 73-3-3, and 73-3-28, 1953; and Rules and Regulations of the Office of the State Engineer.

AGENCY/CONTACT: Office of State Engineer
Utah Division of Water Rights
1636 West North Temple
Salt Lake City, UT 84116
ATTN: Dee Hansen, State Engineer
Rick Hall, Distribution Engineer (801) 533-6071

PROCEDURE: This approval is required prior to repairing, cleaning, deepening, or replacing existing wells in order to prevent water contamination or well cave-in. Application is made by filing Form 112 which requires the following information:

(1) Water claim number or appropriation number.

(2) Name and address of the applicant.

(3) Description of the nature of the proposed work.

(4) Name of the well driller who will perform the work.

SPECIAL CONSIDERATIONS: Replacement of a well must be within 150 feet of the existing well. In addition, regulations stipulate minimum construction standards for drilled wells (gravel packed and artesian), and non-drilled wells (driven, jetted, dug, and bored).

SCHEDULE: An application is normally processed within 30 days.

ACTIVITY: APPROVAL OF WELL PLUGGING

LEGAL CITATION: Water Laws of Utah, UCA 73-5-9, and Regulations for Water Well Drillers, Utah Division of Water Rights, July 1, 1980

AGENCY/CONTACT: Office of State Engineer
Utah Division of Water Rights
1636 West North Temple
Salt Lake City, UT 84116
ATTN: Dee Hansen, State Engineer
Rick Hall, Distribution Engineer (801) 533-6071

PROCEDURE: The State Engineer may require that any well be plugged to prevent pollution or contamination of ground water. Prior to plugging wells, the Office of the State Engineer must be notified to determine the acceptability of plugging techniques.

SPECIAL CONSIDERATIONS: The following procedures shall be observed when sealing monitor wells.

(1) Temporary Abandonment. When any well is temporarily removed from service, the top of the well shall be sealed with a water-tight cap or seal. If the well is temporarily abandoned during construction, it shall be assumed that the well is permanently abandoned after 90 days and a well driller's report will be submitted in compliance with Section 4.3 of these regulations.

(2) Permanent Abandonment. Any well that is to be permanently abandoned shall be filled in a manner so as to prevent the well from being a channel allowing the vertical movement of water and a possible source of contamination of the ground-water supply.

(3) Abandonment of Artesian Wells. A cement grout or concrete plug shall be placed in the confining stratum overlying the artesian zone so as to prevent subsurface leakage from the artesian zone. The remainder of the well shall be filled with cement grout, concrete, or puddled clay.

(4) Abandonment of Drilled and Jetted Wells. A cement grout or concrete plug shall be placed opposite all perforations or openings in the well casing. The remainder of the well shall be filled with cement grout, concrete, or puddled clay.

(5) Abandonment of Gravel Packed Wells. All gravel packed wells shall be pressure grouted throughout the perforated section of the well casing. The remainder of the well shall be filled with cement grout, concrete, or puddled clay.

(6) Plugged Wells. If it is desired to remove the well casing during abandonment, the well shall be plugged as the casing is removed. The well shall be plugged with cement grout, concrete, or puddled clay. In the case of gravel packed wells, the entire gravel section shall be pressure grouted.

Failure to diligently execute plugging requirements determined by the State Engineer constitutes a separate misdemeanor offense for each day of violation.

SCHEDULE: None specified.

ACTIVITY: ENCROACHMENT PERMIT

LEGAL CITATION: Utah Code Annotated, 27-10-1 through 27-12-3.

AGENCY/CONTACT: Utah Department of Transportation
2060 South 2400 West
Salt Lake City, UT 84104
ATTN: Andy Sopko (801) 973-4588

PROCEDURE: A permit is required prior to performing any type of work on a state highway or highway right-of-way. The application must contain a description and duration of the proposed activity, and a map of the location. A field inspection by the Department will be conducted.

SPECIAL CONSIDERATIONS: None.

SCHEDULE: Normal timeframe is one week.

ACTIVITY: REVIEW OF TRANSPORTATION ON STATE HIGHWAYS

LEGAL CITATION: Utah Code Annotated, Title 54-6, and Federal Motor Carrier Code.

AGENCY/CONTACT: Utah State Department of Transportation
4501 South 2700 West
Salt Lake City, UT 84119
ATTN: Legrand Jones (801) 965-4272

PROCEDURE: The Department of Transportation will be responsible for reviewing and approving use of State highway transportation corridors to and from the project site. Information to be reviewed includes routing of trucks, frequency and time of delivery, expected load capacities and procedures for transportation of tailings.

SPECIAL CONSIDERATIONS: None.

SCHEDULE: Review must be completed prior to construction.

ACTIVITY: REVIEW OF FLOOD CONTROL AND DRAINAGE SYSTEM MODIFICATIONS

LEGAL CITATION: N/A

AGENCY/CONTACT: Salt Lake County
Flood Control & Water Quality Division
2033 South State
Building One, Third Floor
Salt Lake City, UT 84115
ATTN: Terry Holzworth, Director (801) 535-5711

PROCEDURE: Any modification of a floodway or storm water drainage system caused by the design will be reviewed and approved by the Flood Control Division. No standards or specifications are promulgated. However, good engineering practice must be used to accommodate the anticipated flows to the South Vitro Ditch from the site. Plans and engineering calculations must be submitted for review and approval.

SPECIAL CONSIDERATIONS: None.

SCHEDULE: Plans must be approved prior to construction.

ACTIVITY: CONSTRUCTION REVIEW - NOISE ESTIMATE

LEGAL CITATION: Noise Control (Ordinance 601, Title 16, Chapter 150, Sections 1 through 13).

AGENCY/CONTACT: Salt Lake City/County Health Department
610 South 200 East
Salt Lake City, UT 84111
ATTN: Dr. Harry Gibbons (801) 532-2002

PROCEDURE: An estimate of noise levels (day and night) to be generated during construction at the Vitro site and the basis for the estimate should be submitted to the Department. The estimates will be used to determine the need for noise measurements and/or a permit.

SPECIAL CONSIDERATIONS: Measurements at the site boundary and/or at affected properties may be required. A permit is needed when noise levels (dBA) exceed:

Land Use	Day	Night
Industrial	80	75
Residential	60	55

SCHEDULE: Review must be completed before construction.

ACTIVITY: REVIEW OF TRANSPORTATION ON COUNTY ROADS

LEGAL CITATION: N/A

AGENCY/CONTACT: Salt Lake County
Department of Public Works
Highway Division
7125 South 600 West
Midvale, UT 84047
ATTN: Ron Flynn (801) 255-4283

PROCEDURE: The County Department of Public Works, Highway Division, will be responsible for approving the use of county roads by vehicles hauling tailings and other materials. Information to be submitted for review includes routing of trucks, frequency and time of delivery, expected load capacities, and dust control measures.

SPECIAL CONSIDERATIONS: None.

SCHEDULE: The review must be completed prior to construction.

ACTIVITY: GRADING PERMIT

LEGAL CITATION: City of South Salt Lake Zoning Code 15-12-11 and 15-12-12.

AGENCY/CONTACT: City of South Salt Lake
2500 South State Street
South Salt Lake City, UT 84115
ATTN: Ronald Stone
Director of Building and Planning (801) 535-7113

PROCEDURE: An application is filed with the Building and Planning Department which shall include the following information:

(1) Name and address of applicant.

(2) Description of the location and duration of the proposed grading operation.

(3) Discussion and drawings of proposed surface drainage, slopes, and structures for retention or diversion of surface runoff.

SPECIAL CONSIDERATIONS: The City has adopted the Universal Building Code which addresses surface grading practices. Application fees may be required.

SCHEDULE: Application review and processing of non-controversial permits involves as little as two weeks. Controversial projects could be subject to a public hearing and processing times that are substantially longer.

ACTIVITY: APPLICATION TO AMEND THE ZONING MAP OF TOOELE COUNTY, UTAH

LEGAL CITATION: Tooele County Zoning Ordinance

AGENCY/CONTACT: Tooele County Corporation
Development Services
47 South Main Street
Tooele, Utah 84074
ATTN: Joseph A. Urbanik, Director
Building and Zoning Administrator (801) 882-5550
Ext. 224

PROCEDURE: An application is submitted by the landowner to Tooele County Development Services which includes the following information:

(1) Present zoning classification.

(2) Requested zoning classification.

(3) Description and plat of property to be considered indicating all roadways, easements, and rights-of-ways as required.

(4) Names, addresses, and telephone numbers of all property owners within the proposed area as well as immediately adjacent property owners.

(5) A statement of how this proposal is consistent with the policies of the Master Plan.

(6) A statement of how this proposal will be beneficial to the general public.

(7) Any other items as required by the Building and Zoning Administrator or the Planning Commission.

The completed application to amend is presented by the Development Services Staff to the Tooele County Planning Commission at one of the monthly meetings. The application and fee must be received ten days in advance of the commission meeting in which the application is to be addressed.

The Planning Commission will set a date for a public meeting and appoint a hearing officer. Notice of the public hearing must be published in a local newspaper 30 days prior to the hearing. A recommendation by the Planning Commission is made within 30 days of the hearing. The Board of County Commissioners issues a decision after considering the Planning Commission recommendation.

SPECIAL CONSIDERATIONS: Currently, the zoning classification of the Clive site is MU-40 (Multiple Use District). Construction of waste disposal facilities are allowed only in the MG zone (Manufacturing General), as a conditional use (Tooele County Zoning Ordinance, Chapter 16-2x.(d)). Conditional uses in a particular zone are approved on an individual basis as explained under a separate heading in this appendix.

APPLICATION TO AMEND THE ZONING MAP OF TOOELE COUNTY, UTAH (Concluded)

SCHEDULE: Approximately 90 days is required for processing a zone change from the time the application is filed with Tooele County until the County Commissioner's decision is announced.

ACTIVITY: CONDITIONAL USE PERMIT

LEGAL CITATION: Tooele County Zoning Ordinance

AGENCY/CONTACT: Tooele County Corporation
Development Services
47 South Main Street
Tooele, UT 84074
ATTN: Joseph A. Urbanik, Director
Building and Zoning Administrator (801) 882-5550
Ext. 224

PROCEDURE: An application is filed with Tooele County Development Services which requires the following information:

(1) Name, address, and telephone number of applicant.

(2) Location of the proposed use by legal description or street address.

(3) Detailed description of the proposed use.

(4) Location map.

(5) Site and building plan.

(6) Names and addresses of all adjoining property owners within 300 feet of the subject property.

A design review is performed by the Development Services and/or the Planning Commission members addressing the County performance standards and design review considerations (Tooele County Zoning Ordinance, Chapters 10 and 11). Issues that are addressed include:

(1) Public nuisance problems (e.g., fires, explosions, radioactivity, noise, vibration, smoke, dust, odor, glare, and solid or liquid waste).

(2) Traffic safety and traffic congestion.

(3) Landscaping.

(4) Buildings and site layout.

(5) Surface drainage.

The application is presented to the Planning Commission by the Development Services Staff. A public hearing is not required, but may be called for if the Planning Commission determines it to be in the public interest. The Planning Commission reaches a decision to approve or disapprove the application usually within 30 days of filing the application. Approval of a conditional use permit is usually subject to stipulations that are specific for the conditional use.

The decision of the Planning Commission can be appealed to the County Commission.

SPECIAL CONSIDERATIONS: Applications for a conditional use permit and zoning map amendment for the Clive disposal facility could possibly be submitted together for simultaneous processing by Tooele County Development Services.

After approval of a conditional use, the Development Services is authorized to inspect the development to ensure compliance with the permit. A building permit should be obtained from the Building Inspector for construction of any building or structure.

Technical review of the application is based on compliance with the zoning ordinance and whether the conditional use will be detrimental to the health, safety, or general welfare of persons residing or working in the vicinity.

Development of new mining activity to supply clay or rock borrow materials should be addressed in the conditional use permit application. Borrow sites that are widely separated from the Clive site may be subject to a separate conditional use permit application.

SCHEDULE: Most conditional use permits are approved within one month after receipt of the application by Tooele County Development Services. A public hearing would extend the public processing time.

APPENDIX B

CALCULATIONS SUMMARIES AND

DESIGN DRAWINGS

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1.0 EARTHWORK VOLUMES

I. PROBLEM STATEMENT

This section provides calculations involving earthwork at the Vitro and South Clive sites. The separate calculations and their purposes are identified as follows:

A. Contaminated Quantities

- o Volume and area of on-site tailings and contaminated materials to be relocated.
- o Volume and area of off-site contaminated materials to be relocated.

B. Embankment Quantities

- o Volume and area of the embankment to contain the contaminated materials.
- o Volume of radon barrier cover soils.
- o Volume of erosion barrier cover materials.

C. Restoration and Miscellaneous Quantities

- o Volume of restoration materials at the Vitro site.
- o Area to be vegetated at the Vitro site.
- o Length and material volumes for access roads.
- o Length and material volumes for the rail spurs.
- o Ditch lengths and material volumes.

II. METHODS OF CALCULATION

A. Contaminated Quantities

- o The volume of the Vitro site contaminated materials was estimated using CPS-1 (Radian, 1979) and automated surface calculation package. The 15 pCi/g contamination surface (see Section 3.0 Limits of Contamination) and the existing topographic surface (Figure 3.3) were used to determine the volume of contaminated materials.

- o The volume of off-site windblown materials was estimated by multiplying the appropriate thickness (see Section 3.0, Limits of Contamination) by the areal extent involved. The volume of contaminated materials from future vicinity properties was calculated using data from previous Salt Lake City vicinity property remedial actions.

B. Embankment Quantities

The required embankment height was calculated geometrically assuming:

- o Contaminated materials placed in an 1100-foot by 2200-foot area.
- o Partial below-grade disposal, extending 9 feet below natural grade.
- o Sideslopes 5 horizontal to 1 vertical.
- o Top slopes 2 percent.

Cover quantities were calculated by multiplying the appropriate thickness by the areal extent involved.

C. Restoration and Miscellaneous Quantities

The volume of restoration fill required at the Vitro site was estimated using CPS-1 (Radian, 1979). The volume between the 15 pCi/g contamination surface and the final grading surface (Drawing .0005) was found.

III. CONCLUSIONS

A. Contaminated Quantities

The volumes of contaminated materials are shown in Table 1.1. Virtually all 128 acres of the Vitro site contain some contamination. Approximately 55 acres outside the Vitro site are covered with contaminated materials.

B. Embankment Quantities

Embankment and cover quantities for the South Clive site are shown in Table 1.1. The covered embankment will cover approximately 55 acres. The final fenced area, including a perimeter road and ditch, will be approximately 60 acres.

IV. REFERENCE

Radian (Radian Corporation), 1979. CPS-1 User's Manual Training Documentation, Volumes I and II, CPS-1 Support Staff, Austin, Texas.

Table 1.1 Earthwork volume summary - train relocation to South Clive

Item description	Estimated volume (cubic yards)
Vitro site:	
Rail spur construction	
Excavation of contaminated materials	180,000
Subgrade and subballast (select fill)	94,000
Contaminated materials	
Tailings and contaminated subsoils	2,220,000
Windblown and vicinity properties	150,000
Rubble	80,000
Restoration (select fill)	945,000
South Clive site:	
Access road construction	
Road subgrade (compacted fill)	27,000
Gravel surface	31,000
Rail spur construction	
Subgrade (select fill)	98,000
Subballast (select fill)	10,000
Embankment construction	2,450,000
Cover	
Radon barrier	740,000
Erosion barrier, ditches, and perimeter roads (pit run rock)	202,000

2.0 MATERIAL PROPERTIES

I. SUMMARY OF MATERIAL PROPERTIES

Detailed site description, stratigraphy, geology, and laboratory test data are presented in the Disposal Site Characterization Report (DSCR, 1984).

A. Tailings and Contaminated Materials

- o The tailings at the Vitro site are divided into sand and slime components. Gradational ranges between the two components due to depositional characteristics are present. The sands are classified as SP, SM, and SM/ML while the slimes classify as CL, ML, and ML/CL material. The near surface natural soils underlying the site consist of organic clay top soil and clay soil. These materials classify as CL.
- o Undisturbed and remolded material properties were determined from numerous samples obtained from 28 borings and 5 test pits (CSU, 1982).
- o Some of the important properties necessary in characterizing the materials are presented in Table 2.1.
- o The long-term average moisture content of the compacted tailings at the South Clive site was calculated using statistical relationships between soil properties, matrix potentials, and soil water contents (Gupta and Larson, 1979; Baumer and Brasher, 1982; Brakensiek et al., 1982); TRUST modeling; and mixed tailings properties (Nielson, 1983a, 1983b; CSU, 1982). The calculations are shown in Table 2.2.

B. Borrow Material

- o The borrow for radon barrier material will be obtained from the excavation (7 to 9 feet) for the embankment. A suitable rock erosion borrow site has been identified approximately 5 road miles to the north of this disposal site. Subsection C addresses the procedures required to select an acceptable rock source.
- o The radon barrier borrow site was investigated by excavating six (6) test pits. Logs were maintained of each test pit and representative bulk samples were obtained for further classification and testing (TAC, 1983). Suitable material was visually identified at the site.
- o Laboratory testing of the radon barrier material consisted of classification according to Unified Soils Classification System (USCS), grain size analysis, Atterberg limits, specific gravity, moisture-density relationships, and remolded permeability (TAC, 1983).

- The radon barrier material will consist of CL-ML and CL soils having material properties as summarized in Table 2.3.

- The long-term average and minimum (at 15 Bars of soil suction) moisture content of the radon barrier material was calculated with the same method used for compacted tailings (See A above). The results are shown in Table 2.2.

C. Rock Testing

The rock that will be used for erosion protection will be screened out of the borrow source. Before the material is placed, the material will be tested by the State of Utah for its grain size distribution and durability. Additionally, once construction has started, the State will conduct an ongoing testing program which will ensure that the material meets the specifications for material selection, testing, and placement. These specifications, to be performed and followed by the State, are described in the following paragraphs.

The sources from which the rock will be obtained should be selected well in advance of the time when the stone will be required for placement. The acceptability of the rock should be determined by service and/or by suitable tests. If testing is required, suitable samples of rock should be taken using Standard Practices for Sampling Aggregate (ASTM D75), at least 60 days prior to the start of construction. Additionally, the approval of some rock from a borrow area will not be construed as constituting the approval of all rock taken from the borrow area.

If service records are not available or do not exist, resistance to disintegration from the type of exposure to which the stone will be subjected should be determined by any or all of the following tests, depending on the rock to be used and the site climatic conditions.

- One of the parameters needed in the design of the size of rock required for erosion protection is the specific gravity. Additionally, the specific gravity and absorption (ASTM C127) can be used to evaluate the durability of a rock. The specific gravity of a rock is an indicator of its strength. The higher the specific gravity the better the quality of the rock. The specific gravity is also a good indicator of a rock's ability to withstand cycles of freezing and thawing.

  Absorption by itself is not a good indicator of a rock's freeze/thaw characteristics by itself. However, a low absorption is a desirable property to prevent the rapid disintegration by salt action and mineral hydration.

  It is recommended that a suitable rock be one that has a specific gravity greater than 2.6 and an absorption less than 1 percent.

- o When riprap must withstand abrasive action from material transported by streams, or large flow on or adjacent to the pile, the Los Angeles Abrasion Test should be used. When the abrasion test in the Los Angeles Machine (ASTM C131 or C535) is used, the stone shall not have a percentage loss of more than 40 percent after testing. Additionally, the ratio of the loss after 100 revolutions to the loss after 500 revolutions for ASTM C131, and after 200 revolutions to the loss after 1,000 revolutions for ASTM C535, should not exceed 20 percent for materials of uniform hardness.

- o In locations subject to freezing or where the stone is exposed to salt water, the Sulfate Soundness Test (ASTM C88) should be used. Stones should not have a loss after five cycles exceeding 10 percent if sodium sulfate is used and a loss exceeding 15 percent when magnesium sulfate is used.

- o A better guide to weathering which may be used in place of item 2 above is AASHTO Test 103 for ledge rock, Procedure A. From this test, the stone should not have a loss exceeding 10 percent after 12 cycles of freezing and thawing.

- o Another method which can be used to evaluate durability of a particular rock is the hardness test as determined by the Point Load Test; or the Schmidt Rebound Hammer. If the Point Load Test is used, a value >300 is acceptable. If the Schmidt Hammer is used, a value of <25 is acceptable.

It must be recognized that considerable judgement is required during site evaluation and laboratory testing procedures. The laboratory or index tests are dependent on the availability of equipment and the contract testing laboratory. There is sufficient interaction among the various tests described to provide a basis for the judgement of the durability of a rock source with a minimum amount of testing. The greatest number of tests should be run on rock types that have been judged to be marginal during site investigations.

Should any of the rock being evaluated for use as erosion protection not meet the recommended standards for acceptable rock durability, a new rock source should be evaluated if one is available within a reasonable distance from the site.

If an alternate rock source of better durability cannot be found, the size of the rock should be increased to take into account the degradation of the rock with time. The increase in size is subjective but it is proposed that the rock size be increased by the percentage that the rock fails a criteria.

When placing the rock, each load of rock should be reasonably well-graded from the smallest to the maximum size specified. Control of gradation can be controlled by visual inspection. If any differences of opinion occur between the engineer and the contractor, the differ-

ence shall be resolved by dumping and checking the gradation of any two radon truckloads of rock. Alternatively, if the rock size is not greater than three inches, the rock can be physically tested using U.S. standard sieves of the appropriate sizes.

D. Foundation Soils

o The stratigraphy underlying the South Clive site as determined by soils exploration borings is summarized below in Table 2.4 (DSCR, 1984; TAC, 1983).

Table 2.4 Description of stratigraphy - South Clive

	Range in depth below existing grade (ft)		
Stratigraphy	Top of layer	Bottom of layer	Material classification
Upper clay	0	7.0 to 13.5	CL, ML, CL-ML
Upper sand	7.0 to 13.5	23.5 to 37.5	SP, SP-GP, SM, SM-CL, CL and ML
Lower clay	23.5 to 37.5	45.0 to 51.0$^+$	CL-ML, CL, CL-CH,
Lower sand	45.0 to --	250.0$^+$	SM

o Ground water was encountered at depths ranging from 23.0 to 31.2 feet below existing grade.

o Undisturbed material properties were determined (DSCR, 1984). Tests included USCS classification, grain size analysis, Atterberg limits, specific gravity moisture-density relationships, permeability, consolidation, triaxial compression and direct shear.

o Consolidation test results indicate the following range of compressibility characteristics for the natural soils:

Material	Preconsolidated pressure (psf)	Compression index (virgin)	Compression index (rebound)
Upper clay	1400	0.120	0.012
Upper sand	6000	0.240	0.048
Lower clay	4000-9500	0.180-0.223	0.030-0.048
Lower sand	N/A	N/A	N/A

Strength parameters, derived from the available test data are presented below:

Material	Cohesion, C in psf	Angle of internal friction
Upper clay	100	23
Upper sand	0	34
Lower clay	N/A	N/A
Lower sand	N/A	N/A

E. Restoration Fill Material

- o The 82-acre borrow site for the restoration fill material is located approximately 10 road miles from the Vitro site, east of 6400 West on 5400 South Street. The site is presently operated as a private borrow source for random and select granular fill material.

- o The borrow area was investigated by excavating 6 test pits and examining the working face. Logs were maintained of each test pit and representative bulk samples were obtained for further classification and laboratory testing (TAC, 1983). Suitable materials were identified at the site.

- o Laboratory testing of the restoration fill material consisted of gradation, Atterberg limits, specific gravity and moisture-density relationships (TAC, 1983).

- o The borrow material consists of GM, GM-GW and SW-GW soils having material properties summarized in Table 2.5.

Table 2.5 Restoration fill material properties

Material description	USCS classification	Atterberg limits	Specific gravity	In-situ moisture content %	Percent passing no. 200 sieve
Restoration fill (silty sand gravel)	GM-GW	Non-plastic	2.60	8-10	9-12

Moisture-density relationships (ASTM D698) and permeability

Test pit number	USCS classification	Maximum dry density (pcf)	Optimum moisture content (OMC) %	Permeability (cm/sec) at 95% compaction and OMC
1	GM-GW	129	8.5	3×10^{-4} cm/sec
2	GM	128	8.6	----
6	GM-GW	129	8.5	----

II. GEOTECHNICAL CONSTRUCTION CRITERIA

A. Material below the excavation should be moisture conditioned to 0 to 3 percent above Optimum Moisture Content (OMC) and recompacted to a minimum of 95 percent of the maximum dry density as determined by the Standard Proctor Test (ASTM D698).

B. Tailings should be compacted to a minimum of 90 percent of this maximum dry density as determined by the ASTM D698 Method of Compaction at 0 to 3 percent below Optimum Moisture Content. Although dry below insitu moisture content is required during excavation and transport, additional spreading, digging and mixing may be required to meet the required moisture range.

C. Radon barrier cover should be compacted to 95 percent of the maximum dry density as determined by this ASTM D698 Method of Compaction, at 0 to 3 percent above Optimum Moisture Content (OMC). Spreading, mixing and digging may be required in order to meet the moisture requirements.

D. Suitable fill material required for restoration of the Vitro site is available from numerous sources in the Salt Lake Valley. This material should be placed to a minimum 90 percent of the maximum dry density as determined by the ASTM D1557 Method of Compaction. Prior to placement of fill material, the subgrade soils loosened by the excavation process should be recompacted to the same density requirements. Deleterious or other objectionable fill material should not be used.

III. REFERENCES

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Table 2.1 Summary of tailings and contaminated soils material properties

Material description	In-Situ Properties				Moisture Density (ASTM D698)	
	Moisture content (%)	Dry density (PCF)	Degree of saturation (%)	Percent passing No. 200 sieve	Maximum dry density (PCF)	Optimum moisture content (%)
Sand tailings	9.0 to 18.0	90 to 107	29 to 100	2.4 to 47.6	101 to 117	12.4 to 15.9
Slime tailings	27.0 to 79.0	59 to 89	63 to 100	68.0 to 85.0	93 to 96	21.1 to 27.0

Table 2.2 Long-term average moisture content of compacted tailings and radon barrier soil at the South Clive site

Material	Porosity n	Dry unit Weight (PCF)	Percent Passing #200 sieve	Percent less than 0.002 mm	Percent organic matter	Depth to water table (ft)	Specific gravity (Gs)	Long-term average moisture content % of dry weight
Compacted tailings	0.447	93	52	7	0	35	2.70	10
Radon barrier	0.477	90	93	29	0	50	2.76	18

Table 2.3 Summary of cover material properties

Material description	In-Situ Properties				Moisture Density Relations	
	Moisture content (%)	Dry density (PCF)	Degree of saturation (%)	Percent passing No. 200 sieve	Maximum dry density (PCF)	Optimum moisture content (%)
Silty clay and clay	23.0 to 45.0	79 to 101	--	76 to 99	92 to 97	25.2 to 28.0

3.0 LIMITS OF CONTAMINATION

I. PROBLEM STATEMENT

The principle objectives of this section are to report the magnitude and characteristics of the radiation emitted from the Vitro tailings pile and provide information toward the removal of the tailings and contaminated soil.

II. RADIATION DATA

A. Background Data

The purposes of background radiation data are to provide a reference point to which levels of contamination on the site can be compared, and to assess construction impacts on the environment. Measurements of background radiation levels near Salt Lake City have resulted in the following determinations:

- The average background external gamma exposure rate at a height of 1.0 meter above the surface is 12 microR/hr (ORNL, 1977), with a range from 9 to 17.
- The average background level of Ra-226 in soil at 18 locations in the Salt Lake valley is 1.5 pCi/g (FBDU, 1981); essentially being in equilibrium with the natural U-238 background. The sampling locations for these determinations are shown in Figure 3.1.
- In January 1983, Bendix Field Engineering Corporation (BFEC) performed additional radiological site characterization, (BFEC, 1983a). Measurements were taken at twelve background locations ranging from 1.0 to 3.0 miles from the pile. Background measurements resulted in an average laboratory assay of 1.22 pCi/g Ra-226 and an average external gamma exposure rate of 11.9 microR/hr. Considering the different locations from which data were taken, the Bendix data are considered in reasonable agreement with the ORNL measurements.
- Monsanto Research Corporation (Mound) conducted an outdoor ambient radon concentration study for the time period January 1982, through July 1983. These data indicate an annual average radon concentration of approximately 0.3 pCi/l from measurements at locations at least one mile from the tailings site (Monsanto, 1983).

B. Pile Ra-226 Concentration

The Ra-226 concentration and distribution in the tailings pile are required in order to design the shaping of the pile and to calculate

the cover thickness to be applied to the final configuration during remedial action.

The Vitro site contains approximately 2.3 million cubic yards of uranium mill tailings, rubble, sewage sludge, and other mill wastes on the site. An additional 0.15 million cubic yards of windblown and other off-site contaminated materials will be included in the final stabilization.

Physical characteristics of the tailings are described by Martin et al. (1980) and by MSRD (1982). The NW tailings consist mainly of medium to fine sands. The SW and SE piles contain mostly fine sands with varying proportions of slimes. The site average tailings moisture content is 20 percent, with the contaminated material beneath the site averaging 23 percent (MSRD, 1982).

In-situ densities are on the order of 1.4 g/cm^3. Results of standard Proctor tests indicate that maximum densities of 1.6 to 1.8 g/cm^3 would be obtained for the sandier materials at 10 to 16 percent moisture content. The maximum densities for finer materials would about 1.5 g/m^3 at 20 to 30 percent moisture. Most field samples were at 75 to 85 percent of the maximum Proctor density (FBDU, 1981).

The radon emanation coefficient is the fraction of radon produced within the soil or tailings grains that is released to the interstitial pore spaces. Vitro tailings samples analyzed at LASL (1981) ranged from 0.12 to 0.20. The NRC (1979) reported a measured value of 0.2 for Vitro tailings and considered this to be a good generic value for tailings.

The principal isotopes of concern are U-238, Th-230, and Ra-226. Concentrations of other isotopes may be estimated based on these radionuclides and the assumption of secular equilibrium. Although many estimates of the radionuclide contents of the Vitro tailings have been made (FBDU, 1981; ORNL, 1977; LASL, 1981; Schiager, 1974), the values reported herein are based on the statistically designed drilling and sampling program of MSRD (1982). Additional work using MSRD samples has been done by Sandia (1982) and Bendix (1983b).

MSRD (1982) found a site average of 0.014 percent uranium (U_3O_8) in the tailings. This corresponds to about 40 pCi/g of U-238, based on 104 boreholes sampled every 2.4 feet with depth.

The Ra-226 concentration in the material on the site averages 560 pCi/g based on 181 samples from 66 of the 104 boreholes drilled by MSRD. The Ra-226 analyses were done by Bendix (BFEC, 1983b) on all samples of sufficient volume that remained from the sampling program.

A Th-230 concentration of 560 pCi/g may be estimated assuming the Ra-226 is in secular equilibrium. Other information indicates the Th-230 concentration is perhaps 30 percent lower than this (LASL, 1981), probably due to extraction during the acid leach process.

Sediment samples from the Jordan River, Mill Creek, and the Vitro drainage ditch were collected and analyzed for U-238, Ra-226, and Pb-210 (ORNL, 1977). Results showed no contamination in Jordan River sediments, and slightly elevated levels (roughly twice estimated background) in Mill Creek sediments. The drainage ditch sediments, however, were shown to contain relatively elevated concentrations of all three radionuclides. Ra-226 concentrations range from 60 to 120 pCi/g, while Th-230 concentrations ranged up to 284 pCi/g, which was higher than any other reported radionuclide.

Radon flux at the Vitro site has been measured or calculated by various groups. Short-term flux measurements by ORNL (1977) averaged 320 pCi/m^2s based on Ra-226 content of the material. Schiager (1974) reported values that, when weighted by the area of the source, yield an average of 400 pCi/m^2s; although he assumed a value of 350 pCi/m^2s. FBDU (1981) reported a measured range of 19 to 440 pCi/m^2s and an area-weighted average of 250 pCi/m^2-s, but used a calculated value of 600 pCi/m^2s in estimating the health effects. The NRC (1979) reported radon flux-to-radium concentration ratios of 0.35 for wet tailings, and 1.2 for dry tailings in units of pCi/m^2s radon flux per pCi/g of Ra-226; however, the NRC prefers a generic value of 1.0 for this ratio. Based on the above estimated average radium concentration of 560 pCi/g, and assumed radon flux-to-radium concentration ratio of 1 gram per square meter-second would yield a radon flux of 560 pCi/m^2s.

C. Sub-Pile Contamination

Depths of the tailings on the bulk of the site were reported to vary from 6 to 17 feet (Martin et al., 1980) but more recent data of Mountain States Research and Development, Inc. (MSRD, 1982) indicate the range may go as much as 40 feet deep on the SE pile. The bulk of the material is in the SE pile, which appears to be the thickest.

Figure 3.2 depicts the locations of the drill holes from which the average radium content of the pile was calculated. The holes prefixed by "DS" are reported as part of the Bendix data report. The remaining holes are from the MSRD program. In conjunction with the MSRD program, data have been reported (SNL, 1982) indicating Ra-226 contamination below the interface between tailings and original surface to a maximum depth of about 5 feet. The average depth below the interface for Ra-226 concentrations of 15 pCi/g was about 2 feet. This is based on only 20 percent of the holes indicated in Figure 3.2. However, all holes have a reported depth to the interface based on visual and textural differences between the tailings and original surface materials.

By using the visual and textural interface depth with 2 feet added, a sub-pile surface can be generated which is the 15 pCi/g average surface below the pile (limit of excavation).

Figure 3.3 indicates this 15 pCi/g surface as a contour of elevations in feet above MSL. Because the surface was generated using the hole locations shown in Figure 3.2 which are all on the pile, the contour lines do not close (i.e., no off-pile control points were used to indicate zero tailings depth immediately beyond the tailings boundary). This results in a display somewhat analogous to a "cookie cutter" approach. In reality, the contamination depth follows the contours shown in Figure 3.3 at all locations except right at the edges, where it rises rapidly to meet the existing topographic surface.

Selected north-south cross-sections, A-A', B-B', and C-C' across the site showing existing topography and contamination depth are shown in Figure 3.4. The cross-section lines are located in Figure 3.2. Note that the edge effects where the two surfaces meet have been drawn schematically.

D. Off-Pile Contamination

Because of the nature of tailings, they are easily moved by the wind. Contamination appearing to be due to wind erosion of the pile has been identified up to 0.25 mile from the site.

The statistically designed soil sampling protocol performed by Bendix does allow accurate definition of the extent of the 5 pCi/g contamination level. That protocol is described in the Bendix data report (BFEC, 1983a). Using good engineering judgement and liberal smoothing, the extent of the 5 pCi/g contamination level in the 0" to 6" layer can be determined. This is shown by the shaded areas of Figure 3.5.

The depth of the windblown contamination does not exceed 6" below the local surface. This may be seen by referring to the BFEC soil sample analyses for the depth interval of 6" - 12" (BFEC, 1983a).

The identified windblown contamination will be removed from the surrounding properties as a part of the vicinity property cleanup action. These data are included here only to indicate the quantities of contaminated material to be added to the final embankment at Clive.

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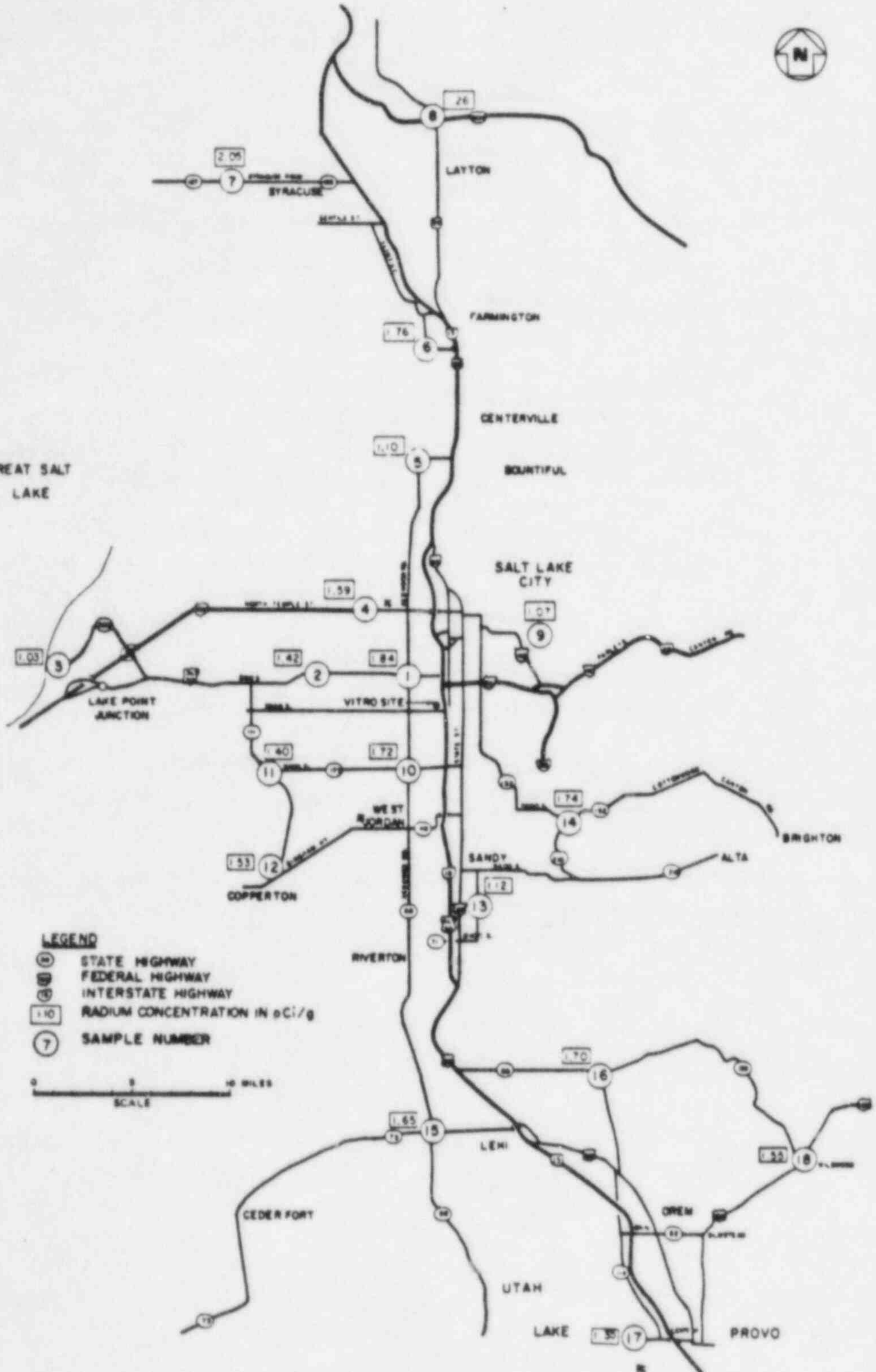

FIGURE 3.1
LOCATIONS FOR Ra-266
BACKGROUND SAMPLES

Ford, Bacon & Davis Utah Inc.

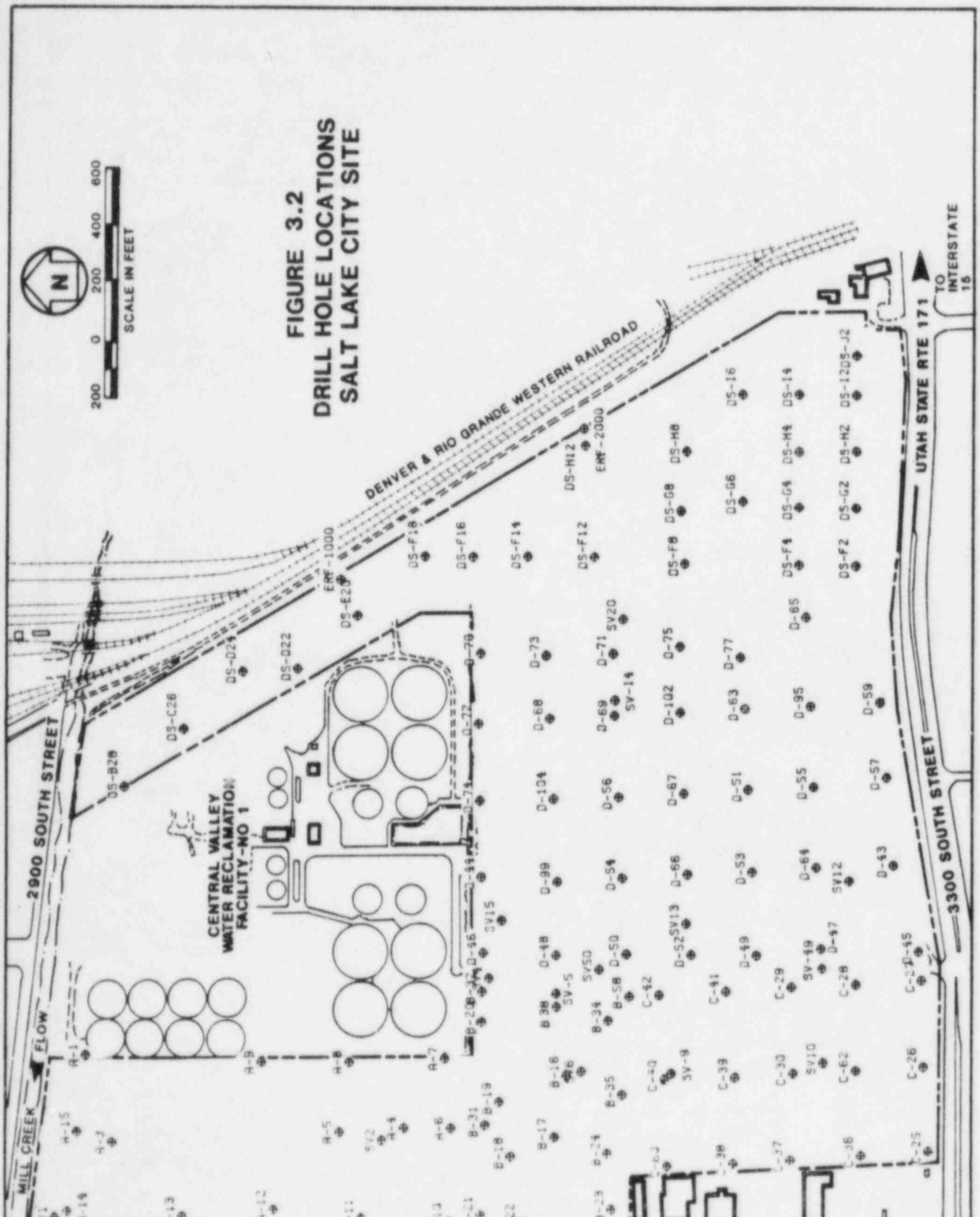
FIGURE 3.2
DRILL HOLE LOCATIONS
SALT LAKE CITY SITE
N
SCALE IN FEET
200 0 200 400 600
DENVER & RIO GRANDE WESTERN RAILROAD
2900 SOUTH STREET
3300 SOUTH STREET
UTAH STATE RTE 171
900 WEST STREET
CENTRAL VALLEY
WATER RECLAMATION
FACILITY-NO 1
MILL CREEK
FLOW
TO JORDAN RIVER
TO INTERSTATE 15

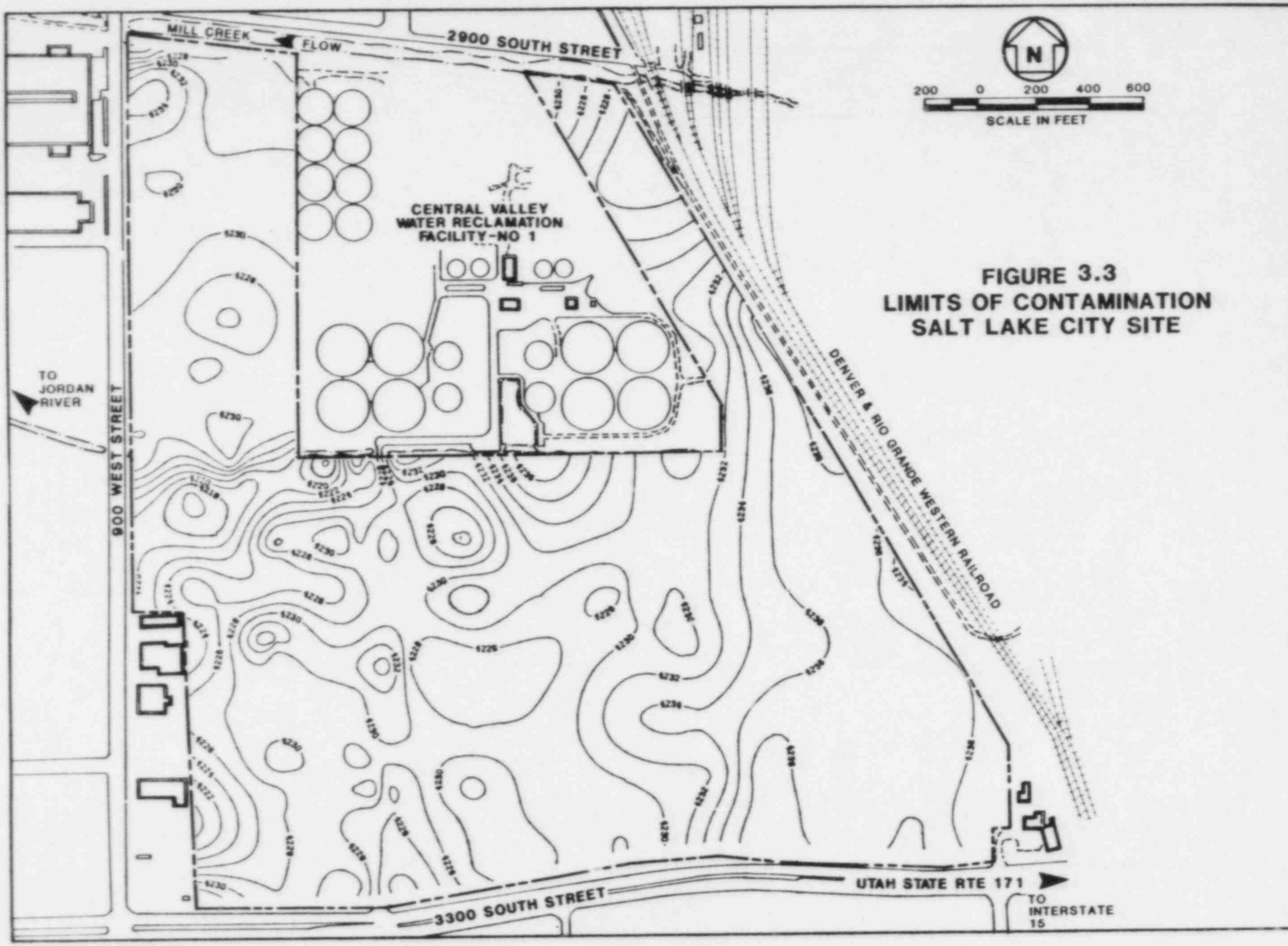

FIGURE 3.3
LIMITS OF CONTAMINATION
SALT LAKE CITY SITE

SLC-03-008

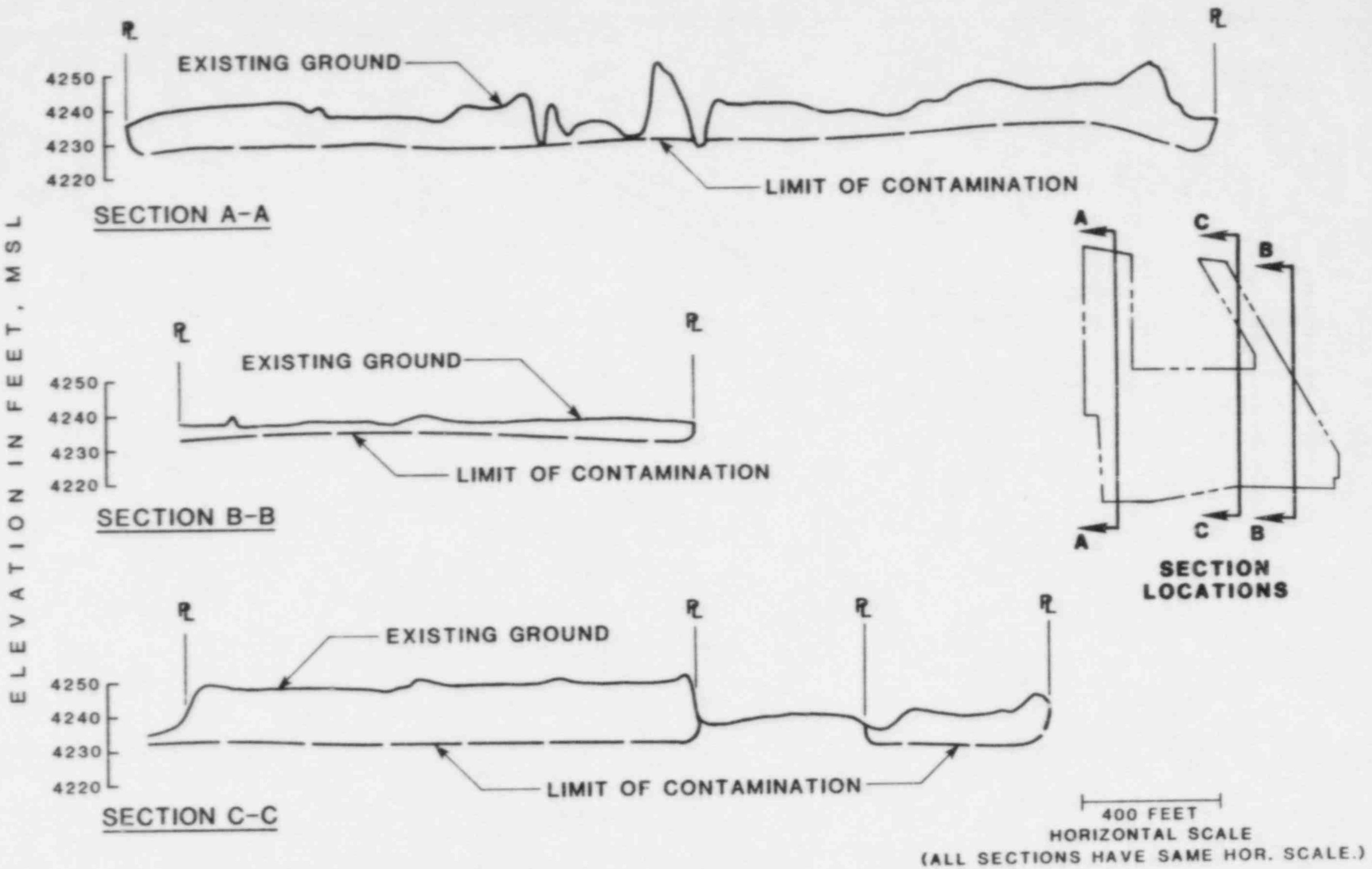

FIGURE 3.4
CROSS-SECTIONS OF EXISTING GROUND AND DEPTH OF CONTAMINATION
SALT LAKE CITY SITE

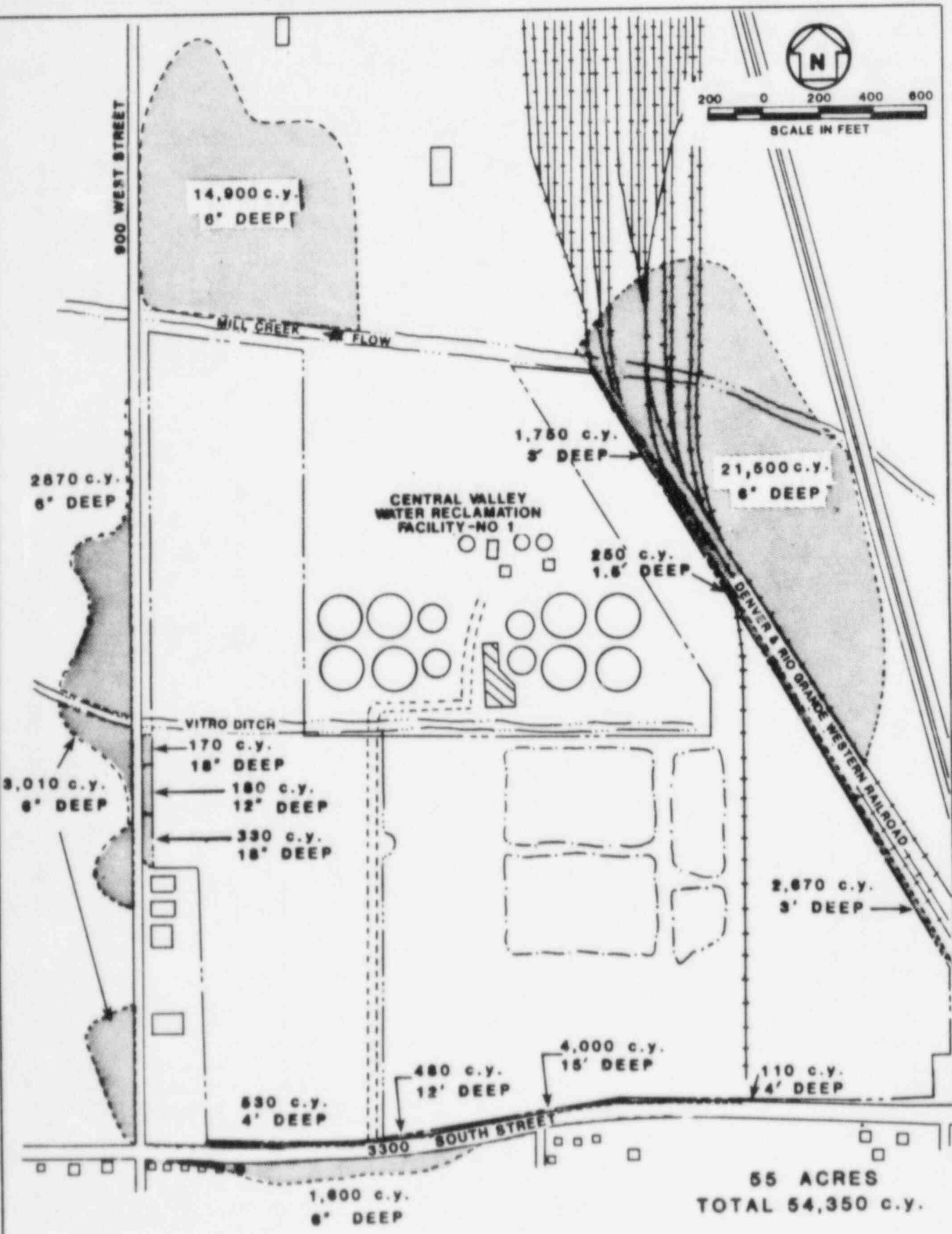

FIGURE 3.5
WINDBLOWN CONTAMINATION SALT LAKE CITY SITE

4.0 RADON BARRIER THICKNESS

I. PROBLEM STATEMENT

The tailings at the Vitro site in Salt Lake City will be moved to South Clive for disposal. Additional material to be moved will be on-site rubble, contaminated material from vicinity properties, contaminated soil from beneath the tailings pile, and contaminated material from the mill site and ore storage area. It will be assumed for the following calculations that all of these materials will be mixed together rather than kept separate. This assumption is based on the expected simultaneous excavation of different materials and the long period of time over which the transport to South Clive will be conducted. For this scenario the following assumptions affect the radon barrier cover design:

- o The radium content, radon emanating fraction, and radon diffusion coefficient used for the stabilized pile should be characteristic of the average mixture of tailings and other materials.
- o The available cover materials are adequately represented by the majority of the borrow samples obtained for geotechnical and diffusion coefficient analyses.
- o The average moisture content for the stabilized pile and cover, as predicted by engineering analyses, are suitable estimates of the long-term annual average condition of the pile.
- o The compaction and placement of the tailings, other contaminated materials, and cover soils is sufficient to inhibit settlement and cracking of the cover.

Based on these assumptions and the calculations summarized in the following paragraphs, it is estimated that a cover reducing the radon flux to the applicable EPA limit of 20 $pCi/m^2 sec$, under the conditions of the South Clive site, can be constructed using a 7-foot thickness of locally available borrow. The calculations summarized below are available in detail in the UMTRA Project files (TAC, 1984).

II. METHODS OF CALCULATION

A. Radon Cover Thickness

The thickness of cover material required to limit radon flux to 20 $pCi/m^2 sec$ is calculated using the computer code RAECOM (NRC, 1984). The mathematical model implemented in RAECOM describes one-dimensional radon diffusion through multiphase systems of porous media.

The diffusion occurs upward through the pile and its cover. Multiple layers of tailings and cover soil are allowed with differences in phys-

ical, radiological, and diffusional properties represented by seven layer-specific input parameters. Radon concentrations in both soil water and soil air phases are treated, as well as the exchange between phases. Boundary conditions are the radon flux into the bottom of the pile, and the air concentration of radon at the surface of the pile. In addition, interface conditions are applied, requiring continuity of both flux and concentration in both phases at layer interfaces. The simultaneous solution to the pair of radon mass balance equations for the two phases, and the gas phase flux equation is performed using matrix manipulation of the coupled analytical solution for the general n-layer case.

The seven values required for each layer of the tailings pile system modeled by RAECOM are:

- o Thickness of layer (cm).
- o Bulk density (g/cm^3).
- o Porosity (fractional).
- o Moisture content (percent dry weight basis).
- o Radon emanating fraction (fractional).
- o Diffusion coefficient (cm^2/sec).
- o Radium concentration (pCi/g).

In addition to these parameters describing the layers of the stabilized pile, RAECOM requires data describing the total number of layers in the pile and the layer to be optimized in meeting the specific flux limit (20 $pCi/m^2 sec$) at the surface. Also, the radon boundary conditions at the top and bottom of the pile must be specified. The bottom condition is always an incoming flux equal to zero $pCi/m^2 sec$ for tailings piles. The top condition is the observed ambient radon concentration (pCi/l) in air near the site.

B. RAECOM Input Values

The selected values for each parameter listed above are shown in Table 4.1 and discussed briefly below. The details of the calculations leading to various parameter values are available in the UMTRA Project files (TAC, 1984). For several parameters it was assumed that the properties of the mixture of tailings and other contaminated materials are represented by measurements made on tailings samples.

1. Layer thicknesses

The proposed structure of the stabilized pile has three layers:

- o 28 feet or more of tailings mixed with other contaminated materials.
- o The compacted radon barrier cover of a thickness to be determined by this analysis.
- o A rock and gravel erosion protection cover which is ignored for the purposes of radon flux estimation.

2. Bulk density

The bulk density of tailings and cover given in Table 4.1 were selected on the basis of standard Proctor tests and reflect the design compaction of 90 percent for tailings and 95 percent for cover. The data on which the densities were based are presented in Tables 4.2 and 4.3.

3. Porosities

The tailings and cover porosities given in Table 4.1 are calculated from the bulk densities at the design compaction, using the specific gravity of the material, which was measured or estimated along with other geotechnical parameters. The equation used is:

Porosity = 1 - (bulk density)/(specific gravity).

4. Moisture contents

The moisture contents given in Table 4.1, 18 percent for cover and 10 percent for tailings, are based on calculations of the long-term average moisture using site specific data. These calculations are described in Section 2.0 of this appendix.

5. Radon emanating fractions

New data on radon emanating fractions measured for tailings at the Vitro site have become available since previous estimates of cover thickness were made for the Environmental Impact Statement (DOE, 1984) and for draft versions of this document. These data are based on a broad sampling of the Vitro pile whereas previously available data were either for samples taken from limited portions of the pile, or for a limited number of samples. The old and new emanating fraction data are presented in Tables 4.5 and 4.6. Since the pile is composed of mixed tailings materials and will retain a moderate moisture content (emanating fractions are a function of moisture content only at very low moistures), an overall average of all of these values is used. This gives an E of 0.22 based on an unbiased representative sampling of the pile. Full details on the sampling used to obtain these data are contained in the UMTRA Project files (TAC, 1984).

6. Radon diffusion coefficients

Radon diffusion coefficients have been measured for samples from the Vitro pile. The available data are presented in Table 4.2. These coefficients were measured at 95 percent of the maximum dry density, rather than the 90 percent compaction planned for placement of the materials in the field. The available data and a correlation curve (NUREG/CR-3533) are plotted in Figure 4.1. By adjusting the porosity and saturation moisture content to values representing the 90 percent compaction at 10 percent moisture, the

correlation predicts a value of $2.3 \times 10^{-2} cm^2/sec$ for the diffusion coefficient. It is clear from the spread and trend of the available data that this value is in the appropriate range. New tailings diffusion coefficient measurements in the appropriate moisture range and at 90 percent compaction are in progress. A sensitivity analysis to evaluate the effect of uncertainty in this value has been done as noted below.

Radon diffusion coefficients for cover materials available at South Clive are presented in Table 4.3. An average diffusion coefficient value for the materials to 8 feet depth, at the estimated moisture content of 18 percent is used for the cover calculation, $1.3 \times 10^{-2} cm^2/sec$, as noted in Table 4.1.

7. Radium concentrations

The radium concentrations given in Table 4.1 are calculated using the assumption that the tailings pile and other contaminated materials will be randomly mixed during pile excavation and emplacement. To do this calculation it was necessary to volume-weight each material by its radium content. Table 4.4 summarizes the volumes and radium concentrations used to calculate the volume-weighted average radium concentration in the stabilized pile, more detail is given in Section 3.0 of this appendix.

8. Other required values

Several other parameters required by RAECOM are not reflected in Table 4.1. One of these is the top-of-the-pile radon concentration boundary condition, which is 0.3 pCi/l based on measurements at Clive (ANL, 1984). The other additional parameter is the number of modeled layers, which are two: a layer of 850 cm thickness representing emplaced tailings and other contaminated material, and a layer of cover of unknown thickness, which is used in the thickness optimization calculations.

III. CONCLUSIONS

The predicted cover thickness from RAECOM needed to limit the annual average radon flux from the stabilized pile to 20 $pCi/m^2 sec$ is 208 cm or approximately 7.0 feet of the available borrow material.

A sensitivity analysis evaluating the effect of error in the values used for estimating the cover thickness was done using reasonable ranges of the important parameters (cover moisture range 16 percent to 23 percent, tailings moisture range 8 percent to 13 percent, emanating fractions range of two standard deviations about the mean 0.12 to 0.32 tailings diffusion coefficient range 0.015 to 0.03 cm^2/sec). Under worst case situations, a flux of 38 $pCi/m^2 sec$ could be expected through the 7-foot cover; the best case flux could be 5 $pCi/m^2 sec$. Since the values used to estimate the cover thickness are the best average values, this range of variability around the mean of 20 $pCi/m^2 sec$ is reasonable. The full details of the sensitivity analysis are available in the files of the UMTRA Project Office (TAC, 1984).

The cover design for a pile is intended to give a long-term annual averaged flux of 20 pCi/m^2sec. However, some conservative assumptions are implicit which indicate the actual flux should, in fact, be less.

The design moisture content of the pile is intended to be the driest long-term moisture content maintained by the pile materials considering climate, the consistency and compaction of the material, and the depth of the material in the pile. To the degree the actual moisture content at depth within the pile remains above the design moisture content, the actual flux will be less than the design flux.

At South Clive any periods of harsh winter will add an additional degree of safety not reflected in the design. Whenever the soil is very wet, frozen, or covered with snow, the radon is effectively blocked from escaping into the atmosphere. Depending on the period over which such conditions exist, there will be a reduction in the actual annual average flux as compared to the design flux.

In the design of the pile, no radon flux attenuation was attributed to the 2-foot rock and gravel cover that is to be applied to the pile as erosional protection. There is some decrease in the radon flux due to this cover; thus, a safety factor is present, although it may be a factor which is not available over the entire life of the pile.

No safety factors are intentionally applied in the design of the radon barrier, which is in agreement with the design nature of the radon flux standard as expressed by the EPA in its comments on the basis of the regulations. It is the intent, however, of this discussion to make clear that there are reasons to expect that the annual average flux measured around a stabilized pile would be lower than the design flux.

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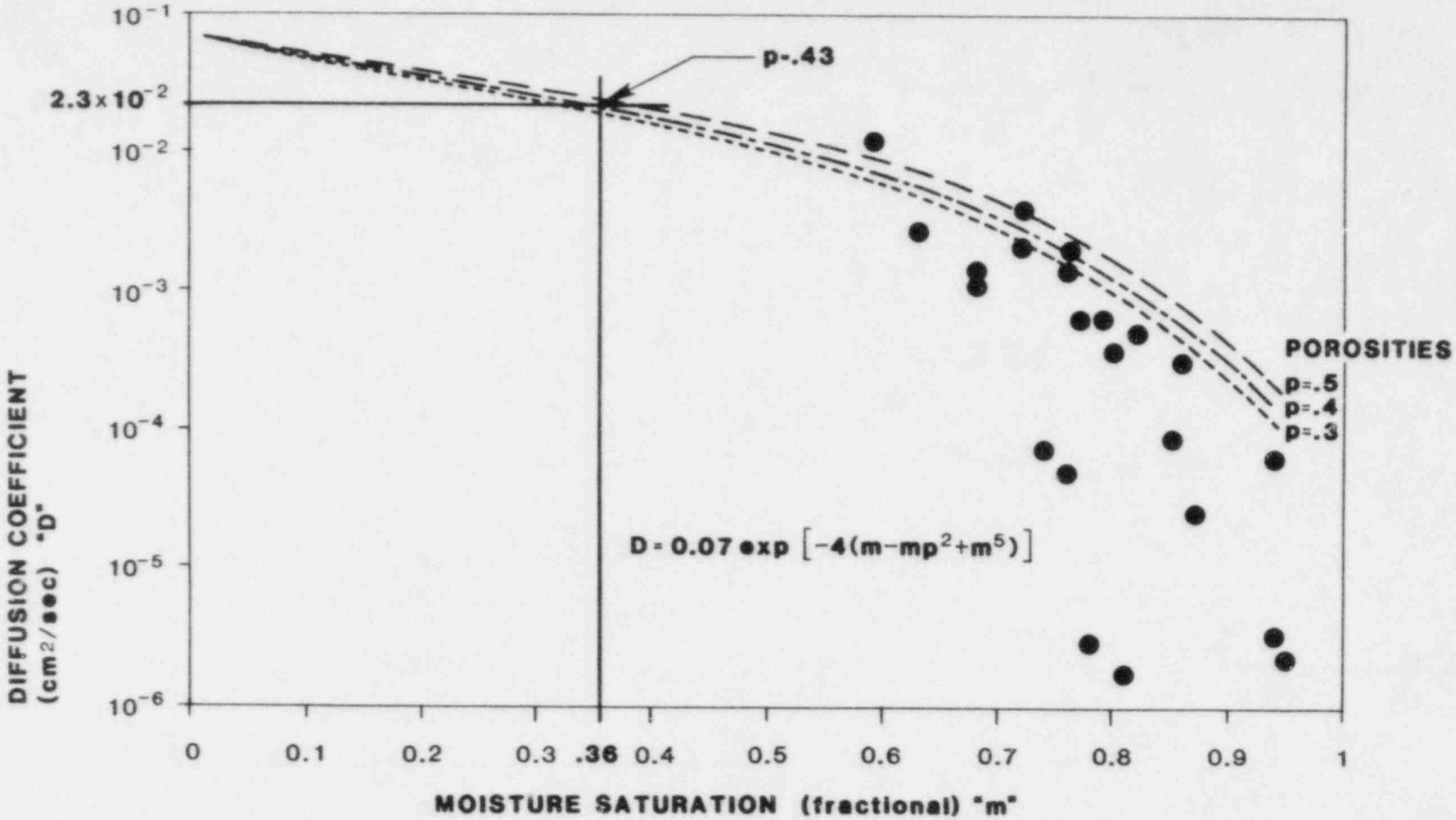

FIGURE 4.1 VITRO TAILINGS DIFFUSION COEFFICIENTS

Available diffusion coefficient data for Vitro tailings overlaid on the correlation curve from NUREG/CR-3533 plotted for three porosities. Moisture saturation of 0.36 at porosity 0.43 corresponds to average tailings at a 90% compaction. Estimated diffusion coefficient is $2.3 \times 10^{-2} cm^2/sec$.

Table 4.1 Input data for RAECOM

Layer	Thickness ft.	Thickness cm	Moisture % dry wt.	Porosity fraction	Bulk Density g/cm^3	Coefficient cm^2/sec	Ra-226 pCi/g	Emanating fraction
Cover	a	a	18.	0.48	1.4	1.3×10^{-2}	0	0
Tailings mixture	28.	850.	10.	0.43	1.5	2.3×10^{-2}	470.	0.22

[a] Values are determined by the results from the RAECOM model; not part of input data set.

Table 4.2 Radon diffusion coefficients for Vitro tailings

Sample	Max. dry density (pcf)	Specific gravity	Optimum moisture (% dry wt.)	As-tested[a] dry density (g/cm^3)	Test moisture (% dry wt.)	Radon diffusion coefficient (cm^2/sec)	Porosity (fraction)	Saturation (fraction)
SAND V1-83	117.3	2.7[b]	13.2	1.79	11.1	1.2×10^{-2}	.34	0.59
				1.80	12.6	1.4×10^{-3}	.33	0.68
				1.78	13.8	2.1×10^{-3}	.34	0.72
				1.77	14.0	3.9×10^{-3}	.34	0.72
				1.79	14.7	3.0×10^{-6}	.34	0.78
				1.78	15.5	1.8×10^{-6}	.34	0.81
SLIME V1-83	95.3	2.7[b]	27.0	1.48	23.5	6.5×10^{-4}	.45	0.77
				1.43	26.0	6.5×10^{-4}	.47	0.79
				1.45	27.5	3.1×10^{-4}	.46	0.86
				1.45	27.5	3.2×10^{-4}	.46	0.86
				1.45	30.0	6.5×10^{-5}	.46	0.94
				1.45	30.0	3.4×10^{-6}	.46	0.94
50% SAND V1-83 50% SLIME V1-83	103.5	2.7[b]	21.5	1.58	19.6	7.4×10^{-5}	.41	0.74
				1.56	20.5	5.1×10^{-5}	.46	0.76
				1.58	21.0	3.8×10^{-4}	.41	0.80
				1.58	21.5	5.1×10^{-4}	.41	0.82
				1.59	22.3	3.1×10^{-4}	.41	0.86
				1.55	26.2	2.3×10^{-6}	.43	0.95
70% SAND V1-83 30% SLIME V1-83	111.5	2.7[b]	16.4	1.71	13.6	2.7×10^{-3}	.37	0.63
				1.69	15.0	1.1×10^{-3}	.37	0.68
				1.70	16.6	1.4×10^{-3}	.37	0.76
				1.69	16.7	2.0×10^{-3}	.37	0.76
				1.69	18.8	9.0×10^{-5}	.37	0.85
				1.68	19.7	2.6×10^{-5}	.38	0.87

[a]These densities represent 95% of the maximum dry density.
[b]Assumed value.

Table 4.3 Radon diffusion coefficient measurements for Clive cover soils

Sample	Max. dry density (pcf)	Specific gravity	Optimum moisture (% dry wt.)	As-tested dry density (g/cm^3)	Test moisture (% dry wt.)	Radon diffusion coefficient (cm^2/sec)	Porosity (fraction)	Saturation (fraction)
SLC-303-84 4-8'	92.1	2.83	28.0	1.35	8.2	2.6×10^{-2}	.52	.21
				1.31	9.7	2.6×10^{-2}	.54	.24
				1.38	9.9	2.7×10^{-2}	.51	.27
				1.40	17.6	1.2×10^{-2}	.51	.49
				1.41	17.6	1.2×10^{-2}	.50	.49
				1.40	18.4	2.0×10^{-2}	.51	.51
				1.38	19.9	1.1×10^{-2}	.51	.54
				1.37	20.7	7.5×10^{-3}	.52	.55
				1.40	28.0	3.2×10^{-3}	.51	.78
				1.39	28.7	1.1×10^{-3}	.51	.78
				1.39	29.0	7.6×10^{-4}	.51	.79
SLC-303-84' 10.5-13'	112.5	2.83	13.9	1.71	4.7	3.5×10^{-2}	.40	.20
				1.68	6.7	3.4×10^{-2}	.41	.28
				1.66	7.8	1.5×10^{-2}	.41	.32
				1.66	7.9	2.6×10^{-2}	.41	.32
				1.72	9.3	1.3×10^{-2}	.39	.41
				1.71	9.9	8.4×10^{-3}	.40	.43
				1.70	10.7	9.2×10^{-3}	.40	.46
				1.72	13.8	2.5×10^{-3}	.39	.61
				1.72	14.7	3.4×10^{-3}	.39	.64
				1.71	15.4	4.4×10^{-3}	.40	.67
*SLC-303-84 4-8'	92.1	2.83	28.0	1.41	7.8	1.2×10^{-2}	.50	.22
				1.40	9.4	1.2×10^{-2}	.51	.26
				1.40	17.6	1.2×10^{-2}	.51	.49
				1.41	17.6	1.2×10^{-2}	.50	.49
				1.40	27.0	3.9×10^{-3}	.51	.75
				1.41	26.2	2.1×10^{-3}	.50	.74

Table 4.3 Radon diffusion coefficient measurements for Clive cover soils (Concluded)

Sample	Max. dry density (pcf)	Specific gravity	Optimum moisture (% dry wt.)	As-tested dry density (g/cm^3)	Test moisture (% dry wt.)	Radon diffusion coefficient (cm^2/sec)	Porosity (fraction)	Saturation (fraction)
SLC-306-84 0-3'	97.0	2.71	25.2	1.48	7.9	1.7×10^{-2}	.45	.26
				1.48	8.7	2.3×10^{-2}	.45	.28
				1.48	9.1	2.2×10^{-2}	.45	.30
				1.47	15.5	1.1×10^{-2}	.46	.50
				1.48	18.0	1.5×10^{-2}	.45	.59
				1.48	18.3	1.3×10^{-2}	.45	.60
				1.47	18.9	1.3×10^{-2}	.46	.61
				1.48	21.7	5.6×10^{-4}	.45	.71
				1.48	21.8	8.0×10^{-4}	.45	.71
				1.51	25.5	3.3×10^{-4}	.44	.87
				1.50	26.2	4.3×10^{-4}	.45	.88
				1.48	27.6	6.3×10^{-4}	.45	.90

*Testing done with special soil packaging procedure, for comparison to normal procedure results.

Table 4.4 Volumes and average Ra-226 concentration of components of stabilized pile

Component	Volume (cy)	Average Ra-226 pCi/g
Tailings and mill site and ore storage	18.06×10^5 cy	560.
Subbase	4.13×10^5 cy	280.
Rubble	0.80×10^5 cy	25.
Windblown	0.54×10^5 cy	46.5
Vicinity property	0.50×10^5 cy	100.
Total	24.03×10^5 cy	
Volume-weighted average		470.

Table 4.5 Emanating fraction data from early Vitro sampling

Sample	Test moisture (% dry wt.)	Radon emanating fraction (fraction)
SAND V1-83	4.6	0.17
	4.6	0.17
	9.5	0.14
	10.0	0.18
	14.4	0.17
	14.4	0.17
SLIME V1-83	11.4	0.13
	11.8	0.11
	24.1	0.09
	24.8	0.11
	58.8	0.12
	68.0	0.12
50% SAND V1	11.4	0.08[a]
50% SLIME V1	11.8	0.09[a]
	24.1	0.11[a]
	24.8	0.12[a]
	58.8	0.11[a]
	68.0	0.11[a]
SAND V2	10.9	0.17
	13.6	0.21
SLIME V2	81.3	0.17
	83.2	0.17
68% SAND V2	28.4	0.19[a]
32% SLIME V2	28.0	0.15[a]
		x = 0.14
		s = 0.04

[a]Statistics for asterisked samples: x = 0.12, s = 0.04.

Table 4.6 Emanating fraction data from expanded Vitro sampling

Sample	Test moisture (% dry wt.)	Radon emanating fraction (fraction)	Material type (sand/slime/mix)
SAND V1-83	14.4	0.16	sand
SLIME V1-83	11.8	0.10	slime
SAND V2-83	13.6	0.20	sand
SLIME V2-83	81.3	0.11	slime
V1-84 1-2.5'	9.6	0.27	mix
V1-84 3.5-5'	11.9	0.26	mix
V2-84 1-2.5'	14.4	0.24	slime
V2-84 3.5-5'	17.6	0.18	slime
V3-84 1-2.5'	22.3	0.29	sand
V3-84 3.5-5'	7.0	0.16	sand
V4-84 1-2.5'	17.8	0.24	slime
V4-84 3.5-5'	15.0	0.27	mix
V5-84 1-2.5'	9.4	0.23	slime
V5-84 3.5-5'	13.0	0.24	slime
V6-84 1-2.5'	13.4	0.28	slime
V6-84 3.5-5'	17.8	0.28	slime
V7-84 1-2.5'	13.9	0.17	slime
V7-84 3.5-5'	17.3	0.19	slime
V8-84 1-2.5'	10.6	0.21	sand
V8-84 3.5-5'	10.3	0.18	sand
V9-84 1-2.5'	18.2	0.21	sand
V9-84 3.5-5'	14.2	0.20	sand
V10-84 1-2.5'	15.4	0.21	sand
V10-84 3.5-5'	12.4	0.20	sand
V11-84 1-2.5'	13.8	0.15	sand
V11-84 3.5-5'	11.6	0.26	sand
V12-84 1-2.5'	10.5	0.13	sand
V12-84 3.5-5'	17.6	0.18	sand
V13-84 1-2.5'	20.1	0.30	sand
V13-84 3.5-5'	13.4	0.24	mix
V14-84 1-2.5'	9.2	0.16	sand
V14-84 3.5-5'	9.3	0.16	sand
V15-84 1-2.5'	13.6	0.26	sand
V15-84 3.5-5'	16.2	0.28	sand
V16-84 1-2.5'	10.6	0.24	sand
V16-84 3.5-5'	17.0	0.22	sand
V17-84 1-2.5'	16.7	0.19	sand
V17-84 3.5-5'	52.3	0.28	sand
V18-84 1-2.5'	14.0	0.22	sand

Table 4.6 Emanating fraction data from expanded Vitro sampling (Concluded)

Sample	Test moisture (% dry wt.)	Radon emanating fraction (fraction)	Material type (sand/slime/mix)
V18-84 3.5-5'	13.5	0.19	sand
V19-84 1-2.5'	11.5	0.12	slime
V19-84 3.5-5'	9.8	0.23	slime
V20-84 1-2.5'	11.2	0.21	sand
V20-84 3.5-5'	16.2	0.17	sand
V21-84 1-2.5'	14.5	0.25	mix
V21-84 3.5-5'	8.3	0.20	mix
V22-84 1-2.5'	4.1	0.21	slime
V22-84 3.5-5'	8.4	0.28	slime
V23-84 1-2.5'	12.5	0.28	slime
V23-84 3.5-5'	10.4	0.23	slime
V24-84 1-2.5'	16.2	0.27	slime
V24-84 3.5-5'	11.2	0.24	slime
		x = 0.22	
		s = 0.05	

5.0 SITE DRAINAGE

I. PROBLEM STATEMENT

The purpose of this calculation is to determine the characteristics of site drainage during and after remedial action for appropriate erosion and sediment control measures. The following design situations will be analyzed:

- o During remedial action - site runoff from a 10-year 24-hour storm event will be used to size the sedimentation basins and waste-water treatment plant.
- o During remedial action - drainage ditch flow rates and velocities resulting from a 10-year 1-hour storm event will be used to determine minimum ditch sizes and the need for ditch erosion protection.
- o During remedial action - peak flow rates of the retention basin emergency outlets resulting from the 25-year 1-hour storm event will be determined.
- o After remedial action - the drainage ditch flow rates and velocities resulting from the 100-year 1-hour storm event will be used to determine the size of the final ditches at the South Clive site.
- o After remedial action - The PMP intensity on the tailings embankment will be determined for use in design of the embankment erosion protection.

II. METHODS OF CALCULATION

The rainfall intensities for the 10-year, 25-year, and 100-year storm events were obtained from the Salt Lake City County Flood Control and Water Quality Division and the Precipitation - Frequency Atlas of the Western United States (Miller et al., 1973). The PMP rainfall intensity was determined using charts from HMR-49 (Hansen et al., 1977) and data from the "Staff Technical Position WM-8201" (NRC, 1983). Times of concentration were found 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). Ditch velocities were determined using the Manning formula (see Section 6.0) (COE, 1970). Ditch erosion protection was designed using the Safety Factor method (Simons and Senturk, 1976).

III. CONCLUSIONS

A. During remedial action, one sedimentation basin will initially be located for drainage from the eastern portion of the site. This basin will require a minimum storage capacity of 2.6 acre-feet for direct runoff. As the remainder of the site becomes disturbed, three new basins will be located and use of the initial basin will be discontinued. The three basins will require a total minimum storage of 8.3 acre-feet for direct runoff; the individual runoff volumes are 4.9, 2.0, and 1.4 acre-feet.

B. During remedial action, drainage ditches will require a minimum depth of 2 to 3 feet to contain the 10-year flow rates. Velocities in the ditches range between 2 and 3 feet per second for the 10-year storm event. These velocities are just high enough to carry sediments. Lining the ditches with erosion-resistant material will be necessary if excessive buildup of silts in the sedimentation ponds becomes a problem.

C. Peak 25-year, 1-hour waste-water retention basin overflow rates range from 22 to 40 cfs at the Vitro site and 59 cfs at the South Clive site.

D. The 100-year 1-hour storm event will result in a peak flow of approximately 32 cubic feet per second in the embankment perimeter ditches at the South Clive site. A flow depth of approximately 2 feet and a flow velocity of approximately 1.5 feet per second were calculated. Thus, a ditch depth of 3 feet will provide 1 foot of freeboard.

E. The PMP rainfall intensity on the embankment is 29.7 inches per hour for a 5-minute duration. The peak sheet flow rate is 0.3 cfs per width for the embankment top and 0.4 cfs per foot-width for the embankment sideslopes. These flow rates were used in the design of erosion protection for the embankment cover system (Section 6.0).

IV. REFERENCES

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6.0 EROSION PROTECTION DESIGN

I. PROBLEM STATEMENT

The embankment design for the South Clive site must include long-term protection against the effects of erosion. Specifically:

- o The rock layers, embankment, top, and sideslopes will be designed to prevent sheet erosion from a PMP on the embankment.
- o The rock layers on the embankment ditches and sideslopes will be designed to prevent erosion from the PMF on the site.

II. METHODS OF CALCULATION

A. Flow Rates

Rainfall rates for the PMP were developed using National Weather Service techniques (Hansen et al., 1977) and Nuclear Regulatory Agency Guidelines (NRC, 1983a).

B. Sideslope Erosion Orotection

The rock size on the embankment sideslopes was determined using rockfill hydraulic design techniques because of the steep, 20 percent, slope (Stephenson, 1979). The rock size required to resist the expected sheet flow was set equal to the 50 percent finer rock diameter. No additional safety factor was applied to this size since the method itself has an embedded safety factor.

C. Top Slope Erosion Protection

Flow hydraulics for the embankment top slopes were calculated using Manning's equation and U.S. Army Corps of Engineers (COE, 1979) methods which relate relative submergence of the roughness element and the hydraulic radius to the friction coefficient and boundary shear stress. The safety factors method was used to find the stability of a given rock size. This calculation was iterated for various rock sizes and the rock size for a safety factor greater than 1.0 was found. The stable rock size was set equal to the 30 percent finer size to ensure "self-armoring" of the cover.

<u>Manning's equation</u>:

$$y = (1.49/n)R^{2/3}\ S^{1/2}$$

where:

$n = R^{1/6}/(23.85 + 21.95\ \mathrm{Log}(R/k))$
y = depth of flow (feet)
n = Manning's friction coefficient

R = hydraulic radius (feet)
S = slope
k = equivalent roughness height (feet)

Shear stress formula:

$$t = K_2 V^2$$

where:

K_2 = $62.4/(32.2 \text{ Log } (12.2y/D_{50})^2$

t = boundary shear stress (psf)

V = vertically averaged velocity (fps)

D_{50} = theoretical spherical diameter of average stone size (feet)

D. Flood Erosion Protection

Flow depths around the embankment were calculated in the Flood Analysis, Section 12.0. Flow hydraulics where the embankment perimeter ditch has the greatest slope were found using the method described in C., Top Slope Erosion Protection, above. The point shear stress was found for the bottom of the ditch and for shallower points. The calculation was iterated to find rock sizes with factors of safety greater than 1.0.

III. CONCLUSIONS

A. Rock protection requirements for the embankment top and sideslopes for PMP sheet erosion are shown below.

Location	Rock size requirements (inches)	Thickness (ft)	PMP design sheet flow rates (cfs/ft)
Top	$D_{30} \geq 0.4$ inch	$\geq 1.5 \times D_{100}$	0.3
	$D_{50} \geq 0.6$ inch		
	$D_{100} \leq 1.2$ inches		
Sides	$D_{50} \geq 3.0$ inches	$\geq 1.5 \times D_{100}$	0.4
	$D_{100} \leq 6.0$ inches		

Damage to the cover is unlikely even in the PMP event.

B. The PMF flow depth and velocity at the ditch center line were found to be 5.5 feet and 10.3 feet per second, respectively, requiring a 3.5-inch mean diameter rock for a safety factor greater than 1.0. At a depth of 4.5 feet, a 3.0-inch diameter rock is required, thus the rock required to prevent sheet erosion on the embankment sideslopes would be adequate to resist erosion from the PMF for most of the perimeter ditch. A 10-foot width at the ditch bottom will require a 3.5-inch mean diameter rock.

Rock sizes at ditch junctions and bends will be determined during final design using EM 1110-2-1601 criteria (COE, 1970).

The following filter criteria will be used in final design:

$$\frac{D_{15}\text{ filter}}{D_{85}\text{ base}} < 5$$

It is anticipated that one filter layer will be required on the side slopes, and that the filter material used will be the same material used for the erosion protection of the top slopes. The gradations of the filter layers will be determined during final design once the grain size distributions of the radon barrier and erosion protection materials are defined.

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7.0 WASTE-WATER RETENTION BASIN

I. PROBLEM STATEMENT

The purpose of this calculation is to analyze the required storage capacity of the waste-water retention basin for runoff, dewatering, and other sources of waste water. The calculation also analyzes requirements for freeboard allowance and emergency spillway outlet capacity.

II. METHODS AND ASSUMPTIONS

A. Sediment Storage Volume

The sediment storage volume was determined by calculating the soil loss during the 3-year construction period. Typical Vitro site tailings grain size distributions (Martin et al., 1980) and area weighted scope-length factors were used in the Modified Universal Soil Loss Equation (Israelsen et al., 1980) to find the soil loss over the project life. A sediment delivery ratio of 1.0 and bare soil conditions were assumed. The bulk dry density of the sediment was assumed to be 90 pounds per cubic foot.

B. Storm Runoff Storage Volume

The runoff resulting from the 10-year 24-hour precipitation event was added to the required sediment storage volume. See Section 5.0, Site Drainage , for details.

C. Excavation Dewatering

It was assumed that the contaminated flows from excavation dewatering would be retained in the basins for 4 hours prior to treatment. Dewatering of the Vitro site will produce approximately 300 gallons per minute (see Section 8.0, Waste-Water Treatment). Dewatering at the South Clive site was considered negligible.

D. Miscellaneous Storage Volumes

It was assumed that flows to the basin from equipment decontamination, worker showers, laundry facilities, and other waste streams will be negligible and were disregarded for this analysis.

E. Emergency Outlet

The emergency outlet was designed to pass the peak flow resulting from a 25-year precipitation event with 1 foot of freeboard on the pond. The 25-year peak flow calculation is found in Section 5.0, Site Drainage. A rectangular emergency outlet weir was selected, and the length was calculated assuming a flow depth of 6 inches.

F. Evaporation

The rate of evaporation in the South Clive site basin was calculated using average lake evaporation data (U.S. Weather Bureau, 1959). Monthly precipitation was subtracted from seasonal lake evaporation to find the net evaporation rate from the basin, 33 inches/year. Seepage was considered insignificant.

III. CONCLUSIONS

A. The design storage volume of the basins are as shown below. They will hold the 10-year 24-hour runoff, the sediment volume for the 3-year construction period, and 4 hours of excavation dewatering.

Storage volumes (acre-ft)

Pond	Storm runoff	Sediment	Excavation dewatering	Total
Vitro				
1	2.6	0.01	0.22	2.8
2	4.9	0.07	0.22	5.2
3	2.0	0.01	0.22	2.2
4	1.4	0.01	0.22	1.6
South Clive				
1	3.3	0.39	--	3.7

B. The widths of the emergency outlet weirs to allow passage of the peak 25-year precipitation event with a flow depth of 6 inches are shown below.

Pond	Flow (cfs)	Weir width (ft)
Vitro		
1	37	32
2	40	34
3	29	25
4	22	19
South Clive		
1	59	50

C. The runoff resulting from the 10-year 24-hour precipitation event at the Clive site will evaporate in two summer months from a 4-acre basin.

IV. REFERENCES

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8.0 WASTE-WATER TREATMENT (DEWATERING)

I. PROBLEM STATEMENT

Unit processes must be selected and sized to treat waste water prior to discharge to Mill Creek in order to comply with an NPDES permit. Sources of waste water are identified as follows:

- o Ground water collected from excavation dewatering.
- o Storm-water runoff.
- o Decontamination water from equipment washdown.
- o Laundry wastes from washing protective clothing.
- o Shower and wash basin waste water.

The design will provide adequate treatment capacity, after flow equalization in a sedimentation basin, for all resulting waste water to quality levels necessary to protect the creek, as identified in the forthcoming NPDES discharge permit. The treatment facility will operate continuously with minimum down time for maintenance. Sedimentation basins and the treatment plant will be sized to handle the runoff from a 10-year 24-hour storm over the entire site.

Excavation below the water table will be necessary to remove contaminated subsoil at the Vitro site. Estimates of dewatering flow rates are needed to design properly the water removal and treatment systems.

II. METHODS AND ASSUMPTIONS

A design flow was projected by estimating the maximum flows from each of the sources identified above. The characteristics of the waste water to be treated were projected by calculating a composite from the characteristics of the individual waste streams. The need for treatment was assessed by projecting the anticipated limitations of the forthcoming NPDES discharge permit. Alternative unit processes were considered with a system selected on the basis of relative capital costs, operations and maintenance costs, and reliability. The selected system was sized to permit the forecasting of a preliminary cost estimate.

To dewater the Vitro site to the depth of excavation, a sequence of trenches is proposed. These trenches will have a depth of one foot greater than the necessary depth of excavation. The trenching design and design parameters are shown on Figure 8.1. Because saturation of tailings is very sporadic and minimal, it is expected that dewatering will be limited to saturated subsoils.

To predict the time needed to dewater to the depth of the excavation with a trench in a sequence of trenches, a two-part calculation is needed:

- o Determine a value of T from Figure 8.2(b) (h, H, x, and L are as shown on Figure 8.2(a)). The trench will be one foot deeper than

the proposed excavations. Dewatering will be needed to lower the water level at the midpoint between trenches to the depth of the proposed excavation. It is assumed that the induced ground-water divide between adjacent trenches can be represented as an impermeable boundary, so x/L is equal to 1.0. h/H is equal to 1/H given that the water level will be lowered to the base of the excavation, which is one foot above the bottom of the trench.

- Given the value of T from Figure 8.2(b) and the aquifer and design parameters, t can be calculated from

$$t = \frac{SyL^2}{KH} T \quad ,$$

where

T = dimensionless time,

K = hydraulic conductivity (L/T)

H = distance from the water table to a horizontal, impermeable boundary (L) (see Figure 8.2(a)),

Sy = specific yield,

L = distance from the excavation to a vertical, impermeable boundary (L) (see Figure 8.2(a)),

t = time that trench must be open for sufficient dewatering (T).

To predict the dewatering flow rates, a method created by Ibrahim and Brutsaert, 1965, was adapted to a design with a sequence of trenches. The method requires a three-part calculation to determine inflow to each side of each open trench:

- Calculate T with the equation

$$T = \frac{KH}{SyL^2} t \quad ,$$

(All the parameters are as defined in the previous section, except t = time since trench was opened.)

- Determine G, dimensionless discharge from T. This relationship has been plotted on a semi-log graph (see Figure 8.2(c)). To adapt the method to a microprocessor, the curve was divided into three segments and digitized.

For $T < 0.154$; $G = 10 (-4.55\ T + 0.7)$

For $0.15 < T < 4$; $G = 10\ (0.07065T^2 - 0.69338T + 0.10518)$

For $T > 4$; $G = 10\ (-0.16T - 0.9)$

o Calculate q with the equation

$$q = \frac{GKH^2}{SyL} ,$$

where:

q = discharge per unit length of trench (L^2/T), and

$Q = qw$, where w = the length of the trench (L^3/T).

The assumptions implicit to this method are:

- The excavated face is vertical.
- The excavation is emplaced instantaneously.
- The boundary conditions and initial conditions of the hydrogeologic system are as shown on Figure 8.2(a).
- The geologic stratum is homogeneous and isotropic.
- The excavation is long and lineal in shape, rather than circular.

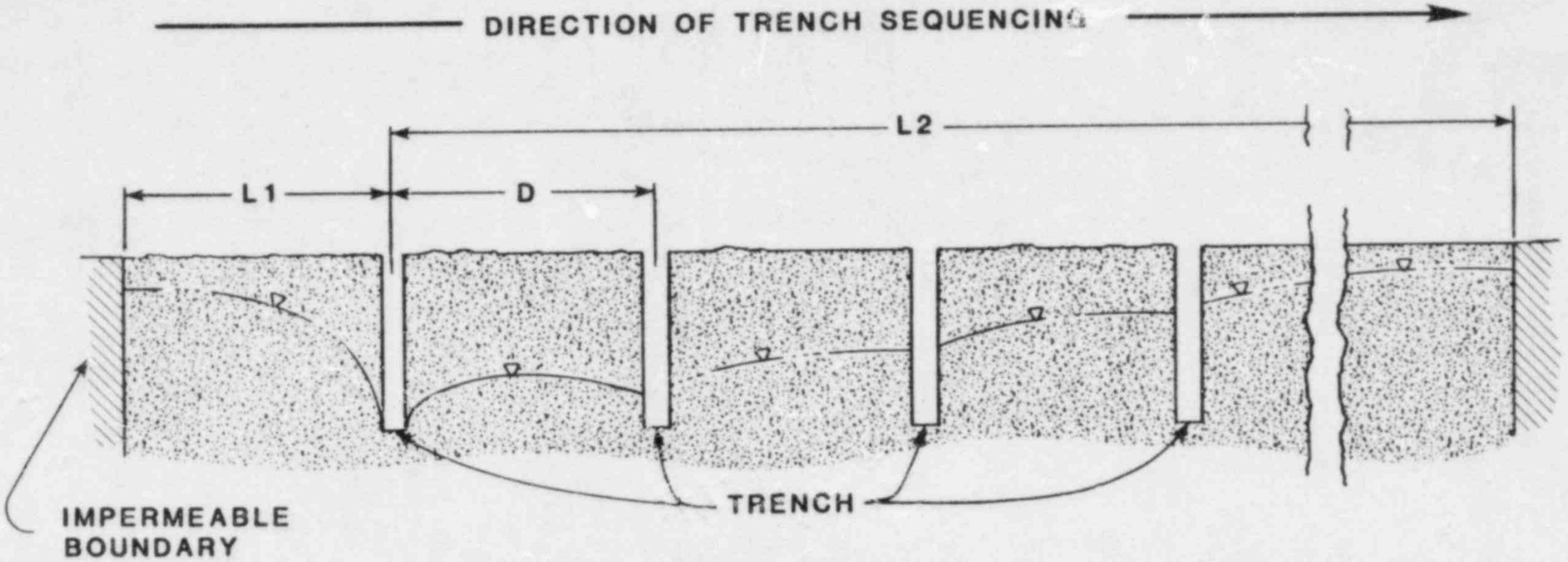
The method was applied to a sequence of trenches. For the calculation, it is assumed that the line midway between two adjacent trenches acts as an impermeable boundary. Because the aquifer parameters (K, Sy, and H) are not known explicitly and because the distance to an impermeable boundary to the north or south and the trenching sequencing is not known, a sensitivity analysis was used to bound the dewatering flow rates. The distance to the hypothetical impermeable boundaries was varied from 200 to 5000 feet. In most simulations, distances of approximately 500 feet resulted in the maximum calculated discharge. The assumed distance did not affect the results, greatly.

III. CONCLUSIONS

A waste-water treatment system composed of a sedimentation basin, filter, and ion exchange units is proposed for treatment of expected waste streams. The system shall have the capacity to treat a maximum daily volume of waste water generated largely from dewatering (300 gpm) and stormwater runoff (200 gpm) for a total of 500 gpm.

Table 8.1 contains the bounding input parameters and the subsequent calculations of dewatering flow rates. Hydraulic conductivity was set at 3.0 and 30.0 based on field hydraulic testing and hydrodynamic numerical modeling. Specific yield was set at 0.10 and 0.30 which are reasonable for heterogeneous, unconsolidated materials. Varying the distance between

trenches, distance to impermeable boundary, the depth of trenches below the water table, hydraulic conductivity and specific yield, the calculated, maximum discharges ranged from 17.4 to 950.6 gpm. The extreme values appear unreasonable and a more likely range would be 50 to 300 gpm. Considering that the deeper CVWRF excavation north of the site yields approximately 300 gpm, the size of the dewatering system, which is sized for 300 gpm of ground-water discharge, is conservatively high. The trenches should be spaced 20 to 50 feet apart with a new trench opened every 1 to 4 days.



D = UNIFORM DISTANCE BETWEEN TRENCHES

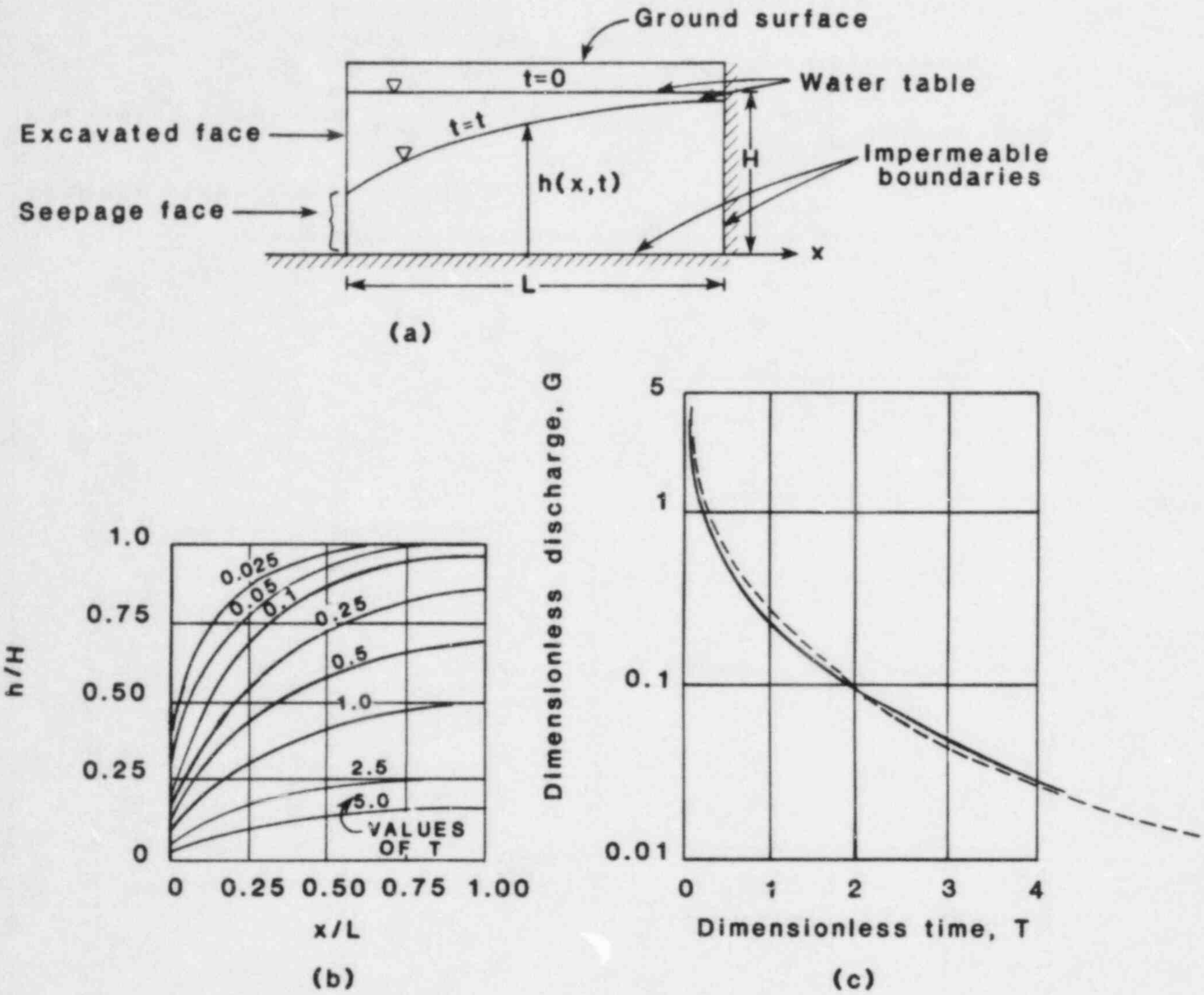
∇ = WATER LEVEL

L1 = DISTANCE FROM INTIAL TRENCH TO IMPERMEABLE BOUNDARY AWAY FROM TRENCHING DIRECTION

L2 = DISTANCE FROM FIRST TRENCH DEVELOPED TO IMPERMEABLE BOUNDARY IN DITCHES OF EXCAVATION

FIGURE 8.1
DEWATERING TRENCH SEQUENCE

SLC-08-005



——— = Curve from Ibrahim and Brutsaert, 1965

– – – – = Digitized Approximation

FIGURE 8.2

PREDICTION OF GROUND-WATER INFLOWS INTO AN EXCAVATION (AFTER IMBRAHIM AND BRUTSAERT, 1965)

Table 8.1 Input and output of dewatering sensitivity analysis

Distance between trenches (ft)	Distance to impermeable Boundary (ft)	Depth of trenches below water table (ft)	Hydraulic conductivity K (ft/day)	Specific yield Sy	Dimension-less time T	Dewatering time t (days)	Time between excavations (days)	Number of trenches open at one time	Maximum discharge Q (gpm)
20	5000	4.0	3.0	0.10	2.5	2.1	1	4	37.9
20	500	4.0	3.0	0.10	2.5	2.1	1	4	68.7
20	200	4.0	3.0	0.10	2.5	2.1	1	4	103.0
20	5000	6.0	3.0	0.10	5.0	2.8	1	4	43.5
20	5000	8.0	3.0	0.10	6.0	2.5	1	4	47.3
20	5000	4.0	30.0	0.30	2.5	0.63	1	4	17.4
20	500	4.0	30.0	0.30	6.0	0.75	1	4	36.2
20	500	8.0	3.0	0.10	6.0	2.5	1	4	140.7
20	500	8.0	30.0	0.30	6.0	0.75	1	4	323.5
20	500	8.0	30.0	0.10	6.0	0.25	1	4	950.6
20	500	8.0	3.0	0.30	6.0	7.5	1	8	160.8
50	500	4.0	30.0	0.10	2.5	1.3	1	4	311.9
50	500	4.0	3.0	0.30	2.5	39.1	4	10	100.7
50	500	6.0	3.0	0.30	5.0	52.1	6	9	94.7
50	500	8.0	3.0	0.30	6.0	46.9	5	9	151.1
50	500	6.0	3.0	0.10	5.0	17.4	2	10	249.3
50	500	6.0	30.0	0.30	5.0	5.2	1.5	5	289.5
50	500	6.0	30.0	0.10	5.0	1.7	1	4	562.5
100	500	6.0	3.0	0.30	5.0	208	20	10	36.8
100	500	6.0	30.0	0.10	5.0	6.9	2	4	552.5

9.0 SETTLEMENT AND COVER CRACKING

I. PROBLEM STATEMENT

The settlement resulting from compression and consolidation of the reworked tailings and undisturbed foundation soils due to the placement of the tailings embankment was analyzed. The results of the settlement analysis were then used to evaluate potential for cracking of the cover materials due to horizontal strains developed by the settlement.

II. METHODS, DATA, AND ASSUMPTIONS

A. Stratigraphy and material properties of foundation soils and tailings are as outlined in Section 2.0, Material Properties.

B. Settlement in tailings is predicted by the following equation:

$$\Delta S = \frac{C_c H}{He_o} \text{ Log } \frac{P_o + \Delta P}{P_o}$$

where

ΔS = settlement (inches)

H = thickness of layer of interest (inches)

C_c = Compression index from laboratory test data by CSU

e_o = initial void ratio

$P_o \Delta P$ = initial effective stress in layer and additional stress caused by overlying with material (pounds per square foot).

C. Due to preconsolidation effects on the native soils, settlement within these materials is predicted by the following equation:

$$\Delta S = \frac{H(\epsilon_2 - \epsilon_1)}{(1 + \epsilon_1)}$$

where

S = settlement (inches)

H = initial thickness of layer (inches)

ϵ_1 = strain associated with initial effective stress at midpoint of layer, from consolidation test curve for material (inch/inch).

ϵ_2 = strain associated with final effective stress at midpoint of layer, from consolidation test curves (inch/inch).

D. Cracking potential of cover due to horizontal strain resulting from settlement was evaluated using procedure developed by Lee and Shen (1969).

E. Effect of matrix suction pressure for settlements in the short-term due to embankment loading was taken into account by performing laboratory consolidation tests at in-situ; partially saturated conditions. The test data was then applied using conventional consolidation theory.

III. CONCLUSIONS

A. Maximum total settlement due to compression of tailings is estimated to be on the order of 2.2 feet.

B. Settlement within the tailings will be predominately elastic in nature and between 50 and 75 percent will occur prior to placement of cover.

C. Maximum total settlement within the foundation soils is estimated to be on the order of 1.8 feet.

D. Settlement within the foundation soils will be as a result of consolidation and accordingly could continue after placement of the cover. In order to limit settlement of the cover, the settlement of the site should be monitored during construction and final grading of the cover should be accomplished only after most of the settlement is over.

E. Horizontal strains resulting from the settlement occurring after cover placement will not be sufficient to cause cover cracking.

F. While the short-term effects of matrix soil suction have been accounted for in the above settlement estimates, the long-term effects of moisture change within the pile has not been accounted for. The type of analysis and the test apparatus for determining partially saturated consolidation parameters is still in the research phases of development. It is estimated that the long-term drying of the tailings pile will be limited to less than 5 feet and thus long-term settlements due to matrix suction will be minimal and contained within the radon barrier cover material.

IV. REFERENCES

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10.0 GEOHYDROLOGY/WATER BALANCE

I. PROBLEM STATEMENT

To ensure that the existing or anticipated beneficial uses of ground water at the South Clive site are not adversely affected by the stabilized tailings. This includes the evaluation of the potential for seepage from the tailings. The design situation to be analyzed is for the stabilized tailings over a 1000-year period.

II. METHODS, DATA, AND ASSUMPTIONS

The design is based on a calculation of Darcy velocity for ground-water flow beneath the disposal area; a review of water quality data for the site; a review of well locations in the vicinity of the site, and a review of literature discussing the water balance in the area. In calculating the Darcy velocity it is assumed that seepage from the tailings will not substantially increase the hydraulic gradient in the ground water below the disposal area. The assumption is justified by three facts:

- o The tailings will be emplaced at less than saturation.
- o At least 20 feet of unsaturated material will be between the tailings and the underlying ground water.
- o Net infiltration is expected to be minimal and is not expected to augment seepage from the tailings.

III. CALCULATIONS

A. Darcy Velocity

$$q = K \frac{\Delta h}{\Delta l}$$

where:

q = Darcy velocity (ft/day).

K = saturated hydraulic conductivity (ft/day).

Δh = change in ground-water potential (hydraulic head) over a representative flow length (ft).

Δl = distance along a flow line perpendicular to lines of equal potential (ft).

$T = 0.8$ to $166\ ft^2/day$ (DOE, 1984), assuming saturated thickness of 27 ft, then $K = 0.33$ to $6.15\ ft/day$

$$\frac{h}{l} = \frac{0.5\ ft}{840\ ft} \quad \text{(from ground-water contour map; DOE, 1984)}$$

$$= 6 \times 10^{-4}$$

Assuming a porosity of 0.1, $q\ max = \frac{(6 \times 10^{-4})\ (6.15\ ft/day)}{0.1} =$

$$3.7 \times 10^{-2} ft/day = 13\ ft/year$$

Over a 1000-year period the maximum distance of ground water movement can be calculated by:

$$d = t \cdot q\ maximum$$

where

d = distance moved

t = time of movement

q = seepage velocity

$$d = 13\ ft/year \times 1000\ years = 13,000\ ft$$

The nearest well is 16,000 feet. This well and other wells in the area are topographically and stratigraphically above the site.

B. Water Balance

Studies of the hydrology of areas near the South Clive site indicate that there is minimal potential for significant ground-water recharge on the site in its present condition (Hood and Waddell, 1968; Price and Bolke, 1970; Stephens, 1974). Potential evaporation is much larger than precipitation. With a compacted, low-permeability cover over the tailings it is expected that there will be minimal net infiltration into the tailings.

C. Ground-Water Use

Water quality at the South Clive site can be classified as salty with one classification scheme (Davis and DeWiest, 1965), with concentrations of total dissolved solids ranging between 20,000 and 50,000 mg/l (DOE, 1984). The potential use of this water is severely limited without treatment. Excepting on-site monitoring wells, there are no wells within about 3 miles of the site (DOE, 1984).

IV. CONCLUSIONS

A. Seepage from the tailings to the ground water at South Clive is expected to be small because the tailings will be emplaced at less than saturation above 20 feet of unsaturated material.

B. Infiltration is not expected to substantially augment the seepage from the tailings because the potential for infiltration is limited by the high potential evaporation and low precipitation.

C. Any seepage that did enter the ground water would travel less than 600 feet in 1000 years.

D. Existing uses of ground water in the area are minimal, with the nearest well about 3 miles away. Therefore any seepage from the tailings is not expected to impact existing uses over a 1000-year period.

E. Potential uses of ground water are limited by the salty character of the water.

V. REFERENCES

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11.0 SLOPE STABILITY AND LIQUEFACTION POTENTIAL

I. PROBLEM STATEMENT

The relocated tailings disposal site at Clive, Utah, was evaluated for static and seismic slope stability. The potential for liquefaction of the site materials during ground motion was also evaluated. The proposed remedial action requires that the tailings be disposed of in an engineered pile. Procedures and material properties are summarized below.

II. SLOPE STABILITY ANALYSIS

A. Material Properties

Site geology, stratigraphy, and material properties obtained from field and laboratory testing programs conducted at Clive, along with remolded material properties of the Vitro tailings, are contained in the Disposal Site Characterization Report (DSCR, 1984).

In addition to the foundation soils, the disposal pile will be composed of three material types: recompacted blended tailings, clay cover radon barrier, and erosion barrier.

The erosion barrier will consist of an armoring riprap layer and perhaps select sublayers. Since specific borrow sites are not available at this time, material properties for the cover were estimated from existing data in soil mechanics literature (Lambe and Whitman, 1969; NAVFAC, 1982). An angle of effective internal friction was estimated at 40 degrees along with zero pounds per square foot (psf) cohesion and a total unit weight of 130 pounds per cubic foot (pcf).

The compacted radon barrier clay cover will be obtained from near surface material excavated directly below the embankment prior to construction. The material will be placed between 0 and plus 3 percent of optimum moisture content, at 95 percent of the maximum dry density as determined by the standard Proctor test (ASTM D698). Thus, a total unit weight of 115 pcf was selected as the in-situ density of this material. In the absence of specific soil strength data, a conservative estimated value of 30 degrees was used for the effective stress friction angle and 0 psf for the cohesion (NAVFAC, 1982).

The embankment design requires that the tailings be blended to eliminate slimes pockets and that material be placed at 90 percent of standard Proctor (ASTM D698) and minus 0 to 3 percent below the optimum moisture content. Test data on the tailings indicates that an average in-situ moisture content of 110 pcf will result. Only limited strength data for an in-situ slime sample was available for the Vitro tailings. From this test a very conservative effective stress angle of internal friction of 31 degrees and a cohesion of 0 psf was selected for use in the design analysis.

The foundation soils were represented by an idealized section consisting of an upper clay and an upper sand. Test data available for these materials resulted in the selection of a total stress angle of internal friction equal to 23 degrees, a cohesion of 100 psf, and a total unit weight of 105 pcf. For the upper sand, in-situ moisture and density test data yielded a total unit weight of 130 pcf. Standard penetration test data were used to correlate an effective stress angle of internal friction of 34 degrees and a cohesion of 0 psf.

B. Ground Water

The ground water table was determined to be in excess of 20 feet below the existing ground surface.

C. Earthquake Loading

An evaluation of the potential earthquake effects at the Clive site was performed for the EIS (DOE, 1984). The study recommended a Maximum Credible Earthquake (MCE) of magnitude 7.1 on the Richter scale, located on the east front of the Cedar Mountains or the northern segment of this zone combined with faulting in southeastern Pudole Valley. This results in a design horizontal ground acceleration at the site of 0.31 g with expected variations of plus or minus 0.06 g.

D. Embankment Geometry

Based on the Remedial Action Plan recommendations, an idealized cross-section of the stabilized pile was developed. The pile will extend approximately 35 feet above and 7 feet below existing grade. A top slope of 2 percent and sideslopes of 5 horizontal to 1 vertical will be constructed. The erosion barrier will be 2 feet thick and the radon barrier, 5 feet thick. The idealized section is shown on Figure 11.1.

E. Method of Analysis

Slope stability calculations for both the static and seismic cases were made using the computer program REAME (Huang, 1983). The factor of safety against slope failure is calculated using the simplified Bishop method. Effective stress and strength parameters were used, except for the upper foundation clay layer where only total stress strength parameters were available. No phreatic surface was considered due to the large depth to ground water at the site.

A grid search was instituted with failure surfaces covering the entire slope. A minimum factor of safety of 3.1 was computed for the static case.

A horizontal seismic coefficient of .37 (.31 + .06) was applied to the embankment to model seismic loading conditions. Amplification of the ground motion in the embankment was not considered necessary due to the low embankment height and large surface area of the pile.

A factor of safety for the seismic case is 1.0. The condition analyzed is expected to improve with time due to consolidation of the upper clay foundation soil under the weight of the overlying soils and an associated strength increase for the material. Critical failure surfaces are presented in Figures 11.1 and 11.2. Critical failure surfaces passed through the upper clay foundation zone and were bounded on the bottom by the stronger foundation sands. Although the minimum acceptable factor of safety was obtained for the seismic loading condition, the conservative selection of soil parameters of the tailings materials makes the results acceptable. The static factor of safety is well above the accepted minimum value of 1.5.

III. LIQUEFACTION ANALYSIS

The embankment and underlying natural soils were evaluated for liquefaction potential by the simplified method of Seed and Idriss (1982). An idealized cross-section of the embankment used in the liquefaction analysis is presented in Figure 11.3. The section is similar to that used in the slope stability analysis. Tailings slimes were considered unsaturated with the water surface well into the foundation soils at a depth of 25 feet below the existing ground surface. A standard penetration blow count of 13 was assigned to medium dense sand zones within the foundation soils based on a review of boring logs.

Seed and Idriss (1982) present techniques to evaluate the liquefaction potential of level ground under earthquake induced ground motions. These methods were considered adequate as an approximation for the gradually sloping embankment and the large areas involved. Methods are presented for materials with particle size $D_{50} < 0.15$ mm (silty sands) and $D_{50} >$ 0.25 (sands). Since the natural soils are composed of both sands and silty sands, both techniques were used.

Analyses were performed in order to estimate the liquefaction potential at the embankment full height, or top of the slope, and outside the area influenced by the embankment. The factor of safety in the liquefaction analysis is defined as the horizontal shear stress required to produce liquefaction in the layer divided by the shear stress induced by the ground motion. The factors of safety under the main portion of the embankment were 1.4 and 1.6 for the more shallow (25 feet) and deeper (55 feet) medium dense sand zones. The factor of safety against liquefaction was less than 1.0 for areas outside the embankment.

Due to the depths at which liquefaction is anticipated near the edges and outside the embankment, it is anticipated that surface manifestations may include the expulsion of water, sand boils, and some minor cracking of the ground surface. The lower portion of the embankment side slopes may also exhibit some disruption in the form of cracking and minor slumping. Since the entire embankment will consist of unsaturated structural fill, flow slides or embankment liquefaction will not occur.

Since a potential exists for disruption of the cover system, the site post-remedial action maintenance and surveillance plan will call for

inspection of the pile following a major seismic event along the associated faults. Immediate action will then be taken to assess damage to the containment system and restore it if necessary.

IV. CONCLUSIONS

A. A static minimum factor of safety for the slope equal to 3.1 was calculated for the long-term stability conditions. Since the material properties of the clay foundation soils represent "undrained" strength parameters while those of the tailings and the foundation sands represent "drained" conditions. The factor of safety represents a hybrid and unconservative stability. However, since the calculated factor of safety is well in excess of 1.5 which is considered acceptable for dam design, the embankment will not fail under static conditions.

B. A factor of safety of 1.0 was determined for the embankment analyzed with an applied horizontal load seismic coefficient of 0.37. Unity is considered an acceptance safety factor for embankments subjected to Maximum Credible Earthquake (MCE) loading.

C. Although a potential for liquefaction of deep foundation sand zones exists under the toe and outside of the embankment, any damage to the embankment should be light and easily detected and repaired under the site post-remedial action maintenance and surveillance plan.

V. REFERENCES

DOE (U.S. Department of Energy), 1984. Final Environmental Impact Statement, Remedial Action at the Former Vitro Chemical Company Site, South Salt Lake, Salt Lake County, Utah, DOE/EIS-0099-D, prepared by Dames & Moore, Los Angeles, California, for the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

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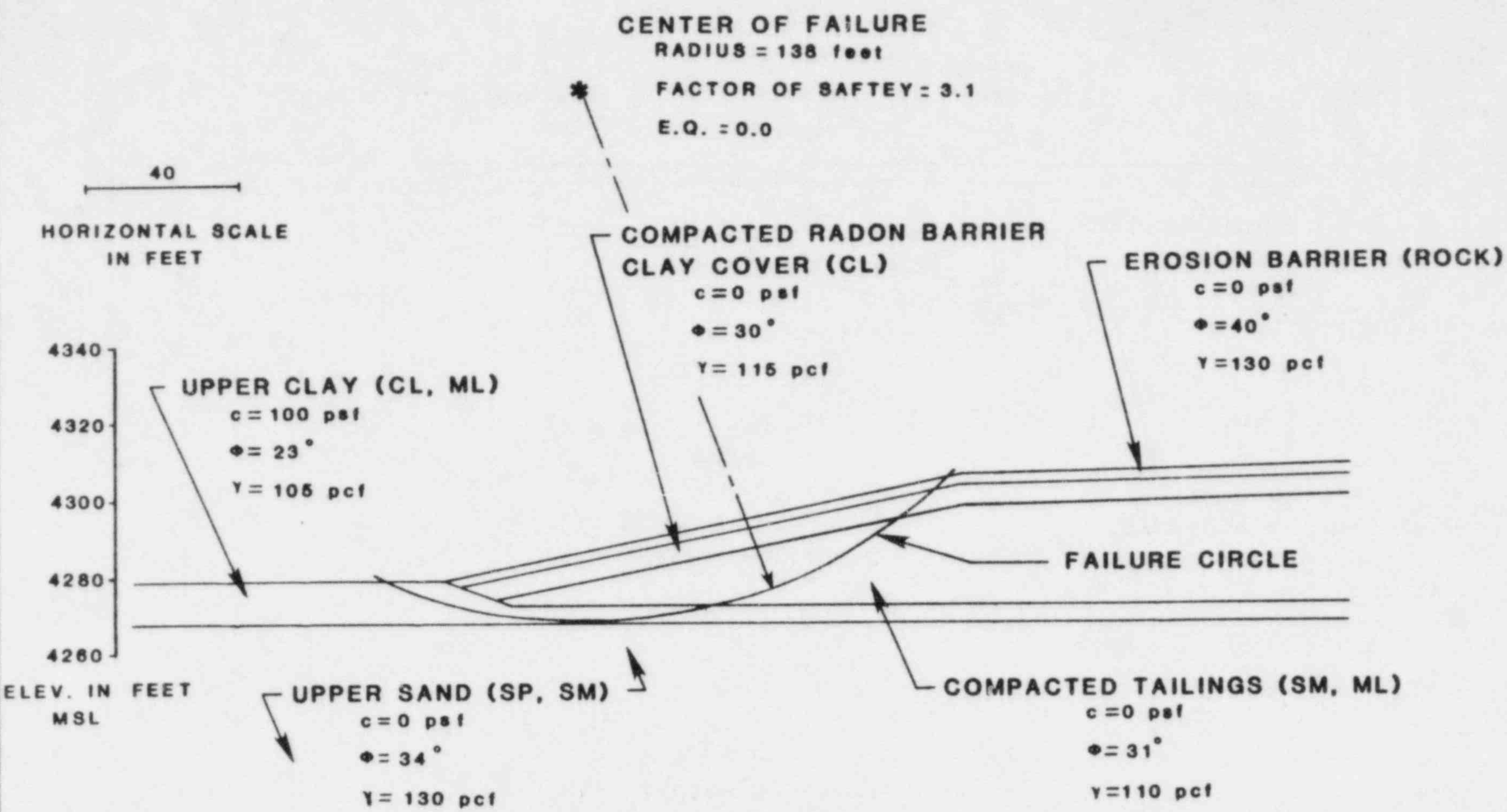

FIGURE 11.1
SLOPE STABILITY - STATIC FOR SOUTH CLIVE SITE

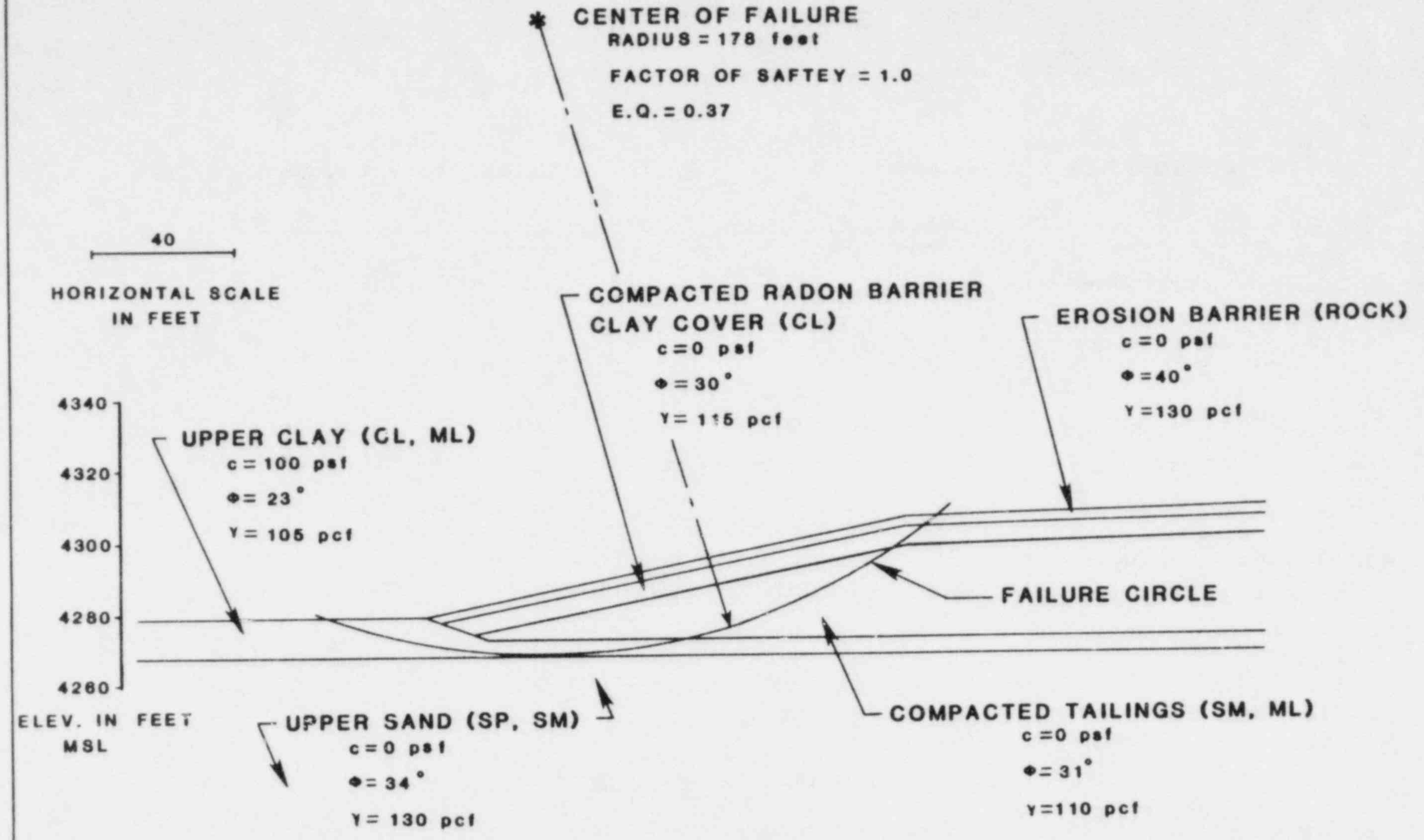

FIGURE 11.2
SLOPE STABILITY - SEISMIC
FOR SOUTH CLIVE SITE

SLC-11-006

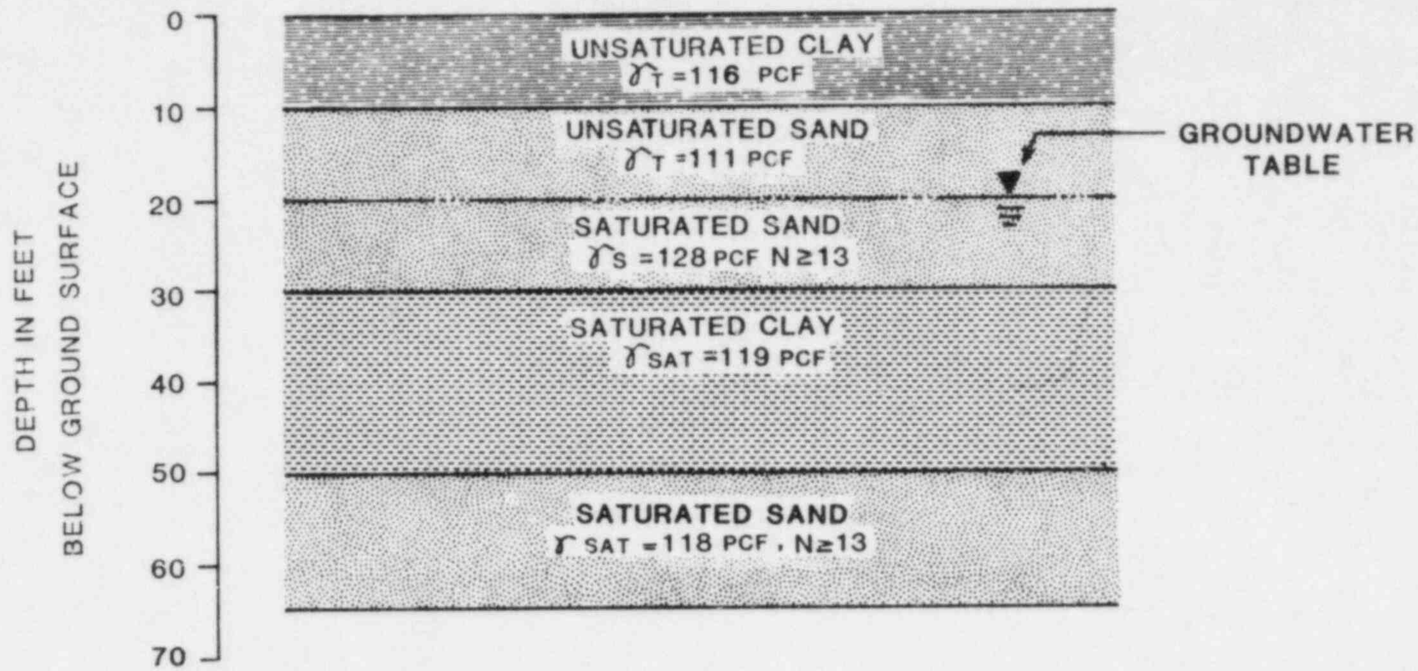

FIGURE 11.3
IDEALIZED FOUNDATION SOIL PROFILE
FOR LIQUIFACTION ANALYSIS

SLC-11-007

12.0 FLOOD ANALYSIS

I. PROBLEM STATEMENT

The purpose of this calculation is to determine the effects of flooding on the embankment. The Probable Maximum Flood (PMF) at the South Clive site was analyzed. The depth and velocity of the peak flow were calculated.

II. METHOD

A. The maximum height of the PMF was calculated through the following process:

- o The PMP rainfall hydrograph was determined using charts from HMR-49 (Hansen et al., 1977). The time of concentration unit hydrograph and runoff curve number (AMC-III) were found using Soil Conservation Service Methods (USDOI, 1977). The rainfall hydrography was convoluted with the unit excess hydrography (McCuen, 1982) to find the peak discharge.
- o The typical cross section and average overland slope at the South Clive site were found from the Aragonite Quadrangle map (USGS, 1983).
- o The peak flood elevation was then found using Manning's equation with a friction coefficient of 0.05.

B. The maximum average velocity of the PMF was calculated using the same procedure as above except that Manning's friction coefficient was assumed to be 0.03.

III. CONCLUSIONS

A. The 6-hour general-storm PMP for the 46-square mile Cedar Mountain watershed is 4.4 inches. The 6-hour local-storm PMP is 9.7 inches, and was used as the design storm.

B. A conservative PMF estimate for the South Clive site is 83,000 cubic feet per second.

C. The depth of flow at the base of the embankment due to the PMF is estimated to be 5.5 feet.

D. The average velocity of the PMF was calculated to be approximately 3 feet per second.

E. Erosion around the embankment area is not expected during passage of the PMF due to the low overland velocity of the flow.

IV. REFERENCES

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13.0 AQUIFER RESTORATION

I. PROBLEM STATEMENT

A relic contaminant plume was identified in the unconfined aquifer downgradient of the Vitro site. Samples of the water contained concentrations of total dissolved solids, uranium, sulfate, sodium, chloride, calcium, and magnesium significantly higher than samples from upgradient unconfined wells. The three potentially affected available water supplies are surface water (Jordan River and Mill Creek), the unconfined aquifer, and the confined aquifer. A cost-benefit study was performed to determine the value of restoring the unconfined aquifer downgradient of the Vitro site. Details of the ground-water regimes, water quality, and the aquifer restoration study may be found in the Environmental Impact Statement (DOE, 1984).

II. METHODS AND ASSUMPTIONS

Several factors which were input to the cost-benefit analysis are listed below:

A. The natural flow in the unconfined aquifer is to the northwest; therefore, the Jordan River and Mill Creek are considered discharge boundaries of the shallow ground water.

B. The plume dimensions are 3,100 feet wide and 1500 to 2600 feet in length (Figure 13.1).

C. The plume thickness is 50 feet which is the depth from the water table to the bottom of the aquifer.

D. The maximum area of contaminated, unconfined ground water is 7×10^6 ft^2. Assuming a conservatively high value of porosity of 0.30 (Hely et al., 1971), the maximum volume of off-site contaminated, unconfined ground water is 1×10^8 ft^3.

E. To ensure a worst-case analysis, the assumption was made that the quality of all the water contained within the contaminated volume is equal to the poorest quality found in the downgradient, unconfined groundwater samples.

F. The loss of benefit would extend through the time needed for the contaminated water to travel and discharge to the Jordan River or Mill Creek (period of natural purging). Geochemical retardation was not considered because the contaminants are mobile in the ground water. To bound this time, two methods of calculation were used. First, for a lower bound, a shallow ground-water flux to Mill Creek and the Jordan River of 62,600 ft^3/day was considered (See Section D.3.4.1, Table D-20 of the EIS). Given a flux of 62,600 ft^3/day (325 gpm),

it would require 4.4 years for the entire contaminated volume of 1×10^8 ft^3 to discharge to the surface water streams. For an upper bound, a seepage velocity of 0.3 ft/day was considered (See Section D.3.5.1 of the EIS). Given a maximum travel distance of 2,600 feet, the calculated travel time was 23.7 years. The average discharge through this period would be 11,500 ft^3/day (60 gpm).

G. The State of Utah states that the cost of water in the Salt Lake area is approximately $105 per acre-foot (State of Utah, 1983).

H. A second method of calculating the loss of benefit due to the volume of contamination is the spatial apportionment method which assumes that a portion of the water rights claimed within a half-mile radius of the Vitro site is not available during the natural purging of the unconfined aquifer. Contaminated, unconfined ground water cannot be used during the 4.4 to 23.7 year purging period due to contamination. Also, for a worst-case assessment, it is assumed that ground water beneath the contaminated area cannot be used for the full purging period. The ground water upgradient or lying outside of the contaminated boundary is not affected and may be used to fulfill water rights. Apportionment is made as to the percentage (30 percent) of the surrounding water rights that will be reduced or not available. Even though a greater density of water rights are in the area outside the contaminated area, for conservatism it is assumed that water rights are equally distributed throughout the half-mile radius circle. It is assumed that the entire depth of ground water beneath the contaminated area is unusable.

I. There are several methods to remove the contaminants contained within the plume. These include:

- o Intercept trench with recharge control.
- o Barrier walls and removal by pumping.
- o Pumping of contaminated water and recharge of fresh water using a series of wells.

All of these methods would lead to treatment and disposal of discharge; however, the intercept trench with recharge control appeared to be the least expensive and most efficient method. The trench placement and recharge controls are shown in Figure 13.1.

J. The goal of the water treatment plant would be to generate an effluent of sufficient quality to discharge to the surface waters of the State of Utah. The treatment processes involve neutralization to precipitate metals, fixation for the sludge created, and reverse osmosis.

III. CONCLUSIONS

A. The average flow of the Jordan River near the Vitro site is 68,000 gpm (State of Utah, 1943-1968). The degradation of the river was calculated with a ground-water discharge of 235 gpm. This maximum discharge rate was used to calculate the maximum degradation of river quality.

The quality of the discharge from the unconfined aquifer to the Jordan River is assumed to be equal to the poorest quality found in the aquifer to determine the worst-case degradation of river quality. The results of the worst-case degradation calculations indicate that the increase in total dissolved solids, sulfate, sodium, chloride, calcium, and magnesium would not change the beneficial uses of the river. The change in river water quality would be insignificant and there would be no loss of benefit because there would be no effect on the river's beneficial use.

B. There are no known wells other than monitor wells completed to the unconfined aquifer and within the boundaries of contamination. A maximum loss of benefit could be calculated by assuming all the water within the boundary of contamination in the unconfined aquifer would have been of drinking water quality and the entire volume of water could be used before discharging to Mill Creek or the Jordan River. The maximum volume of contaminated ground water was calculated as 1×10^8 ft^3, (2,300 acre-feet). Therefore, the maximum loss of benefit to the unconfined ground water is $240,000.

C. Although future degradation of the confined aquifer would occur only with localized, heavy pumping, the potential loss is considered. The areal extent of potential contamination in the confined system would be the same as in the unconfined system. The depth of contamination would be dependent on the magnitude of the downward vertical gradient induced by the localized pumping. Because this pumping is hypothetical, the depth of mixing is impossible to predict. A reasonably conservative estimate would be mixing to 160 feet below the ground surface or to the 100 foot depth of the aquifer. This estimate assumes that pumping-induced drawdowns will be less than 170 feet. For this hypothetical case, the volume of contaminated ground water would be 2×10^8 ft^3, assuming a porosity of 0.30. This volume is 4,600 acre-feet and, at a value of $105 per acre-foot (State of Utah, 1983), the loss of resource would be $480,000.

D. During treatment the ground water would be captured at a rate of approximately 500 to 1000 gpm and it is estimated that approximately 250 to 500 gpm would be from the plume while the remainder would be ambient, unconfined ground water. At this collection rate, it is estimated that the remedial action will require approximately three to six years to completely remove the 1×10^8 ft^3 plume. The annual operating costs range from $1.93 to 3.525 million. The capital costs range from $6.162 to 10.374 million to include salvage values.

E. Benefits were calculated using two different methods:

- o Maximum lost value of degraded or potentially degraded water resource on a volumetric basis.
- o Lost value according to spatial apportionment of water rights.

In addition, a range of time required for natural purging of the contamination was considered. This range is 4.4 to 23.7 years. Also, two periods and rates of discharge, 500 gpm discharge for six years and 1000 gpm discharge for three years with trenching are considered.

The total cost is calculated as the capital cost plus the annual cost multiplied by the number of years of required treatment. The benefit using the maximum lost value is the sum of lost value to the unconfined and confined systems ($240,000 + $480,000 = $720,000). The benefit using the spatial apportionment approach is the difference between the time required for natural purging and the time required for treatment multiplied by the annual loss of benefit ($245,000). No benefit is considered for the Jordan River because, with dilution, the ground-water contamination does not restrict its use. The bounding cost-benefit ratios are 4.1 and infinity. Given the result of the conservative analysis (i.e., maximum possible benefits and cost discounted), and the absence of ground water use in the maximum area of contamination, aquifer restoration seems unwarranted.

IV. REFERENCES

DOE (U.S. Department of Energy), 1984. Environmental Impact Statement, Remedial Actions at the Former Vitro Chemical Company Site, South Salt Lake, Salt Lake County, Utah, Report No. DOE/AL-0099-F, prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

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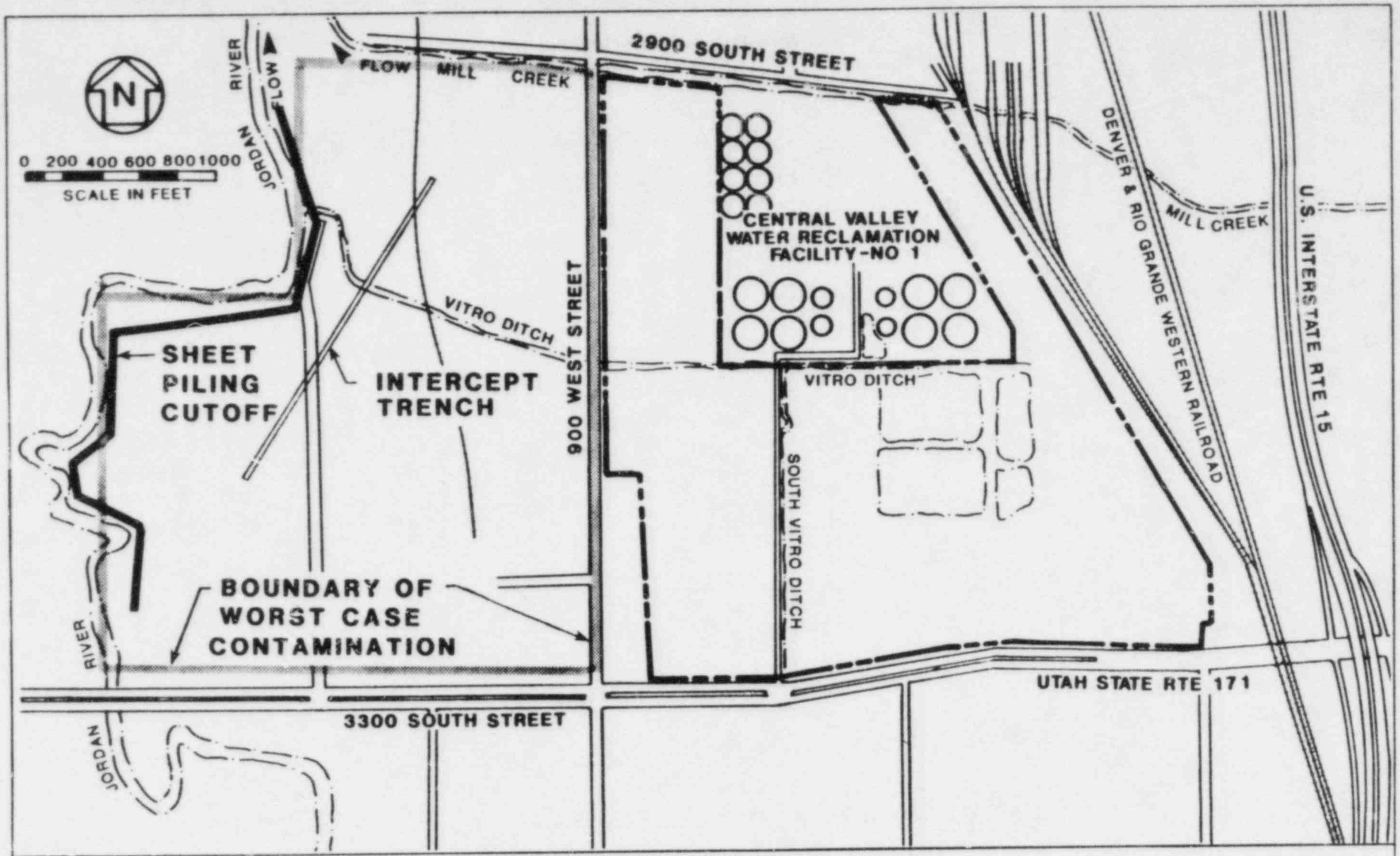

FIGURE 13.1

AQUIFER RESTORATION DESCRIPTIVE MAP SOUTH SALT LAKE SITE

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SITE MANAGER K. M. Peil
PROJECT MANAGER R Kushman DATE 9/3/84
DOE PROJECT MANAGER J Morley DATE 9/5/84

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JACOBS - WESTON TEAM
ALBUQUERQUE, NEW MEXICO

PROJECT NO. DE-AC04-82AL14086

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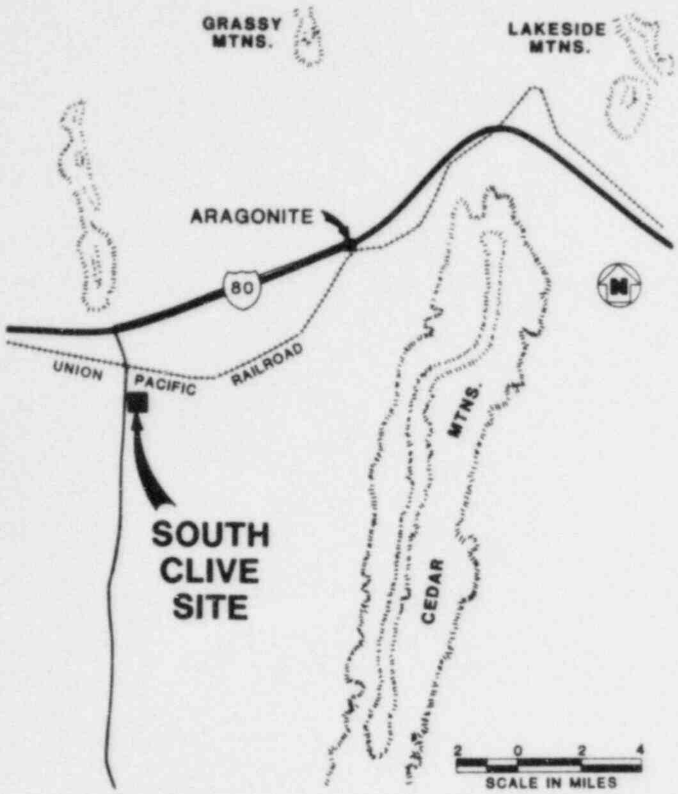

VICINITY MAPS

LIST

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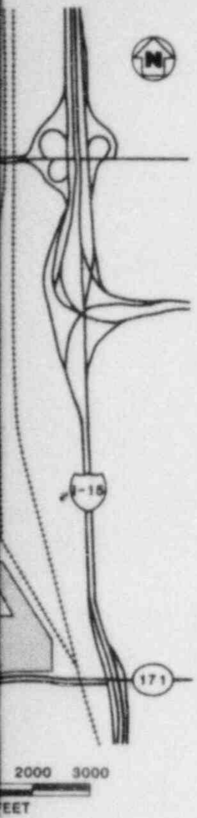
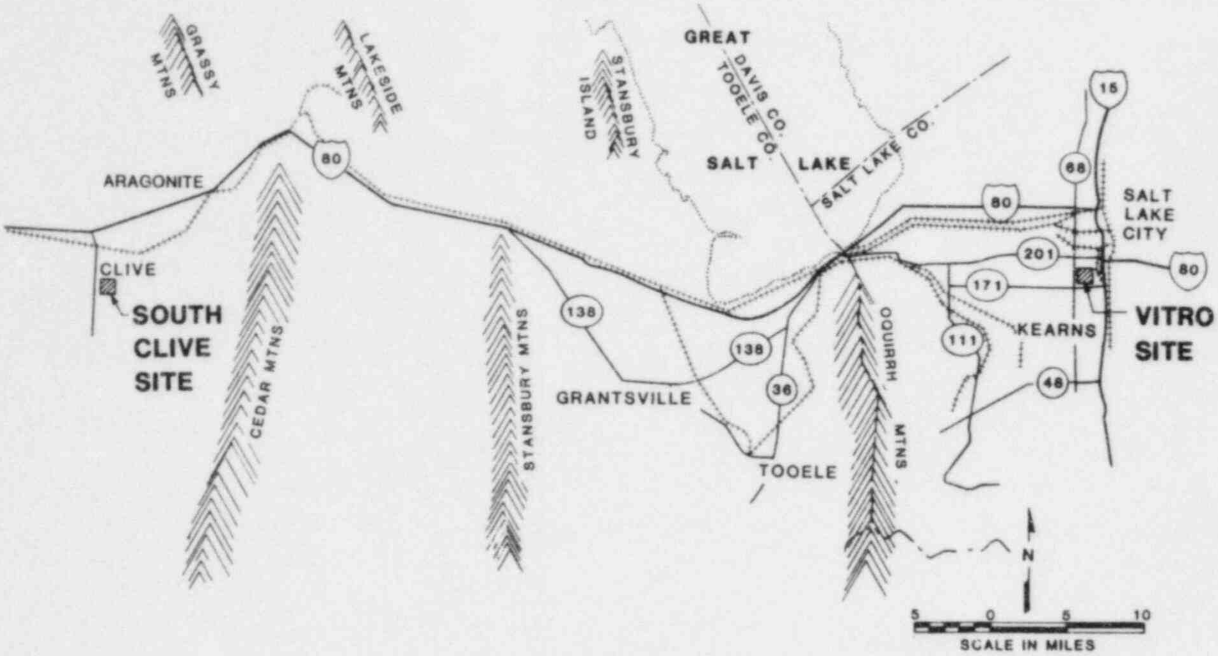
2. VICINITY MA
3. VITRO SITE
4. SOUTH CLIV
5. VITRO SITE
6. SOUTH CLIV
7. SECTIONS
8. VITRO SITE





LOCATION MAP

Also Available On Aperture Card

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OF DRAWINGS

PS, LOCATION MAP, & LIST OF DRAWINGS
PLOT PLAN
E SITE PLOT PLAN
GRADING PLAN
E GRADING PLAN

UTILITY LOCATION PLAN

8508140049-02

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

SALT LAKE CITY , UTAH

VICINITY MAPS, LOCATION MAP & LIST OF DRAWINGS

DESIGNED: [signature]
CHECKED: M.T. Be...
CHC E./ENGR MGR: [signature]
SITE MANAGER: K.M. Paul

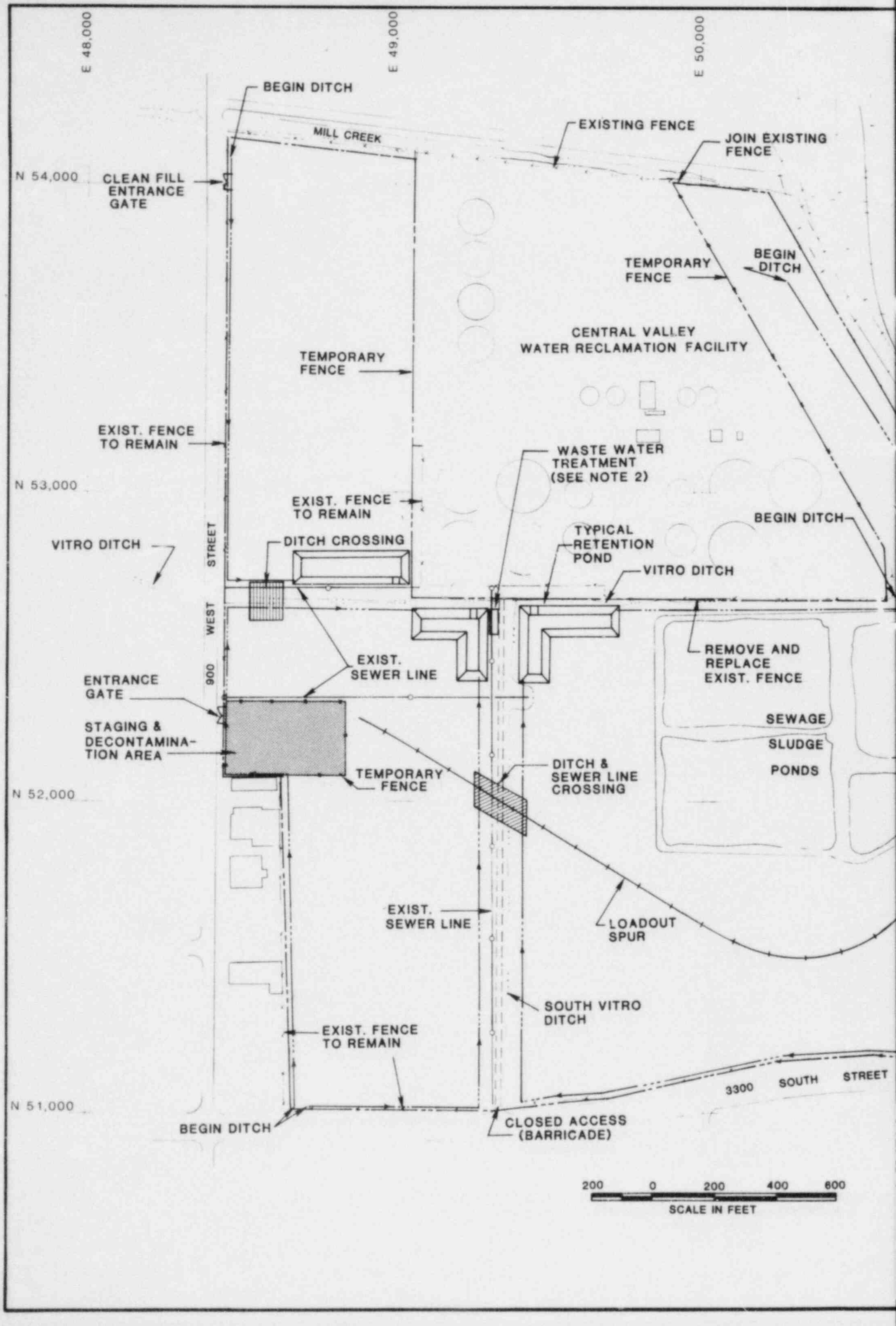
PROJECT MANAGER	DATE	DOE PROJECT MANAGER	DATE		DATE
R Kushner	9/5/84	J. Morley	9/5/84		

JACOBS ENGINEERING GROUP INC.
JACOBS - WESTON TEAM
ALBUQUERQUE, NEW MEXICO

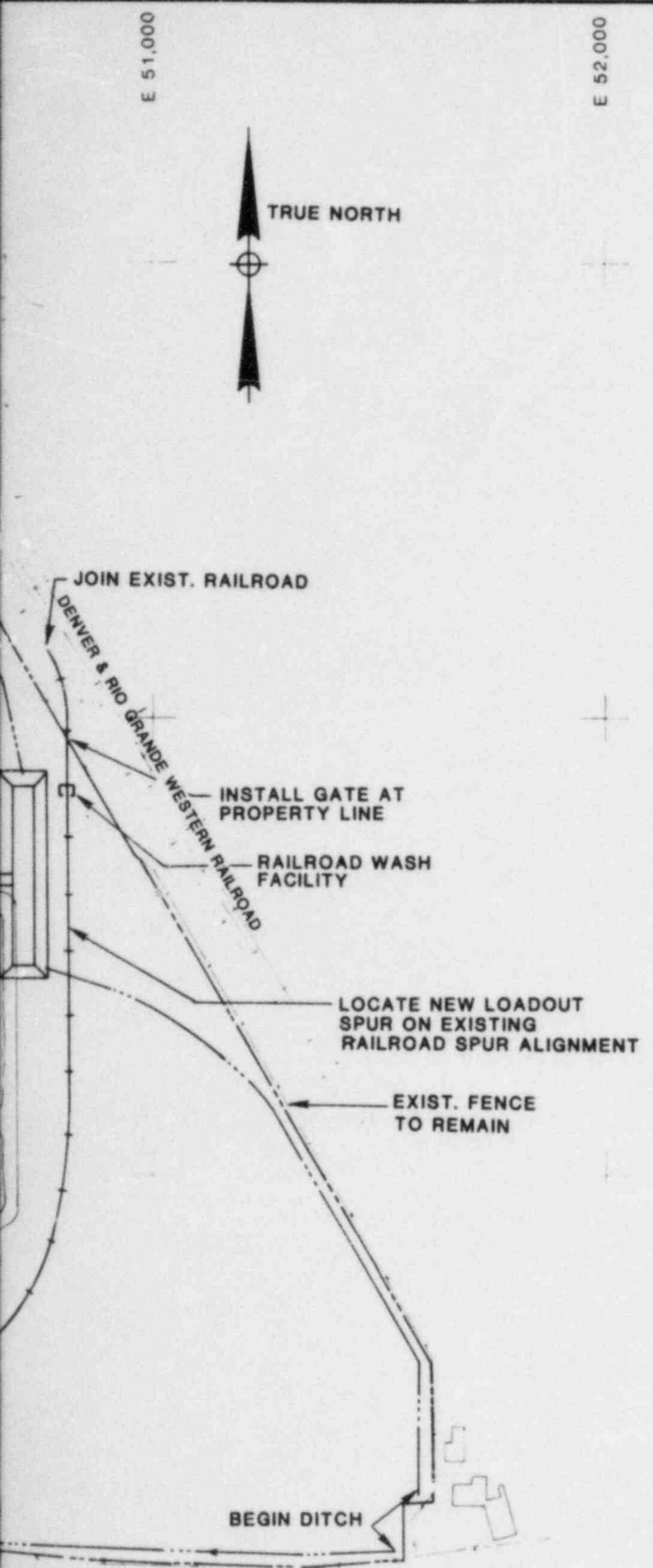
PROJECT NO. DE-AC04-82AL14086

DRAWING NO. SLC-DS-40-0002 REV B

NO.	DATE	REVISIONS	BY	CK	ENG.	APP.
B	8/31/84	ISSUE FOR APPROVAL	TJS	[illegible]	[illegible]	[illegible]
A	8/31/84	ISSUE FOR REVIEW	TJS	[illegible]	[illegible]	[illegible]



E 48,000
E 49,000
E 50,000
BEGIN DITCH
MILL CREEK
EXISTING FENCE
JOIN EXISTING FENCE
N 54,000
CLEAN FILL ENTRANCE GATE
TEMPORARY FENCE
BEGIN DITCH
CENTRAL VALLEY WATER RECLAMATION FACILITY
TEMPORARY FENCE
EXIST. FENCE TO REMAIN
WASTE WATER TREATMENT (SEE NOTE 2)
N 53,000
EXIST. FENCE TO REMAIN
BEGIN DITCH
VITRO DITCH
DITCH CROSSING
TYPICAL RETENTION POND
VITRO DITCH
900 WEST STREET
EXIST. SEWER LINE
REMOVE AND REPLACE EXIST. FENCE
ENTRANCE GATE
STAGING & DECONTAMINATION AREA
SEWAGE SLUDGE PONDS
TEMPORARY FENCE
DITCH & SEWER LINE CROSSING
N 52,000
EXIST. SEWER LINE
LOADOUT SPUR
SOUTH VITRO DITCH
EXIST. FENCE TO REMAIN
3300 SOUTH STREET
N 51,000
BEGIN DITCH
CLOSED ACCESS (BARRICADE)
200 0 200 400 600
SCALE IN FEET



NOTES:

1. BOUNDARY SURVEY AND BASES OF BEARING. "VITRO PLANT SITE SURVEY" DATED NOVEMBER 2, 1982. PREPARED BY WESTERN DESIGN CONSULTANTS FOR FORD, BACON & DAVIS UTAH INC.

2. WASTE WATER TREATMENT PLANT TO BE LOCATED AS REQUIRED DURING CONSTRUCTION SEQUENCE

LEGEND

- FLOW LINE
- FENCE
- EMERGENCY SPILLWAY
- WASTE WATER RETENTION POND
- SITE BOUNDARY
- RAILROAD

Also Available On Aperture Card

TI APERTURE CARD

8508140049-03

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

SALT LAKE CITY, UTAH

VITRO SITE
PLOT PLAN

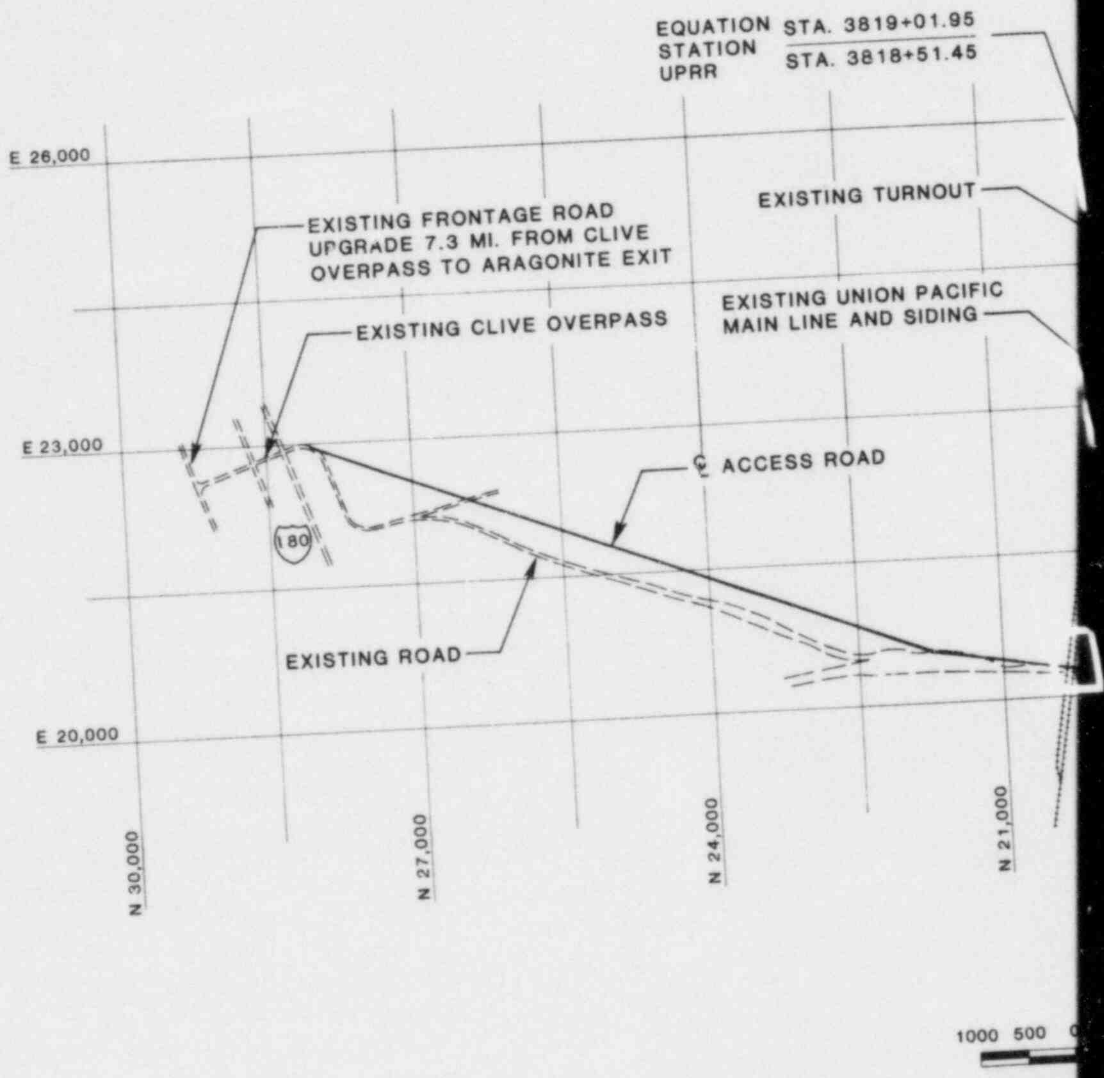
DESIGNED	
CHECKED	
CHIEF ENGR. MGR.	
SITE MANAGER	K. M. Paul
PROJECT MANAGER	R Kushner
DATE	9/5/84
DOE PROJECT MANAGER	A. Morley
DATE	9/5/84

JACOBS ENGINEERING GROUP INC.
JACOBS - WESTON TEAM
ALBUQUERQUE, NEW MEXICO

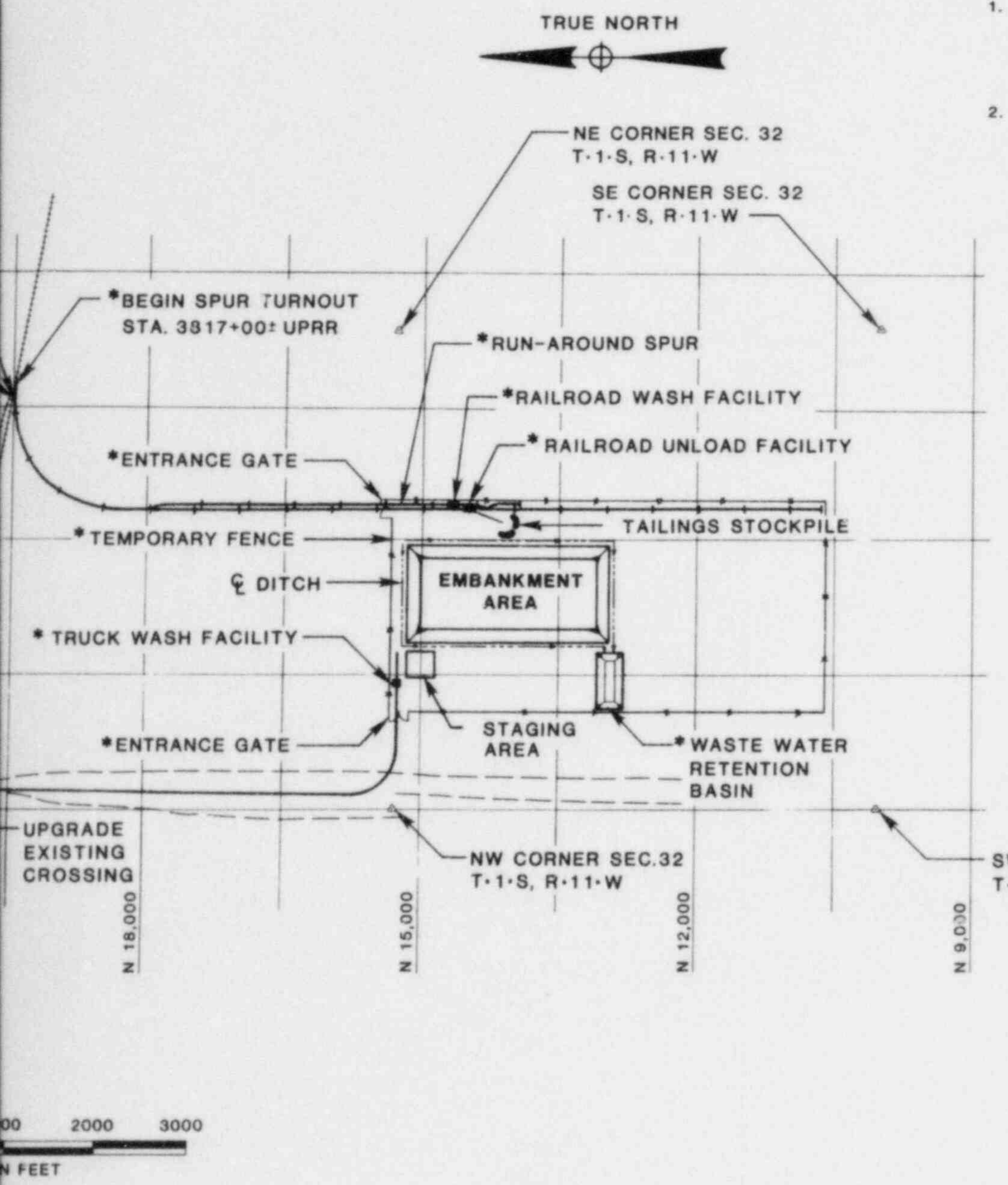
PROJECT NO. DE-AC04-82AL14086

DRAWING NO. SLC-DS-40-0003 REV. B

NO.	DATE	REVISIONS	BY	CK	ENG.	APP.
B	9/5/84	ISSUE FOR APPROVAL	TJS			
A	8/31/84	ISSUE FOR REVIEW	TJS			



EQUATION STATION UPRR
STA. 3819+01.95
STA. 3818+51.45
E 26,000
EXISTING TURNOUT
EXISTING FRONTAGE ROAD UPGRADE 7.3 MI. FROM CLIVE OVERPASS TO ARAGONITE EXIT
EXISTING UNION PACIFIC MAIN LINE AND SIDING
EXISTING CLIVE OVERPASS
E 23,000
℄ ACCESS ROAD
I 80
EXISTING ROAD
E 20,000
N 30,000
N 27,000
N 24,000
N 21,000
1000 500 0



NOTES

1. ORIGIN OF SURVEY (FROM NATIONAL CARTOGRAPHIC INFORMATION CENTER, DENVER, COLO.): SOUTHWEST CORNER SECTION 32, TOWNSHIP 1 SOUTH, RANGE 11 WEST. ASSUMED POINT OF ORIGIN COORDINATES NORTH 10,000.00, EAST 20,000.00, ELEVATION 4270.00.
2. BASIS OF BEARING: FROM THE SOUTHWEST CORNER OF SECTION 32 TO THE NORTHWEST CORNER OF SECTION 32 = N 0°00'00" W.

LEGEND

*	INDICATES INTERIM CONSTRUCTION
△	SECTION CORNER
- - → - -	FLOW
▶——	SLOPE
—•—•—	TEMPORARY FENCE
········	RAILROAD

Also Available On Aperture Card

TI APERTURE CARD

8508140049-04

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

SALT LAKE CITY, UTAH

SOUTH CLIVE SITE PLOT PLAN

NO.	DATE	REVISIONS	BY	CK	ENG	APP
B	8/14/84	ISSUE FOR APPROVAL	TJS			
A	7/13/84	ISSUE FOR REVIEW	TJS			

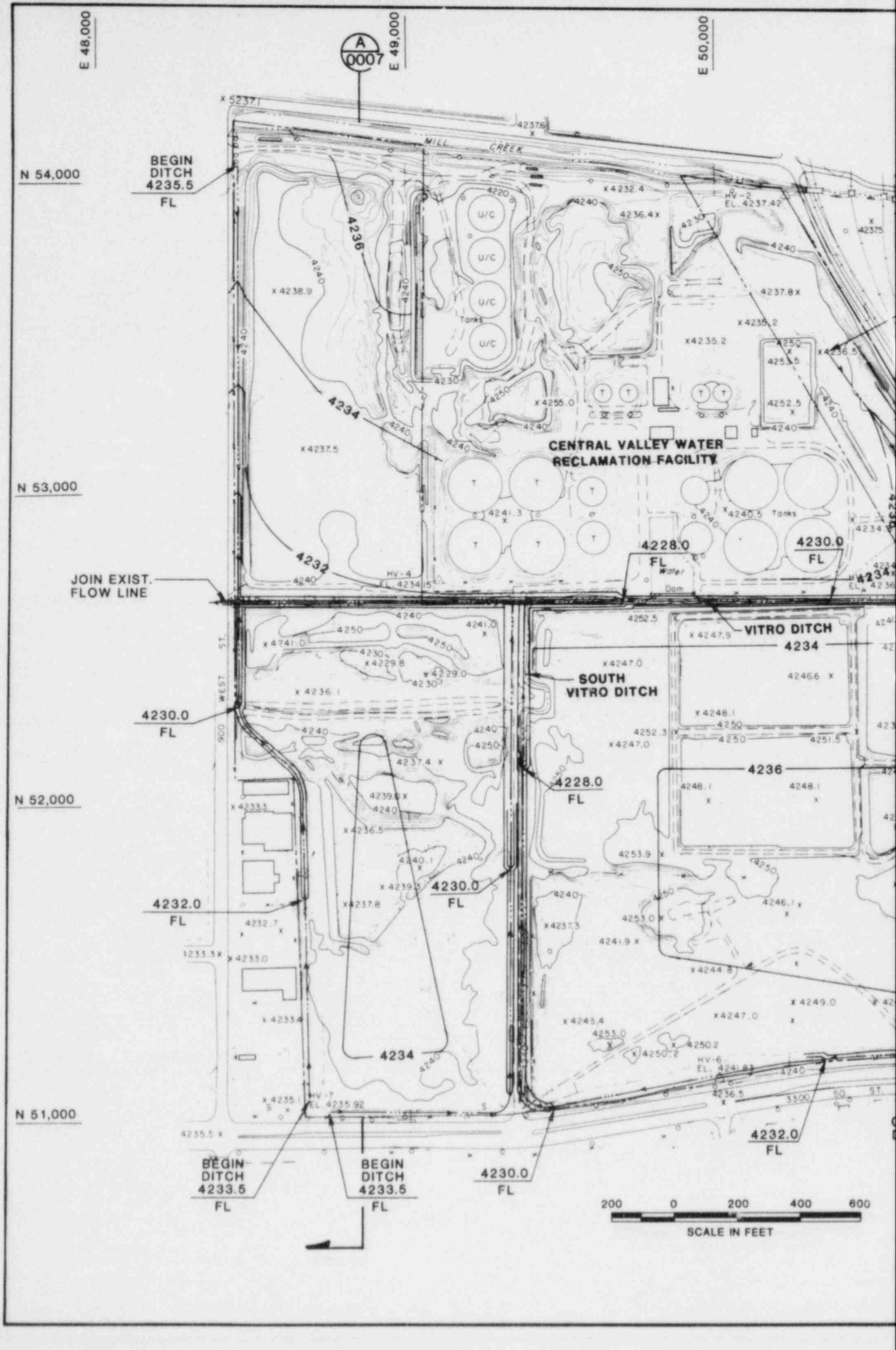
DESIGNED / CHECKED / CHC E / ENGR MGR / SITE MANAGER

PROJECT MANAGER: R. Kushman — DATE 9/5/84
DOE PROJECT MANAGER — DATE 9/5/84

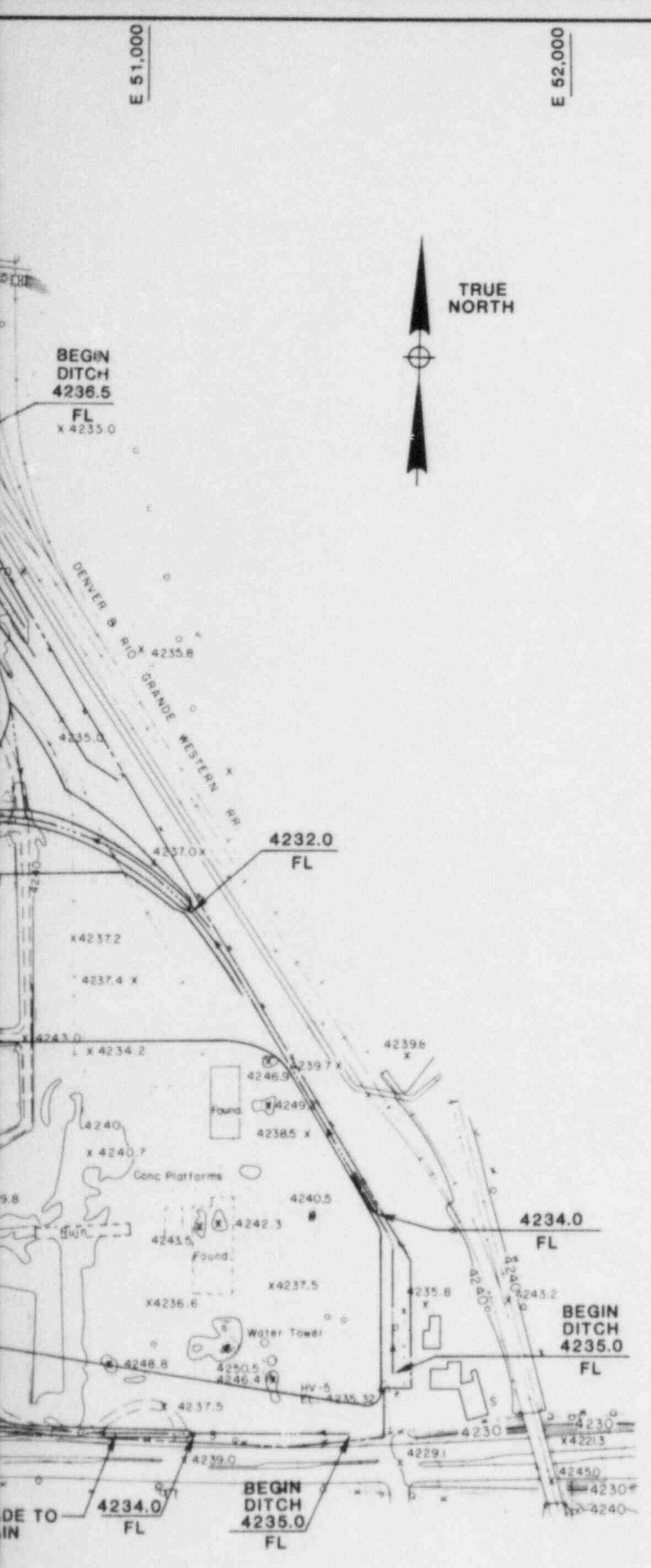
JACOBS ENGINEERING GROUP INC.
JACOBS - WESTON TEAM
ALBUQUERQUE, NEW MEXICO

PROJECT NO. DE-AC04-82AL14086

DRAWING NO. SLC-DS-40-0004 REV B



E 48,000
E 49,000
E 50,000
A
0007
N 54,000
N 53,000
N 52,000
N 51,000
BEGIN DITCH 4235.5 FL
MILL CREEK
JOIN EXIST. FLOW LINE
CENTRAL VALLEY WATER RECLAMATION FACILITY
4228.0 FL
4230.0 FL
VITRO DITCH
4234
SOUTH VITRO DITCH
4236
4228.0 FL
900 WEST ST.
4230.0 FL
4232.0 FL
4230.0 FL
4232.0 FL
BEGIN DITCH 4233.5 FL
BEGIN DITCH 4233.5 FL
4230.0 FL
200
0
200
400
600
SCALE IN FEET



NOTE

1. AERIAL TOPOGRAPHY BY OLYMPUS AERIAL SURVEY INC., SALT LAKE CITY, UTAH DATED SEPTEMBER 18, 1982

LEGEND

4232	GRADED CONTOUR
FL	FLOW LINE
	SITE BOUNDARY
	EXISTING FENCE

Also Available On Aperture Card

TI APERTURE CARD

8508140049-05

NO	DATE	REVISIONS	BY	CK	ENG.	APP
B	9/5/84	ISSUE FOR APPROVAL	TJS	MTB	CGT	KMP
A	8/24/84	ISSUE FOR REVIEW	TJS	MTB	CGT	KMP

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

SALT LAKE CITY, UTAH

VITRO SITE GRADING PLAN

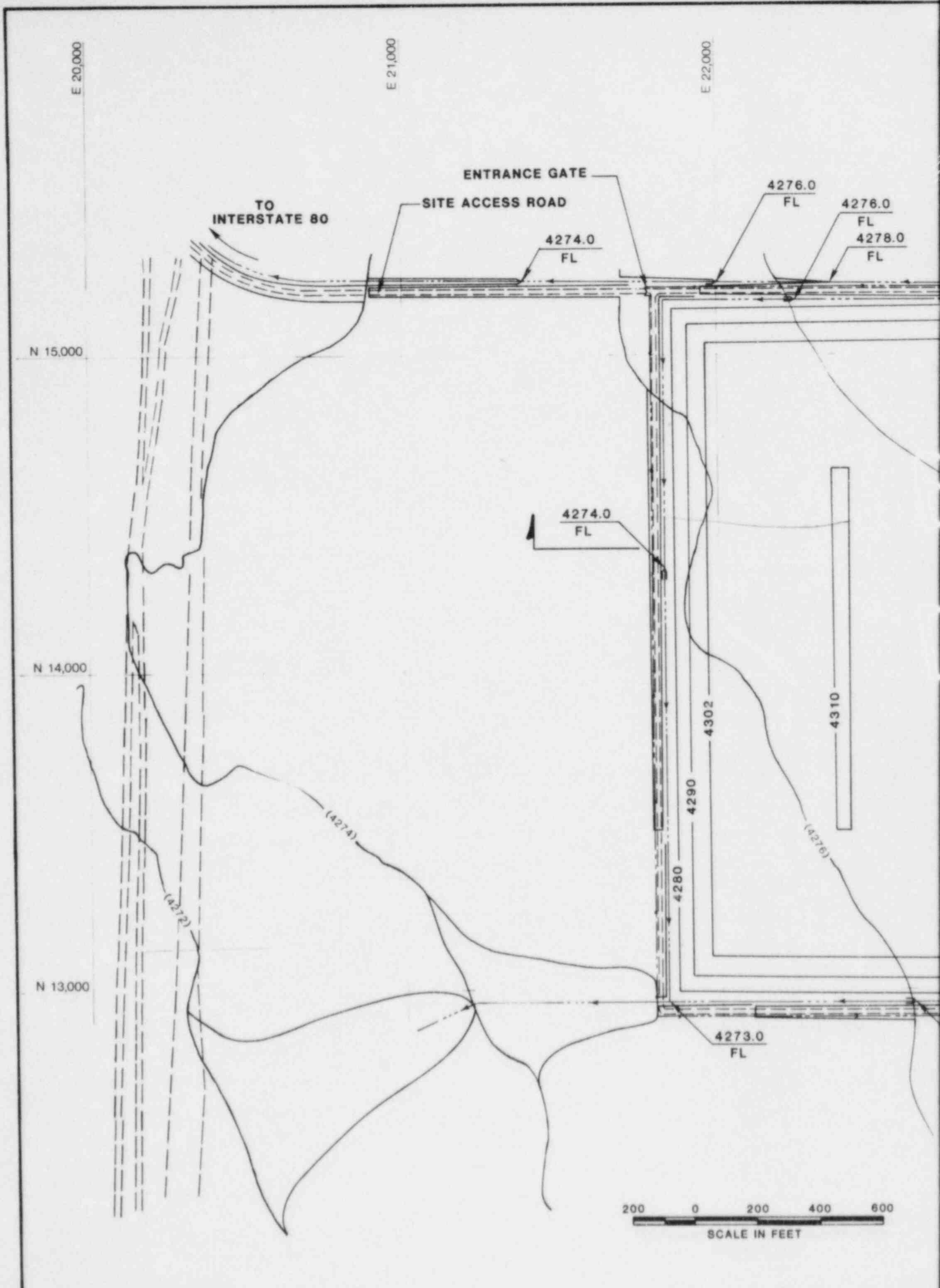
DESIGNED	[signature]
CHECKED	M.T. Bone
CHIEF ENGINEER	[signature]
SITE MANAGER	K. M. Paul

PROJECT MANAGER	DATE	DOE PROJECT MANAGER	DATE	DATE
R Kirshman	9/5/84	J.G. Morley	9/5/84	

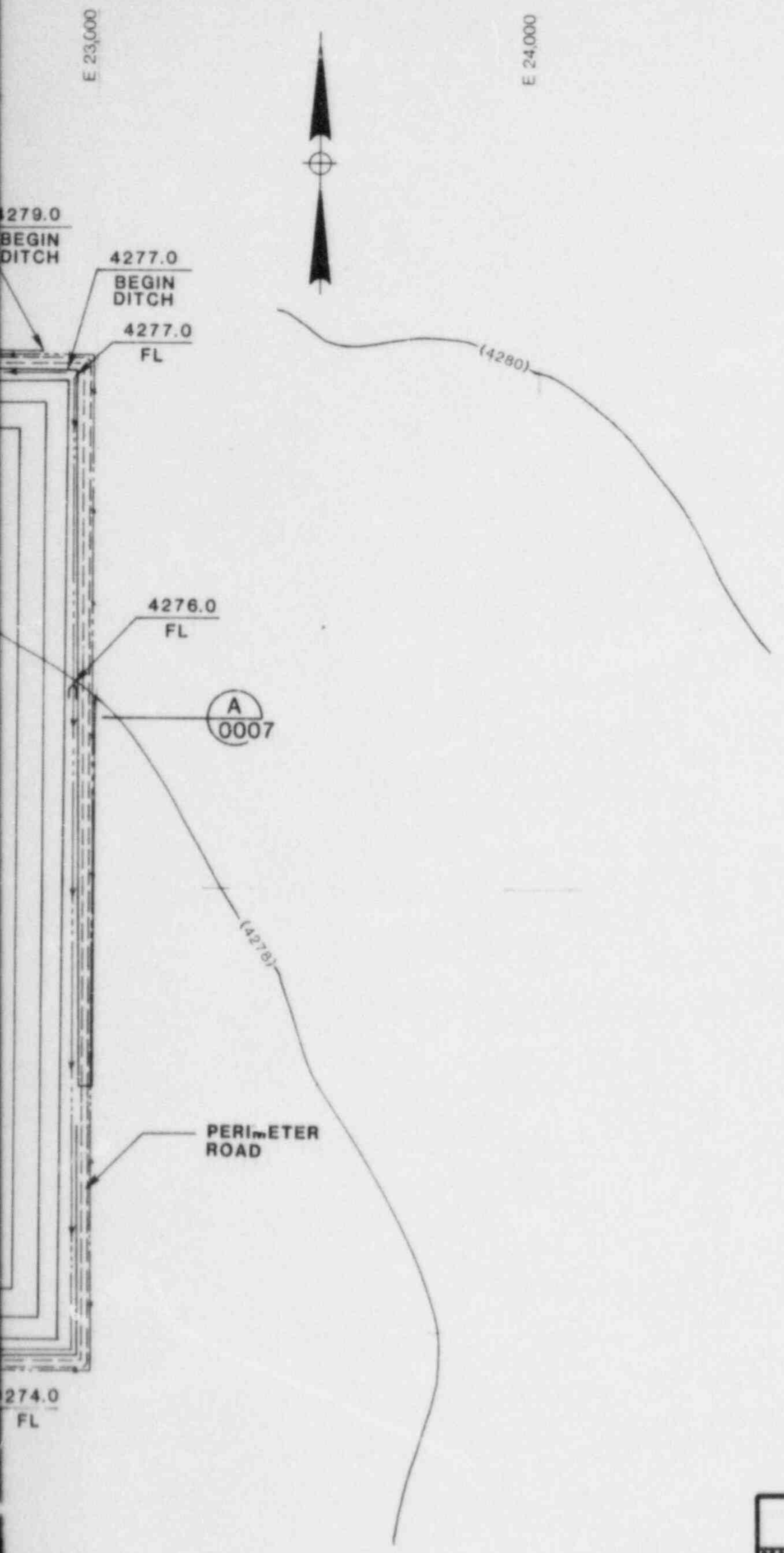
JACOBS ENGINEERING GROUP INC.
JACOBS - WESTON TEAM
ALBUQUERQUE, NEW MEXICO

PROJECT NO. DE-AC04-82AL14086

DRAWING NO. SLC-DS-40-0005 REV. B



E 20,000
E 21,000
E 22,000
ENTRANCE GATE
SITE ACCESS ROAD
TO INTERSTATE 80
4274.0 FL
4276.0 FL
4276.0 FL
4278.0 FL
N 15,000
4274.0 FL
N 14,000
4302
4310
4290
4280
(4274)
(4272)
(4276)
N 13,000
4273.0 FL
200 0 200 400 600
SCALE IN FEET



NOTES:

1. AERIAL TOPOGRAPHIC MAPS PER AEROGRAPHICS INC., SALT LAKE CITY, UTAH, DATED AUGUST 21, 1981.

LEGEND

FL	FLOW LINE
4280	GRADED CONTOUR
	FENCE
	SITE BOUNDARY
	DITCH CENTER LINE

Also Available On Aperture Card

TI APERTURE CARD

8508140049-06

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

SALT LAKE CITY, UTAH

SOUTH CLIVE SITE GRADING PLAN

DESIGNED		
CHECKED		
CHIEF ENGR.		
SITE MANAGER		
PROJECT MANAGER: R Kuntsman	DATE: 9/5/84	DOE PROJECT MANAGER: [illegible] Morley, DATE: 9/5/84

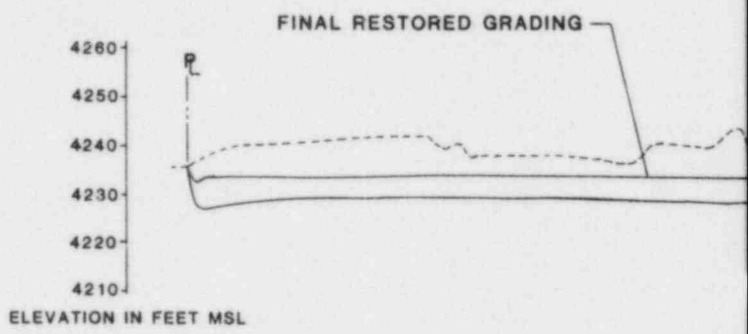
NO.	DATE	REVISIONS	BY	CK	ENG.	APP.
B	9/5/84	ISSUE FOR APPROVAL	TJS			
A		ISSUE FOR REVIEW	TJS			

JACOBS ENGINEERING GROUP INC.
JACOBS - WESTON TEAM
ALBUQUERQUE, NEW MEXICO

PROJECT NO. DE-AC04-82AL14086

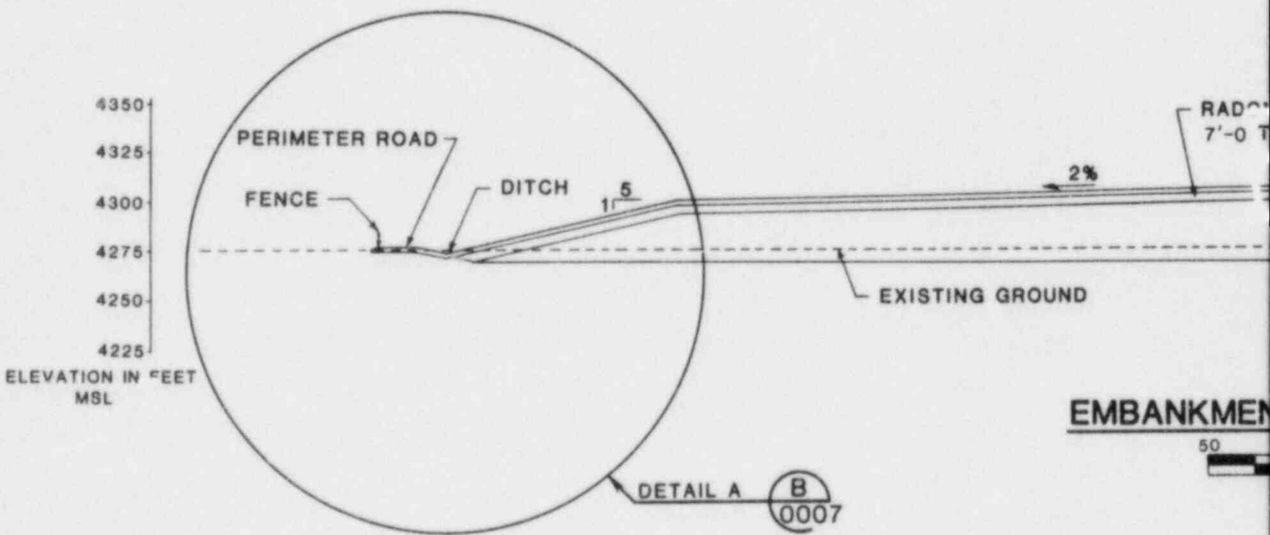
DRAWING NO. SLC-DS-40-0006

REV B



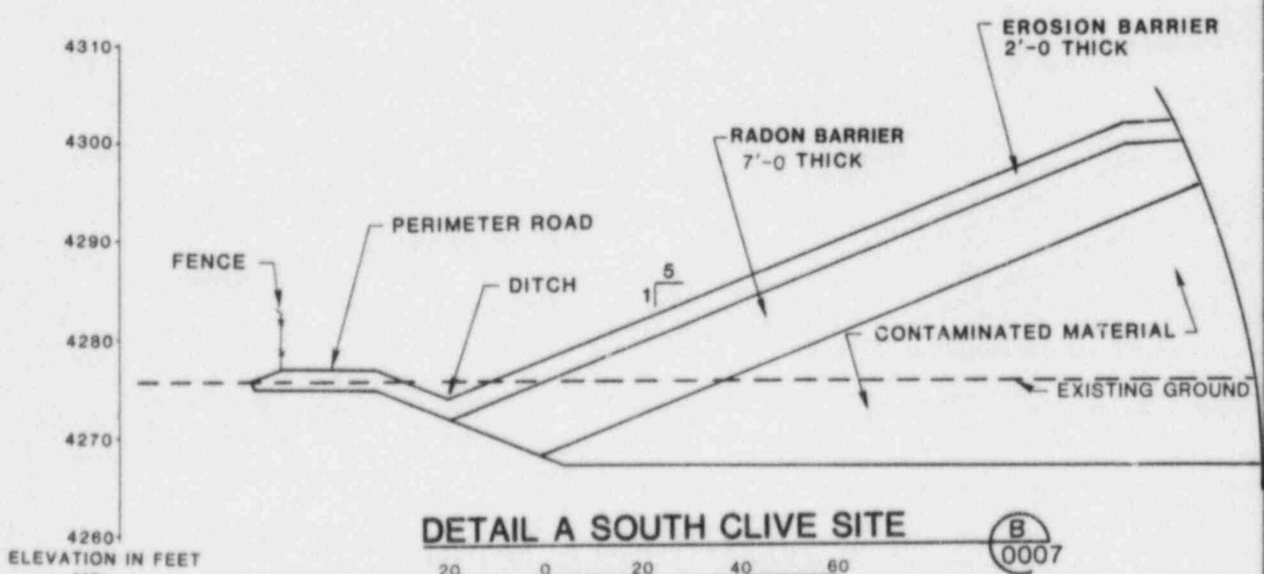
SEC

200



EMBANKMEN

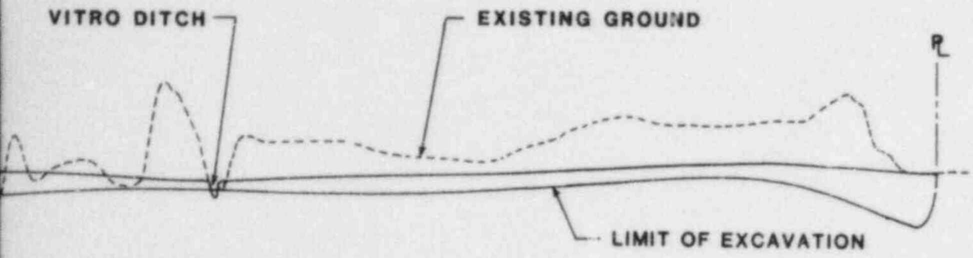
50



DETAIL A SOUTH CLIVE SITE (B/0007)

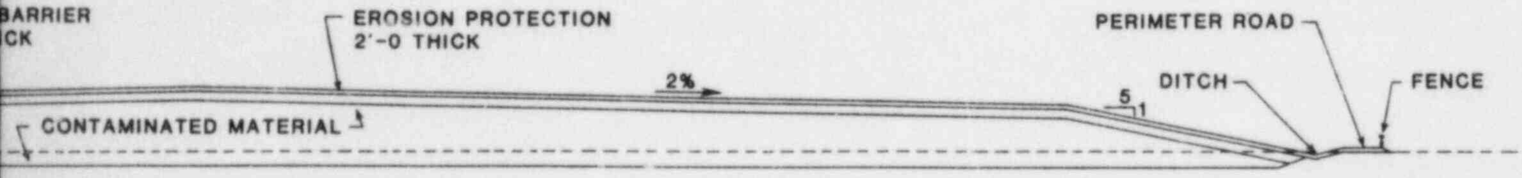
20 0 20 40 60

HORIZONTAL SCALE IN FEET



TION VITRO SITE (A / 0005)

0 200 400 600
RIZONTAL SCALE IN FEET



T SECTION SOUTH CLIVE SITE (A / 0006)

0 50 100 150
RIZONTAL SCALE IN FEET

Also Available On
Aperture Card

TI
APERTURE
CARD

8508140049-07

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

SALT LAKE CITY, UTAH

SECTIONS

DESIGNED	[signature]
CHECKED	M.T. Berg
CHC E./ENGR. MGR.	[signature]
SITE MANAGER	K.M. Paul

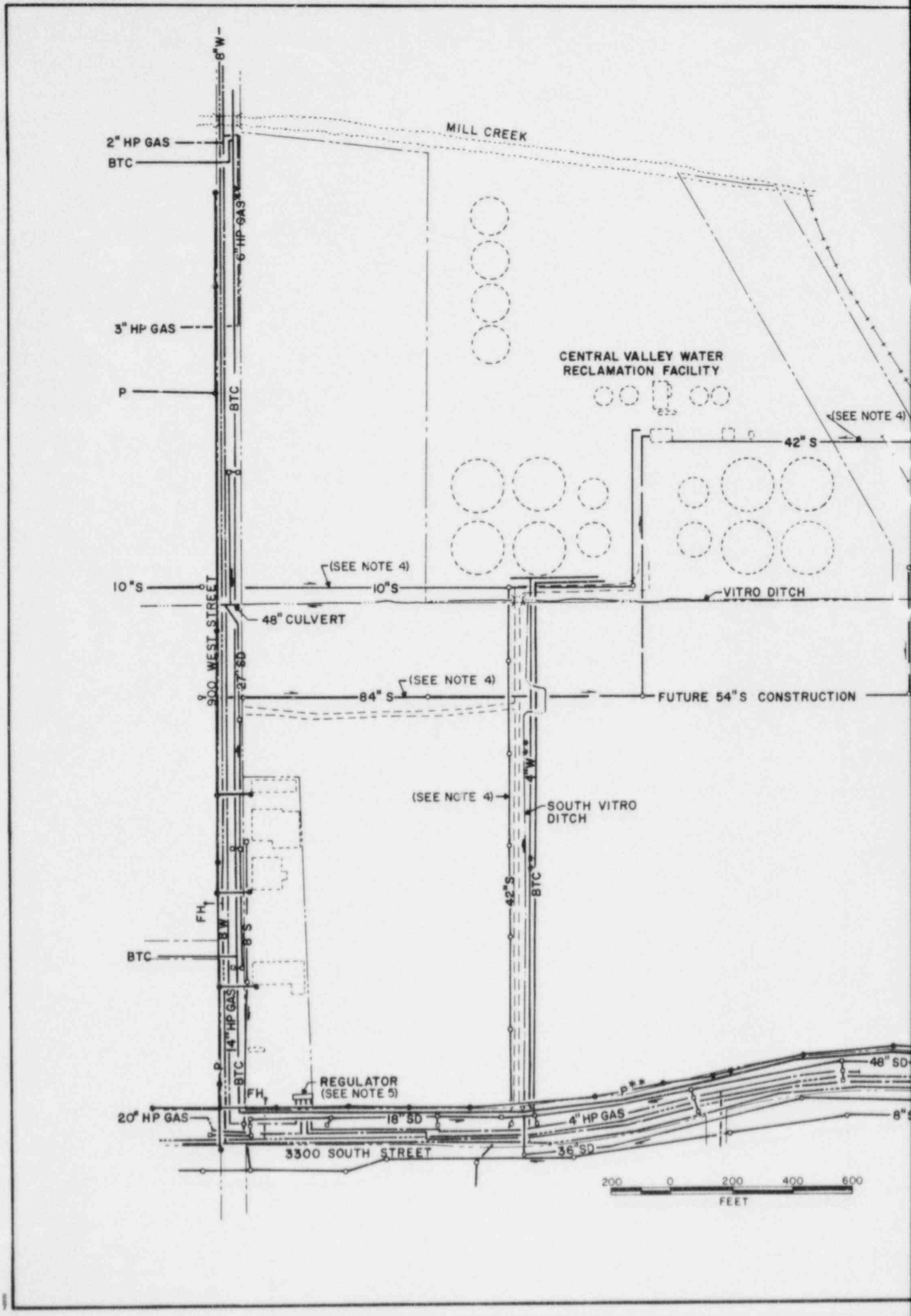
PROJECT MANAGER	DATE	DOE PROJECT MANAGER	DATE		DATE
R. Kushman	9/5/84	A. Morley	9/5/84		

JACOBS ENGINEERING GROUP INC.
JACOBS - WESTON TEAM
ALBUQUERQUE, NEW MEXICO

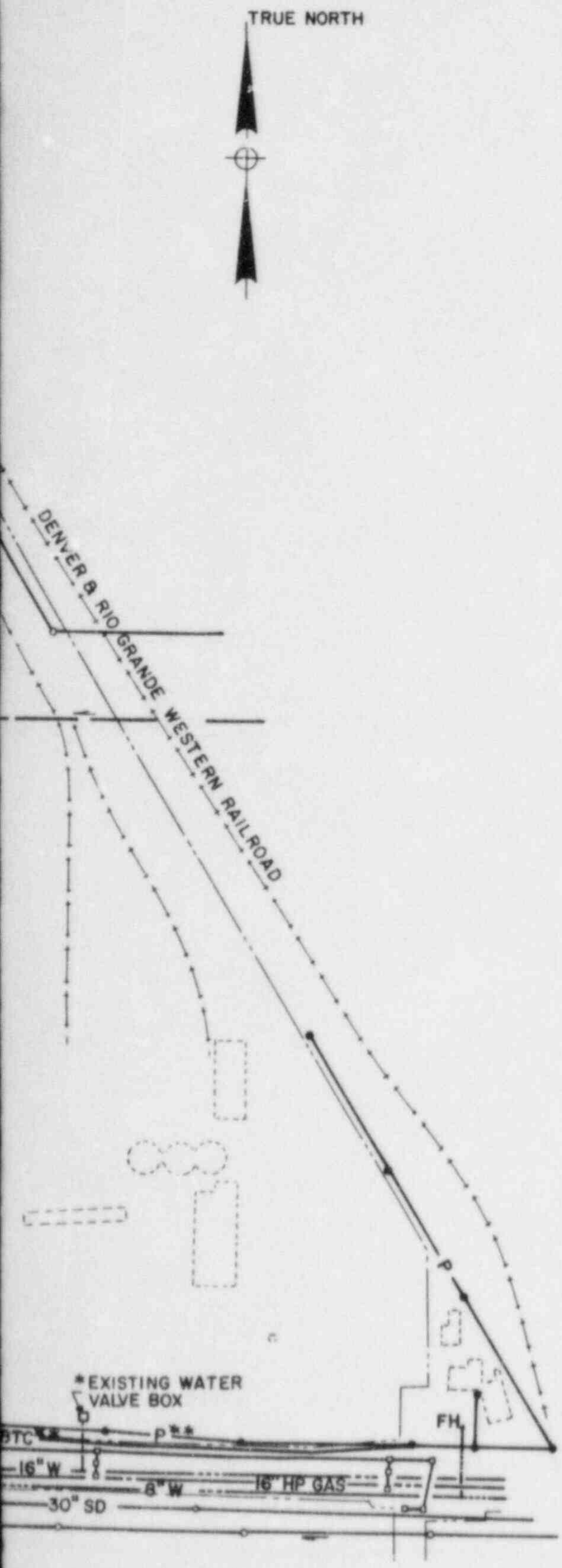
PROJECT NO. DE-AC04-82AL14086

DRAWING NO. SLC-DS-40-0007 REV B

NO.	DATE	REVISIONS	BY	CK	ENG	APP
B	9/4/84	ISSUE FOR APPROVAL	TJS	[initials]	[initials]	[initials]
A	5/11/84	ISSUE FOR REVIEW	TJS	[initials]	[initials]	[initials]



8" W
MILL CREEK
2" HP GAS
BTC
6" HP GAS
3" HP GAS
CENTRAL VALLEY WATER
RECLAMATION FACILITY
P
BTC
(SEE NOTE 4)
42" S
(SEE NOTE 4)
10"S
10"S
VITRO DITCH
48" CULVERT
900 WEST STREET
27" SD
(SEE NOTE 4)
84" S
FUTURE 54"S CONSTRUCTION
4" W
(SEE NOTE 4)
SOUTH VITRO
DITCH
42"S
BTC
FH
8"W
8"S
BTC
4" HP GAS
BTC
FH
REGULATOR
(SEE NOTE 5)
20" HP GAS
18" SD
P**
4" HP GAS
48" SD
8" S
36" SD
3300 SOUTH STREET
200 0 200 400 600
FEET



NOTES:

1. * INDICATES UTILITY REMOVAL OR ABANDONMENT IN PLACE
2. ** INDICATES UTILITY RELOCATION
3. ALL INTERFERING PORTIONS OF EXISTING UNDERGROUND PIPING SHALL BE REMOVED DURING CONSTRUCTION.
4. EXISTING SEWER SHALL BE PROTECTED DURING CONSTRUCTION.
5. EXISTING GAS REGULATOR SHALL BE PROTECTED DURING CONSTRUCTION.

Also Available On Aperture Card

TI APERTURE CARD

LEGEND

POLE — P —	EXISTING UTAH POWER & LIGHT CO.
MH — 8"S —	EXISTING SALT LAKE CITY SUBURAN SANITARY DISTRICT NO. 1.
— - - - — 6"W -	EXISTING WATER CONSERVANCY DISTRICT
— - — 4" HP GAS —	EXISTING MOUNTAIN FUEL SUPPLY CO.
— BTC —	EXISTING BURIED TELEPHONE CABLE MOUNTAIN BELL TELEPHONE CO.
GRATE 18"SD MH	EXISTING SALT LAKE COUNTY FLOOD CONTROL DIVISION
— - - — - - —	RIGHT OF WAY OR PROPERTY LINE
— — o — —	FUTURE SANITARY SEWER

8508140049-08

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

SALT LAKE CITY, UTAH

VITRO SITE
UTILITY LOCATION PLAN

DESIGNED / CHECKED / CHG E/ENGR MGR / SITE MANAGER / PROJECT MANAGER / DATE 9/5/84 / DOE PROJECT MANAGER / DATE 9/5/84 / DATE

JACOBS ENGINEERING GROUP INC.
JACOBS - WESTON TEAM
ALBUQUERQUE, NEW MEXICO

PROJECT NO. DE-AC04-82AL14086

DRAWING NO. SLC-DS-40-0008 REV B

NO	DATE	REVISIONS	BY	CK	ENG	APP
B	[illegible]	ISSUE FOR APPROVAL	TJS	[illegible]	[illegible]	[illegible]
A	[illegible]	ISSUE FOR REVIEW	TJC	[illegible]	[illegible]	[illegible]